14

Enclosure 2

INTERIM
HUD/SOUTH DAKOTA RADIATION
SURVEY PROTOCOL

FEBRUARY 1980

EXHIBIT "A"

CRITERIA

Basic criteria adopted for the South Dakota/HUD radiation level certification program will be drawn from two established sources.

A. U.S. Surgeon General's Guidelines for Grand Junction, Colorado, dated July 27, 1970.

B. U.S. Environmental Protection Agency's Recommendations to the State of Florida, dated June 8, 1979.

Criteria #1

Any weighted indoor Working Level (WWL) determined to be above 0.02 WL (including background) shall be classified as exceeding that level the Administrator of the EPA has found acceptable in terms of the increased long term risk of lung cancer in the exposed population. See Note below.

Criteria #2

If a weighted indoor working level measurement exceeds 0.015 WL, an additional set of measurements shall be made on another day to verify such a reading to determine acceptability of existing residences. All measurements taken will be averaged to determine the WWL.

Note: When annual average air concentrations of radon decay products are less than 0.02 WL, remedial action required to reduce such concentrations to as low as reasonably achievable levels should be taken.

METHODOLOGY I

(For existing residences)

In determining acceptability of a residence for federally supported financing in Edgemont, South Dakota and vicinity, the State will perform indoor radon daughter measurements in the following manner:

1. For each measurement an air sample having a minimum volume of 20 liters will be drawn through a 25 millimeter Millipore Type AA filter having a pore size of 0.80 microns. After an appropriate period of decay, the filter will be counted for alpha activity with a scintillation counter. The radon daughter concentration in Working Levels (WL) will be calculated and recorded.

2. A House Closed Reading (HCR) shall be made in a ground floor or basement room after the residence has been sealed for a minimum period of three (3) hours. Sealed means that all windows, doors, and outside vents are closed. To make the measurement, The State Officer will enter the residence, opening the entry door only to the extent that equipment and staff may enter. If the HCR exceeds 0.02 WL, then a House Open Reading (HOR) will be taken.

3. The House Open Reading will be made in the same location where the HCR was taken. The HOR will be made while the room is being ventilated at a normal level using available doors, windows, fans, etc., that supply fresh outside air. Such ventilation shall be in use for a minimum of 15 minutes before the HOR is taken.

   Weighting Procedure:

   Each reading (HCR and HOR) will receive the following weighting:

   7/12 HCR + 5/12 HOR = WWL

   The WWL shall then be used to certify a given resident's acceptability for further federal financing consideration. In the Edgemont area seven months are chosen as precluding the use of outside ventilation due to inclement weather.

4. The weighted indoor working level procedure may be bypassed by making a "house closed reading" to maximize conditions (worst case) to determine acceptability directly if the working level determination falls below 0.02 WL.

5. An alternate method of determining acceptability of a residence is the use of data acquired by measurement with a Radon Indoor Progeny Integrating Sampling Unit (RIPISU). RIPISU data will be derived from a minimum sampling time of 60 hours. RIPISU data acquired in the period between November 15 and April 1 can be substituted for the HCR. RIPISU data acquired between June 1 and September 30 can be substituted for the HOR.

METHODOLOGY II

(For Undeveloped Vacant Land)

Future radiation exposures in structures built on a given tract of land can be influenced by certain conditions. These can be largely characterized by answering the following questions.

1. Is the land mineralized with geological formations that contain uranium decay chain elements in varying amounts?

2. Is the underlying geology sufficiently disturbed by fracturing, tunneling or other perturbations which can enhance radon seepage and diffusion to the ground's surface?

3. Has the involved tract of land been reclaimed, graded or previously impacted with deposits of phosphate and/or copper slag that contains uranium decay chain elements in varying amounts?

4. Will the building materials used in subsequent construction of a structure on a given tract of vacant land contain a sufficiently low enough level of uranium decay chain elements? (Normally, this is the case if non-waste materials are used in fabrication of building materials.)

In determining acceptability of a given tract of land for its utilization as a federally financed project site in Edgemont, South Dakota and vicinity, the State will handle each evaluation and certification on a case by case basis, This is due to the complexity of parameters that need to be considered in the process.

Methods that can be employed by the State to perform these evaluations will normally include:

1. gamma scintillometer grid surveys;

2. surface soil sampling and ground coring for radioanalytical determinations;

3. charcoal canister or scintillation cell monitoring of radon diffusion and seepage to ground surfaces;

4. use of aerial radiometric or other radioanalytical data to determine existing background gamma radiation.

See Figures 1 and 2 for clarifying data, definitions and depictions concerning this protocol.

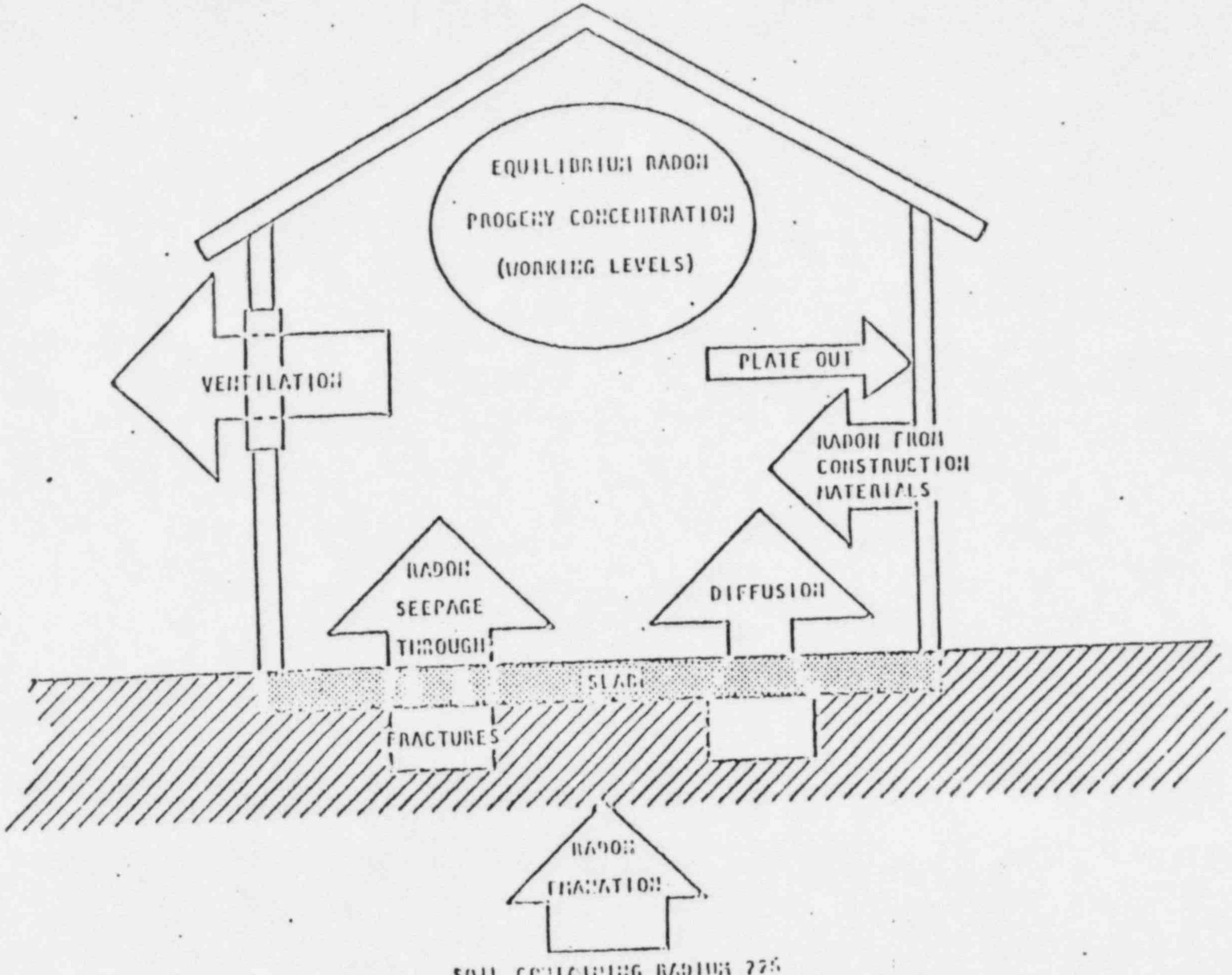

Figure 1 Factors Influencing Radon Decay Product Concentrations In Structures
[Guimond, February 1979]

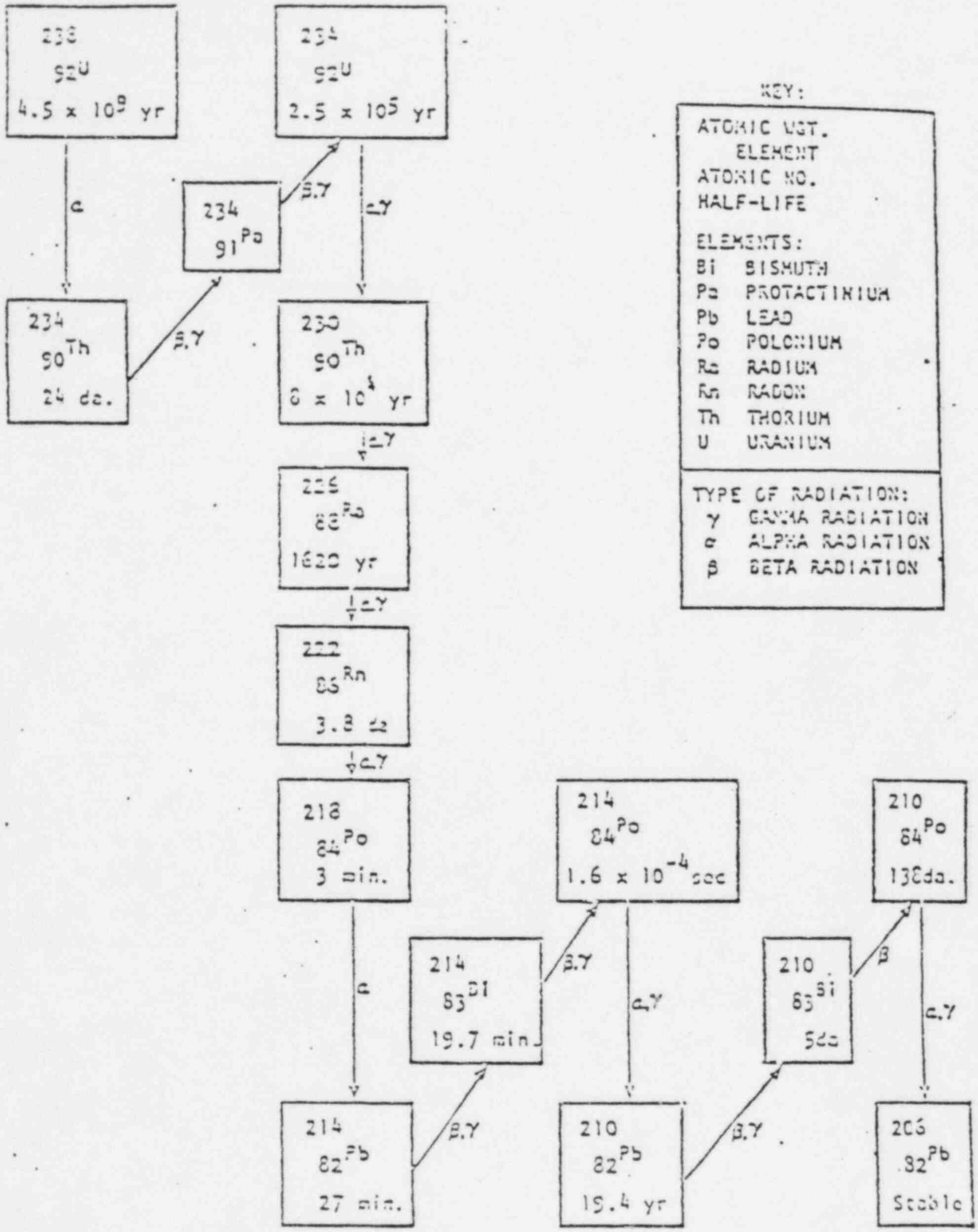

Figure 1 Uranium-238 Decay Series
From Guimond, February 1979

(15)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

CHAIRMAN

3/17

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March 13, 1980

The Honorable Gary Hart, Chairman
Subcommittee on Nuclear Regulation
Committee on Environment and Public Works
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

This letter is in response to your January 16, 1980 request for information on NRC activities concerning the health and safety of residents near the Edgemont uranium mill. In the following, we outline the problem and the appropriate solution as perceived by the NRC.

There are two concerns related to the Edgemont mill tailings: one concern has to do with the decommissioning of the mill site, and the other is related to the cleanup of offsite tailings. The inactive Edgemont uranium mill site, including the tailings, must be decommissioned in an acceptable manner. The Edgemont uranium mill is under an active source material license to the Tennessee Valley Authority (TVA), and the NRC is currently preparing an environmental impact statement (EIS) regarding TVA's proposed plan to decommission the mill site. The proposed decommissioning plan includes moving the tailings from the mill site to an impoundment at a location more remote from the residents of Edgemont. This proposed impoundment would meet present NRC criteria. We feel this part of the problem is being resolved in a timely manner. TVA is now completing the purchase of the new impoundment site to support the start of decommissioning work during the 1980 construction season.

The cleanup of all offsite tailings locations which were identified during the course of our activities related to the environmental review of decommissioning the Edgemont mill involves a two-step process. The first step is to complete the radiation measurement and evaluation program to determine what remedial action is necessary. Second, the remedial action program must be carried out.

As you noted in your letter, we have been working with the Environmental Protection Agency (EPA), TVA and the State of South Dakota on the radiation measurement program in Edgemont to define the extent of the offsite cleanup problem. The initial measurements are proceeding on the basis of evaluating those structures suspected of having the most significant problem. The results of radon daughter measurements made inside houses suspected to be contaminated with tailings revealed significantly high levels of exposure to occupants of one of the houses. This house has been vacated, and we are working to complete the screening program as quickly as possible to determine which other suspected structures have significant radon daughter levels.

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The initial radon daughter grab sample screening of the remaining suspected structures should be completed by the end of March 1980. A more comprehensive long-term monitoring program will follow to determine if remedial action will be necessary for any borderline cases. Of the already monitored structures, only the one noted above had radon daughter levels sufficiently high to require the residents to move out.

The monitoring has progressed to the point of identifying five structures that are likely to require some type of remedial action. Only one of these (the one evacuated) is suspected to have tailings beneath the structure; tailings at the other locations appear to exist around the structure where they can be easily removed. We would estimate that no more than about ten additional locations will have tailings near, but not under, the structures.

The most significant problem in reaching a final solution to the problems at offsite tailings use locations in Edgemont is that no one agency is clearly responsible for performing the extensive monitoring required or for taking the remedial actions which might be identified. We have requested the Department of Energy's (DOE) assistance in this matter by letter dated January 16, 1980 (copy enclosed). We have not yet received a response, but members of DOE have indicated that there may be legal constraints that would preclude their assistance in this matter. We are discussing with other federal agencies the questions of who should administer the remedial actions and how they should be funded. However, it should be noted that federal assistance for remedial actions at the Edgemont site is not provided for in the Uranium Mill Tailings Radiation Control Act of 1978.

We hope this information answers your questions on this matter. If we can be of any assistance in the future, please contact me.

Sincerely,

Original Signed By
John F. Ahearne
John F. Ahearne

Enclosure:
Letter to R. Clusen, DOE, fm
W. Dircks dated January 16, 1980

Identical letters sent to: Senator George McGovern
Senator Alan Simpson
Senator Larry Pressler

bcc: Ruth C. Clusen, DOE
Richard M. Freeman, TVA

Cleared with all Cmrs. by SECY C/R

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MEMORANDUM FOR: Edgemont Remedial Action Program Files (FIN No. B-2217)

FROM: Greg G. Eadie
Uranium Recovery Licensing Branch

SUBJECT: REMEDIAL ACTION PROGRAM FOR EDGEMONT, SOUTH DAKOTA

Background

At the request of the U. S. Nuclear Regulatory Commission (NRC), the town of Edgemont, South Dakota and vicinity was surveyed in early November 1978 to determine if uranium mill tailings from the former Edgemont Uranium Mill had been used for off-site construction purposes. The U. S. Environmental Protection Agency (EPA) conducted the surveys using a specially shielded gamma radiation detection system mounted in a van type motor vehicle. A similar survey had been conducted by the EPA in 1971-72 and comparison of results between the two surveys (i.e., 1971-72 and 1978) indicated a total of 60 possible tailings use locations in the area. However, there is a possibility that additional tailings use locations exist since the mobile van system has inherent detection problems, such as shielding and response time factors, which essentially limit this system's use and require more detailed gamma radiation surveys at each suspect location.

In December 1979, the EPA provided Radon Progeny Integrating Sampling Units (RPISU) to the State to conduct measurements of working levels (WL) inside those structures identified as gamma anomalies (i.e., above background radiation levels). As of June 10, 1980, the following distribution of WL's has been reported for 31 structures surveyed (note that not all of these structures are gamma anomalies).

>0.10WL -- 4 structures
>0.05WL -- 5 structures
>0.03WL -- 6 structures
>0.015WL -- 4 structures
less than 0.015WL -- 12 structures

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Also, the Department of Housing and Urban Development (HUD) has become involved in requiring a grab-WL sampling at any structure in Edgemont prior to guarantying federal mortgage monies. Therefore, in order to fully assess all possible locations having elevated radiological conditions, the following programs, as shown in Figure 1, shall be conducted in the vicinity of Edgemont, South Dakota:

I. Grab Working Level Measurements (HUD/EPA Protocol)

A grab (i.e., brief sampling time of about 5 minutes or a 10 to 20 liter volume) sample to determine the radon progeny concentrations (in WL) should be completed using the Thomas method for analysis. This grab WL sampling shall be conducted based on the HUD/EPA protocol (see Enclosure 2) in the following manner:

1. The structure must be in the "closed-up" condition (i.e., all doors and windows shut, and no air conditioning or heating systems in operation) for at least 3 hours prior to sample collection.

2. The grab WL sample shall be collected in the area of longest occupancy, e.g., the bedroom or finished basement area of a residence, or the main working area of a commercial building.

3. If the inside grab WL exceeds 0.033 WL, such a structure shall then be resampled. If upon confirmation of a value in excess of 0.033WL, that structure shall be considered for the engineering assessment.

4. If the grab WL is between 0.01 and 0.033WL, a definitive gamma radiation survey and/or soil sampling programs shall be completed as discussed below.

5. If the grab WL is less than 0.010WL, the structure shall be cleared and will not require further radiological assessments.

II. Gamma Radiation Measurements

A portable gamma survey meter (e.g., micro R meter) shall be used to complete the gamma radiation measurements both inside and outside of the structure. This survey meter shall be cross-calibrated with a Pressurized Ionization Chamber (PIC) in order to provide realistic exposure measurements. This survey shall be designed to detect the presence of any possible residual radioactive material under, within or around the structure. A map shall be provided indicating all locations having above background radiation levels. This survey need only be performed once for each structure.

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III. Long-term Radon Progeny Sampling

Long-term radon progeny sampling using either the Radon Progeny Integration Sampling Unit (RPISU) or the Measurement of Daughters (MOD) sampling unit may be required in any structure having a grab WL in the range 0.01 to 0.033WL and a radiation survey indicating the presence of residual radioactive material or an exposure rate less than 20 μR/hr above background. Such long-term radon progeny samples shall be collected for at least 100 hours, every other month, for at lease six samples during a yearly cycle.

IV. Soil Sampling

Soil sampling, both surface and at depth, shall be completed at specified locations to determine the concentrations of uranium decay chain series radionuclides (e.g., uranium, radium-226, thorium-230 and lead-210). The lower limit of detection shall be at least 0.50 pCi/gram of soil for radium-226 analysis which shall be used to determine compliance to the regulatory standards. Bore-hole logging to determine the presence of radium-226 at depths of up to 8 feet may also be required.

V. Engineering Assessment

An engineering assessment shall be completed at each stucture which exceeds the EPA's standards for uranium mill tailings cleanup (i.e., as proposed in 40 CFR 192 of an annual average WL greater than 0.015, or having radium in soil greater than 5 pCi/g, or a gamma radiation exposure rate in excess of background of 0.02 mR/hr). The assessment shall provide a detailed map of all residual radioactive material deposits and volume estimates. Such information may be obtained by gamma radiation survey techniques, bore-hole logging techniques, or soil sampling and analysis.

Original Signed by
Greg G. Eadie
Uranium Recovery Licensing Branch
Division of Waste Managment

Approved by: Original Signed by
Ross A. Scarano, Chief

Enclosures:
1. Figure 1
2. Interim HUD/South Dakota Radiation Survey Protocol

8/12/80

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SURNAME ▶	GGEadie/lb	HJMiller	RAScarano			
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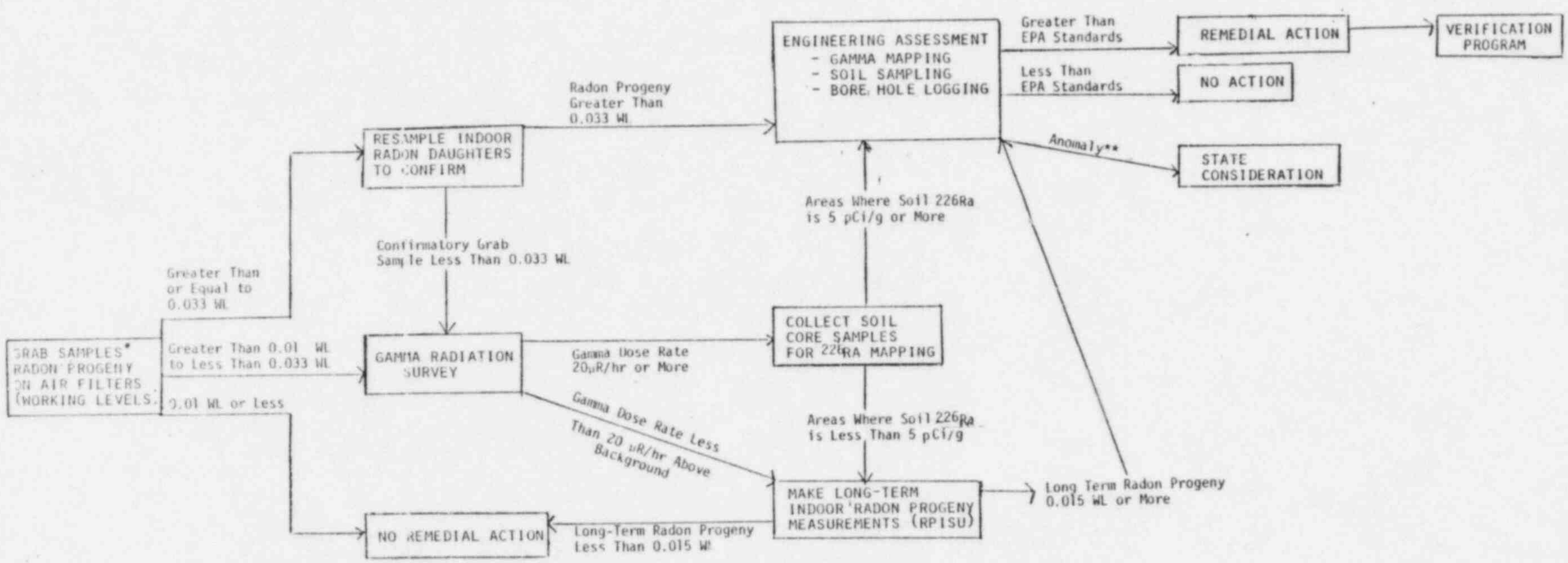
ENCLOSURE 1

FIGURE 1 REMEDIAL ACTION PROGRAM FOR EDGEMONT, SOUTH DAKOTA



*HUD/EPA Protocol

**Anomaly may be natural terrestrial radioactivity resulting in radiological exposure in excess of EPA Standards.

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Mr. R. Perkins
Battelle Pacific Northwest Laboratory
P. O. Box 999
Richland, Washington 99352

Dear Mr. Perkins:

Enclosed for your review is the plan we have developed for the off-site remedial action program at Edgemont, South Dakota. An earlier version of this action plan was reviewed by your staff informally and comments were incorporated. Please note that the grab working level measurements noted on page 2 of the plan are compatible with the HUD/South Dakota Radiation Survey Protocol.

We expect to be able to initiate the program shortly and would like to have your concurrence in the plan by September 2, 1980.

Sincerely,

Original Signed By:

John B. Martin, Director
Division of Waste Management

Enclosure:
As stated

Identical ltr sent to those on the attached list.

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8/12/80 2pp.

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SURNAME ▶	GGEadie	HJMiller for	RAScarano for	JBMartin		
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NRC Form 318 (2-76) NRCM 02040 ☆U.S. GOVERNMENT PRINTING OFFICE: 1976-634-782

LIST OF ADDRESSEES

Mr. James R. Richardson
Commissioner
State Planning Bureau
Pierre, South Dakota 57501

cc: Mr. Ralph Shell, TVA

Mr. Gerald J. Hannon
Regional Administrator, Authorized Agent
Region VIII
Housing and Urban Development
1405 Curtis Street
Denver, Colorado 80202

cc: M. Taranowski
Housing and Urban Development
451 Seventh Street
Washington, D.C. 20410

Dr. David Rosenbaum
Deputy Assistant Administrator
for Radiation Programs
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

cc: Mr. John Geidt
U.S. Environmental Protection Agency
Region VIII
1816 Lincoln Street
Denver, CO 80203

(18)

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NMSS r/f GGEadie
WM r/f REBrowning
JBMartin

MEMORANDUM FOR: Edgemont Remedial Action Program Files (WM-40)

FROM: Gregory G. Eadie
Uranium Recovery Licensing Branch

SUBJECT: MEETING WITH BPNL TO DISCUSS REQUIREMENTS OF REMEDIAL ACTION PROGRAM FOR EDGEMONT, SD

ATTENDEES: R. A. Scarano - NRC
G. G. Eadie - NRC
R. Perkins - BPNL
N. Wogman - BPNL
P. Jackson - BPNL

PLACE: WMUR - Willste Bldg., Silver Spring, MD

TIME: 9:00 a.m. to 4:00 p.m. on August 14, 1980

This meeting was held to discuss the program requirements under the SOW (B-2217) issued to Battelle Pacific Northwest Laboratories for the remedial action program for Edgemont and vicinity, South Dakota. The following items were discussed in detail:

1. Statement of Work (B-2217) work required for each of the four tasks and the overall reporting requirements.

2. Housing and Urban Development (HUD) requirement and the grab-Working Level protocol.

3. Engineering Assessment reports such as the ARIX, Inc. reports for 19 structures in Edgemont, SD.

4. NRC's remedial action program.

5. Priority listing of 8 structures to be scheduled for remedial action.

The following items were agreed upon at this meeting:

1. NRC will expedite the issuance of the SOW (B-2217) and funding authorization by August 23, 1980.

2. BPNL will prepare a draft Form 189 response for the SOW (B-2217) and transmit to NRC for approval by August 27, 1980.

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NRC Form 318 (2-76) NRCM 0240 ☆U.S. GOVERNMENT PRINTING OFFICE: 1976-634-782

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3. BPNL will evaluate the HUD grab-WL protocol with respect to air sample volume and filter type to assure reasonable accuracy at the 0.015 WL value. A letter report shall be issued discussing results and conclusions.

4. BPNL will proceed to develop the written protocols for grab-WL, radiation surveys, and soil sampling and analysis techniques.

5. BPNL will check into the possibility of initiating sub-contracts for such tasks as engineering assessments and also the construction/clean-up remedial engineering work. NRC will check with TVA and the State regarding available construction firms.

6. BPNL will obtain legal opinion on the need for "release forms" from owner/occupant of residence in order to gain entry to perform radiological surveys, soil sampling, etc.; to perform engineering assessments; and to perform the actual remedial actions. NRC legal staff will review such BPNL legal documents.

7. A tentative date of the week of September 8, 1980 was set to have BPNL personnel, and mobile laboratory and equipment arrive in Edgemont to initiate the remedial action program.

8. A tentative date of September 2, 1980 was set to have NRC, BPNL and the state meet in Rapid City, SD to discuss the Edgemont remedial action prgoram; to be followed on September 3, 1980 by a "Town Hall Meeting" in Edgemont for the press and general public concerning the remedial action program.

Original Signed By:

Gregory G. Eadie
Uranium Recovery Licensing Branch
Division of Waste Management

cc: R. Perkins - BPNL
J. Richardson - SD

OFFICE	WMUR	WMUR	WMUR			
SURNAME	GGEadie	HJMiller	RAScarano			
DATE	8/18/80	8/19/80	8/19/80			

SOUTH Dakota
Department of Health
DIVISION OF ENVIRONMENTAL HEALTH
Joe Foss Building
Pierre, South Dakota 57501
(605) 773-3329

19

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January 14, 1981

John McGrath
State Agreements Program
Office of State Programs
U.S. NRC
Washington, D.C. 20555

Dear Mr. McGrath:

On September 18, 1980, I assumed the responsibilities of the State of South Dakota's Radiation Control Program Director. Therefore all duties associated with the Edgemont Uranium Mill, Edgemont off-site cleanup project, and radiation activities in general are performed by myself and staff.

If you have any questions, please contact this office.

Sincerely,

Randy Brich

Randy Brich
Environmental Specialist III
Radiological Monitoring Program

RB/drn

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Project WM-40
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Dr. N. A. Wogman, Manager
Radiological & Inorganic
Chemistry Section
Battelle Pacific Northwest Laboratories
P. O. Box 999
Richland, Washington 99352

Dear Dr. Wogman:

I have reviewed your monthly report for the "Environmental Cleanup Standards" (B-2216-0) for January 1981, and have the following comments:

1. The proceedings of the January 21-22, 1981, Workshop on "Radiological Surveys in Support of the Edgemont Cleanup Action Program" should be finalized and forwarded no later than March 15, 1981, to the NRC for review and concurrence.

2. The following comments apply specifically to your draft protocol to field test the track etch device and the use of the RPISU as detailed in the "Procedure for Long-Term Radon Progeny Measurements."

   (a) Page 1, lines 7 to 10: The RPISU shall be considered to be the standard instrument for measuring radon progeny concentrations; however, upon the approval of the NRC, other devices which yield measurements of comparable accuracy to those provided by the RPISU may be substituted for the RPISU.

   (b) Page 1, lines 12 to 15: Delete these two sentences and substitute: "The minimum sampling time necessary to obtain a valid RPISU measurement shall be a total of 100 hours for sampling using one or more RPISU sampling heads. Since there is frequent plugging of the RPISU sampling head (e.g., due to heavy cigarette smoking by the occupants), which results in short sampling periods less than the required minimum time, more than one RPISU sampling head may be used to obtain the required minimum sampling time of 100 hours. If more than one RPISU sampling head has been used to obtain the minimum total 100 hours of sampling, the valid measurement shall be calculated from the time weighted average of all the individual RPISU sampling head measurements as follows:

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$$\overline{W.L.} = \Sigma \frac{t_i W_i}{T}$$

where ---

$\overline{W.L.}$ = time weighted Working Level

t_i = sampling time for ith sample

W_i = Working Level for ith sample

$T = t_1 + t_2 \cdots t_n$ = total sample time which must be greater than 100 hours

(c) Page 1, lines 16 to 27: Delete these sentences and substitute: "In order to compare working levels, as measured by the RPISU versus the track etch device, one track etch device shall be placed in each residence for the entire bimonthly period corresponding to the RPISU bimonthly sampling schedule. Therefore, the six bimonthly track etch results will be directly comparable to the required six bimonthly RPISU measurements. Another separate track etch device shall be placed for the entire year in each residence in order to provide an estimate of the animal average Working Level based on continuous monitoring using a track etch device. Hence, the annual average of the six bimonthly integrated RPISU measurements may be compared to the average of the six bimonthly track etch device results and to the result from the track etch device which was exposed for the entire one-year period. A minimum of 50 reference structures shall be used for these comparisons between the RPISU and the track etch device. If these measurements indicate that the track etch provides annual average working levels of comparable accuracy to those provided by the RPISU, track etch devices may be used instead of the RPISU instrument subject to the approval of the NRC.

3. The field testing of the track etch device shall utilize the Terradex Type F (detector in a filtered cup) since this configuration minimizes the uncertainties due to radon progeny disequilibrium and to exposures from airborne particulates such as uranium ore dust. Since the available calibration data indicates that the Terradex Type F track etch device has only been calibrated for determining radon concentrations, PNL's procedure for cross-calibrating the track etch device to provide Working Level determinations (i.e., radon progeny concentrations) as discussed above must still be documented and approved before the NRC would authorize the substitution and use of any track etch device instead of the RPISU instrument.

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DATE							

These considerations were discussed with V. W. Thomas on February 23, 1981; but if you have further questions on these matters, please contact me on (301)427-4541.

Sincerely,

Original signed by

Gregory G. Eadie
Uranium Recovery Licensing Branch
Division of Waste Management

cc: R. Perkins, PNL
P. Jackson, PNL
V. W. Thomas, PNL

3/5/81

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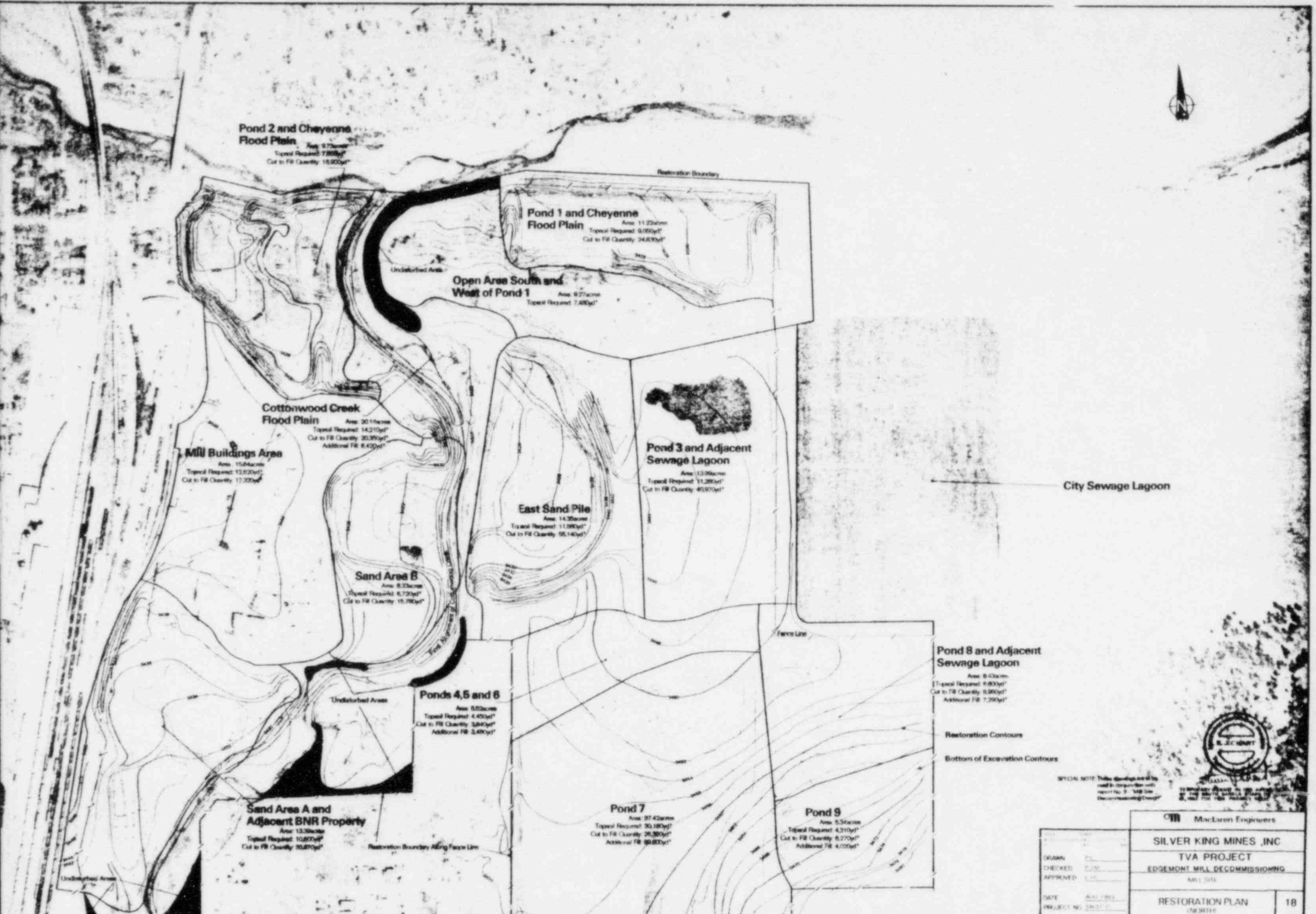
Pond 2 and Cheyenne Flood Plain
Restoration Boundary
Pond 1 and Cheyenne Flood Plain
Undisturbed Area
Open Area South and West of Pond 1
Cottonwood Creek Flood Plain
Mill Buildings Area
Pond 3 and Adjacent Sewage Lagoon
City Sewage Lagoon
East Sand Pile
Sand Area B
Fence Line
Pond 8 and Adjacent Sewage Lagoon
Undisturbed Areas
Ponds 4,5 and 6
Restoration Contours
Bottom of Excavation Contours
Sand Area A and Adjacent BNR Property
Restoration Boundary Along Fence Line
Pond 7
Pond 9
Undisturbed Areas
Maclaren Engineers
SILVER KING MINES ,INC
TVA PROJECT
EDGEMONT MILL DECOMMISSIONING
DRAWN
CHECKED
APPROVED
DATE
PROJECT NO.
RESTORATION PLAN
(NORTH)
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30


Pond 7
Pond 10
Pine Hills Area
Cottonwood Community
Undisturbed Area
Restoration Boundary
Fence Line
Maclaren Engineers
SILVER KING MINES ,INC
TVA PROJECT
EDGEMONT MILL DECOMMISSIONING
RESTORATION PLAN
(SOUTH)
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NUREG-0846

Draft Environmental Statement

related to the decommissioning of the Edgemont Uranium Mill

Docket No. 40-1341

Tennessee Valley Authority

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

September 1981

SUMMARY AND CONCLUSIONS

This Draft Environmental Statement (DES) was prepared under the direction of the staff of the U.S. Nuclear Regulatory Commission (NRC) and issued by the Commission's Office of Nuclear Material Safety and Safeguards (NMSS). The Department of the Interior (DOI), Bureau of Land Management, has been designated a cooperating agency in this action and has reviewed this Statement before its publication.

1. This action is administrative.

2. After an assessment of concerns and alternatives and the addition of conditions related to the proposed decommissioning project operations, the proposed action permits the decommissioning of the existing uranium milling facilities at Edgemont, South Dakota, including removal or cleanup of mill buildings, removal of tailings sands and slimes from the mill site, and removal of contaminated soil from the mill site and local environs. It is estimated by TVA that approximately 2.1×10^6 MT (2.3×10^6 tons) of tailings and an undetermined amount of contaminated soil will be removed from the mill site. It is also proposed that all radioactive materials, removed in the course of carrying out the proposed action, be transported by truck and/or slurry pipeline to an impoundment, located about 3.21 km (2 miles) southeast of the mill site, constructed especially to ensure containment of such waste for the foreseeable future.

   The project area that will undergo major land disturbance consists of 207 ha (514 acres) [including 104 ha (258 acres) at the disposal site, 12 ha (30 acres) for the haul road to be constructed between the mill and disposal site, and the 86-h (213-acre) mill site], plus the potential removal of at least 17 ha (41 acres) of ponderosa pine and surficial soil east of the mill site and an unestablished, but small, area of surficial soil in the Cottonwood community. The latter two areas have been contaminated by windblown tailings (see Fig. 3.3).

   All disturbed areas will be reclaimed and revegetated. The title to the tailings disposal site will be transferred to State or Federal entities so that any future use can be controlled to ensure the health and safety of the public.

3. Concerns receiving special attention are listed in detail in Sect. 1.5, "Results of the Scoping Process. These concerns include staff, public, and individual issues for which analysis and assessment were necessary. The major categories of concern were that

   a. radioactive waste disposal should be accomplished in a manner that would prevent potential human exposure for the foreseeable future;

   b. mitigation measures to eliminate or reduce adverse effects caused by the project should be planned and implemented;

   c. monitoring of project operations shall be adequate to rapidly detect any health and safety or environmental problems, either onsite or offsite, so that additional mitigation measures could be instituted as needed;

   d. present and potential radiological releases and exposures to both the general public and occupational workers should be analyzed and project operations planned to keep such exposures as low as reasonably achievable;

   e. project impacts on surface water and groundwater should be considered and mitigating measures planned to eliminate or minimize potential problems;

   f. project impacts on air quality be reduced as much as possible;

g. the socioeconomic effects of the project be fully considered; and

h. all feasible alternatives for decommissioning and the effects of such alternatives be considered.

4. For the proposed decommissioning project, the following alternatives were considered:

a. Alternative of no action: this alternative is not legally or morally permissible.

b. Alternatives for decommissioning: the staff considered

- mill site decommissioning alternatives,
- alternative methods of tailings disposal,
- alternative tailings disposal sites,
- alternative disposal impoundment designs,
- alternative seepage control measures, and
- waste transportation alternatives.

The staff evaluated the applicant's proposed decommissioning plan in relationship to the above alternatives. The staff conclusions and recommendations are as follows:

For the proposed tailings management plan (Sect. 2.2.3.7):

a. The staff considers the proposed tailings disposal site (alternative C1) to be adequately remote from people.

b. The proposed tailings disposal site and impoundment cover design provide adequate long-term protection from wind erosion.

c. The conceptual design to prevent long-term water erosion appears adequate. The staff would require that detailed engineering studies be performed and submitted for NRC review and approval before final construction.

d. The staff would require that the tailings impoundment embankment be designed to meet the requirements of NRC Regulatory Guide 3.11, "Design, Construction and Inspection of Embankment Retention Systems for Uranium Mills" thereby ensuring embankment stability even under plausible earthquake conditions.

e. Present evidence indicates that the bottom of the proposed tailings impoundment is separated from the nearest confined aquifer by about 170 m (560 ft) of relatively impermeable shales. Therefore, the contamination of a major aquifer by seepage from the impoundment is considered remote. The staff would require that the applicant either demonstrate that the shales forming the proposed impoundment base and sides have a maximum permeability of less than about 1×10^{-7} cm/s (0.1 ft/year) or install a clay liner meeting this permeability standard over the base and sides of the impoundment.

If a clay liner is required, the applicant will define foundation requirements, determine whether subdrains and filters are needed, and establish criteria for clay emplacement and submit detailed emplacement plans to the NRC for approval.

The staff would also require the applicant to dewater the tailings during emplacement to the maximum extent reasonably achievable. The applicant will design a dewatering system and submit the final design to NRC for approval before construction and installation. Recovered fluid can be used to supplement water used in the slurry transport system, thus minimizing groundwater use.

With these provisions, the staff is of the opinion that seepage from the impoundment would be minimal and pose no threat to water resources.

f. The staff is of the opinion that the applicant's plans to minimize windblown transport of tailings during project operations are generally acceptable. The staff would require that a formal interim stabilization program to control dusting during operational and reclamation periods be submitted to NRC. This program shall include periodic documented inspections and monitoring to confirm the adequacy of the stabilization methods implemented.

g. The thickness of the proposed final impoundment cover would minimize the potential for root or burrowing penetration into the tailings and would reduce enhanced gamma radiation to below background levels. Radon exhalation would be reduced to levels approaching background (see Sect. 4.1.9).

With the implementation of the proposed plan as modified by the staff requirements, the staff concludes that all of the NRC performance objectives for tailings management would be met and that this is the preferred alternative of the staff.

<u>For the more general aspects of the project</u>:

a. The mill buildings decommissioning plan proposed by the applicant (i.e., selective decontamination and/or disposal in the tailings impoundment) is acceptable to the staff.

b. The staff found onsite stabilization of tailings to be unacceptable. Of 25 sites considered for offsite disposal, the staff considers alternative site 2 (C1) as the best overall choice (see Sect. 2.2.3.3).

This site eliminates transportation impacts on public roads. The site is amenable to tailings sands transport by slurry pipeline, which minimizes the use of fossil fuel and the increase in fugitive dust from truck transport. (This is the site evaluated in the preceding discussion of the proposed tailings management plan.)

c. The staff approves of the applicant's general plan for mill site decommissioning but recognizes that there will be increased erosion and sedimentation downstream of the site, particularly during the stormflow events. The staff believes that, following stabilization of the streambanks, sediment levels in the stream will return to background levels.

d. The staff approves of the applicant's proposal to stabilize the streambed and provide aquatic habitat. The staff, however, considers 10°-bank slopes and plowing and discing along the stream for shrub plantings to be undesirable. The staff prefers erosion to shape the stream banks in a natural manner, with minor use of riprap where necessary. The staff recommends that the applicant work in cooperation with the South Dakota Department of Game, Fish, and Parks.

e. The seed mixture for revegetation of the mill site and disposal area appears appropriate for expected site uses. The staff will require that the seed mixture for revegetating the haul roads and storage and borrow areas accommodate wildlife as well as provide livestock forage.

f. The applicant reports that sufficient suitable topsoil exists at the disposal site for reclaiming all disturbed areas. The applicant would like the option of using topsoil from other areas, if this option is cost effective. The staff position is that use of topsoil from the disposal site is environmentally preferable to disturbing additional land. To open new borrow areas, the applicant must clearly justify the need.

The staff conclusion is that the applicant's proposal is generally satisfactory, and with the requirements specified in the above evaluation and conditions listed below, the staff concurs with the proposed project operational plans.

5. From the analysis and evaluations made in this Statement, it is proposed that in the license amendment authorizing decommissioning of the Edgemont mill and site, the applicant be required to conform to the following conditions:

   a. The applicant shall implement the monitoring programs specified and recommended in Sect. 4.2 and develop and submit for review an Environmental Monitoring Program designed to evaluate the radiological impacts of the action.

   b. The applicant shall implement the mitigation measures specified and recommended in Sect. 4.3.

   c. The applicant shall establish a program that shall include written procedures and instructions to control all decommissioning activities.

   d. Before engaging in any activity not evaluated by the NRC staff, the applicant shall prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this Environmental Statement, the applicant shall provide a written evaluation of such activities and obtain approval of NRC for the activities.

   e. If unexpected harmful effects or evidence of irreversible damage not otherwise identified in this Statement are detected during construction or operations, the applicant shall provide to NRC an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

6. With these specific requirements and conditions and conformity with other local, State, and Federal regulations, the expected environmental consequences are as follows:

   a. As a short-term consequence, total suspended particulates may exceed State and Federal standards during project operations under adverse weather conditions. This increase would not be expected to result in harm to plants, animals, or humans. Monitoring will provide early detection of such events, and all practical mitigation is planned.

   b. Land disturbance will occur on 207 ha (514 acres), plus an undetermined amount of land [including at least 17 ha (41 acres)] from which removal of windblown tailings is required. Portions of this land will not be subjected to reclamation for up to seven years. Following successful reclamation, there will be a net gain of 52 ha (127 acres), plus the undetermined acreage presently contaminated by windblown tailings, available for use. This is because the present mill site [86 ha (213 acres)] will be available for use, while the impoundment at the disposal site will only encompass 34 ha (86 acres). However, the disposal site will be available to indigenous wildlife.

   c. The maximum amount of groundwater to be used for the project is 1.29×10^5 m^3 (105 acre-ft) over a five-year period. This will not affect local or regional supplies. After decommissioning, the water in the alluvium under the reclaimed mill site will remain chemically contaminated (mostly sulfate) and unfit for potable use. No significant seepage is expected at the disposal site.

   Surface water (runoff) may be temporarily affected by increased sediment loading. At the mill site, earth-moving activity will be controlled to trap runoff on the site. A sediment pond will be used at the disposal site. The decontamination and reclamation of Cottonwood Creek may result in sediment transport into the Cheyenne River. This transport will cause no effects not already present from normal erosion.

   d. The project will provide up to 90 jobs at peak level. Because unemployment rates are low and project operations are scheduled for only six months each year, most employees are expected to be in-migrants. Therefore, the housing and community services will undergo stress. Federal monetary assistance has been requested to aid in mitigating impending impacts.

e. The primary impact to terrestrial biota will result from temporary loss of habitat. However, the mill site is already highly disturbed, and the proposed disposal site is not considered to be unique wildlife habitat. Therefore, even the temporary consequences are considered minor. After reclamation, all the affected land is expected to be improved beyond its present state in this regard.

   Aquatic biota in the reach of Cottonwood Creek through the mill site will be destroyed. After reclamation, the diverse aquatic community upstream will repopulate the mill site. No aquatic effects of consequence are expected from other decommissioning activities.

The following table shows the predicted annual environmental dose commitments (EDCs) to the local population resulting from decommissioning operations for periods during and after the decommissioning. These doses are compared with the estimated dose from naturally occurring background radiation. As can be seen from the table, the predicted dose from the decommissioning operations is less than that from natural background in all categories.

7. The position of the NRC is that, after weighing the environmental, economic, technical, and other benefits from decommissioning the Edgemont mill and site against the environmental and other costs and considering available alternatives, the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is to permit the applicant to proceed with the project as described in this Statement, subject to all requirements and conditions presented above.

Predicted annual environmental dose commitments (EDCs) to local population within 1.6-km (1-mile) radius of the mill site resulting from cleanup operations at Edgemont and disposal site

Exposure pathway	100-year EDCs (person-rem/year)[a]							
	Whole body		Bone		Lung		Bronchial epithelium[b]	
	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning
EDCs	135.0	0.771	286.8	1.512	177.6	0.998	814.7	2.314
Estimated population dose from natural background	306.0	306.0	376.0	376.0	308.0	308.0	1120	1120
Ratio of total annual regional population dose to that from natural background[c]	0.441	0.003	0.763	0.004	0.577	0.003	0.727	0.002

[a]Doses to the whole body, lung, and bone are those resulting from the releases of U-238, U-234, Th-230, Ra-226, and Pb-210 particulates.
[b]Inhalation doses to the bronchial epithelium are those resulting from the inhalation of radon daughters.
[c]Background doses are based on the local population size of 2000.

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1. PURPOSE OF AND NEED FOR ACTION

1.1 INTRODUCTION

This Draft Environmental Statement (DES) is issued by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards (NMSS), as a result of a decision by the Tennessee Valley Authority (TVA) not to pursue renewal of Source Material License SUA-816 for the continued use of existing uranium milling facilities at Edgemont, South Dakota. Consequently, decommissioning of the mill and mill site are required under NRC rules and regulations, and alternatives for conducting these activities are the subject of this Environmental Statement. This document has been prepared in accordance with Commission Regulation Title 10, *Code of Federal Regulations* (CFR), Part 51, which implements requirements of the National Environmental Policy Act of 1969 (NEPA; PL 91-190).

The principal objectives of the NEPA process are to build into the agency decision-making process an appropriate and careful consideration of environmental aspects of proposed actions and to make environmental information available to public officials and citizens before decisions are made and actions are taken. The process is intended to help public officials make decisions based on an understanding of environmental consequences and to take actions that will protect, restore, and enhance the environment.

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the nation may

- fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;
- attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
- preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice;
- achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities; and
- enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Pursuant to the above responsibilities and in accordance with 10 CFR Part 51, the NRC Office of Nuclear Material Safety and Safeguards has prepared this detailed Statement based on the foregoing considerations with respect to the application to decommission the uranium mill and mill site at Edgemont, South Dakota.

In accordance with 10 CFR Part 40, Section 31, the applicant has submitted an Environmental Report[1] (ER) to the NRC to support the decommissioning application. In conducting the required NEPA review, Commission representatives (the staff) met with the applicant to discuss items of information in the ER, to seek additional information that might be needed for an adequate assessment, and generally to ensure that the Commission had a thorough understanding of the proposed project. In addition, the staff sought information from other sources to assist in

the evaluation, conducted field inspections of the project site and surrounding area, met with State and local officials charged with protecting State and local interests, and conducted a public scoping meeting to identify the significant issues to be analyzed in depth. On the basis of the foregoing activities and other such activities or inquiries as were deemed useful and appropriate, the staff has made an independent assessment of the considerations specified in NEPA Section 102(2).

1.2 SUMMARY OF THE PROPOSAL

On August 16, 1974, TVA purchased an existing mill [together with mineral rights on about 41,000 ha (101,000 acres)] in Edgemont, South Dakota. Because the mill site does not meet present NRC criteria for siting of uranium mills, TVA proposes to decommission the mill as described below.

Approximately 2.1 x 10^6 MT (2.3 x 10^6 tons) of tailings were produced at the Edgemont mill from 1956 to 1972. These tailings, highly contaminated soil, building equipment and debris will be removed from the Edgemont mill site to the proposed tailings disposal site approximately 3.2 km (2 miles) to the southeast.

At the disposal site, a diversion system will be constructed to divert uncontaminated offsite runoff around the disposal area during operations, an impoundment dike will be constructed across the lower end of the site, and the disposal area will be excavated into shale to provide sufficient volume to contain the contaminated material.

Contaminated material will be removed from the mill site by trucks and a slurry pipeline. A slurry pipeline will be used to transport up to 80% of the sand tailings present at the site. Structures and equipment destined for burial and any remaining contaminated materials will be removed by trucks over specially constructed haul roads.

Reclamation of the disposal site will involve covering the contaminated material with a clay cap, overburden, and topsoil. At the mill site, it is expected that borrow material will be required for reclamation, some of which is expected to be obtained from the disposal site. The mill site will be recontoured and topsoil will be added; the site will then be revegetated. It is expected that decommissioning activities will result in the release of the mill site for future use possibly subject to land use control measures.

Details of proposed procedures and viable alternatives to the proposed action are discussed in later sections.

1.3 FEDERAL AND STATE AUTHORITIES AND RESPONSIBILITIES

The applicant presently holds a Source Material License (SUA-816) which may not be terminated until the licensee has complied with NRC requirements to protect the public health and safety during and after decommissioning. Moreover, the Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604, November 8, 1978) establishes the role of the NRC in establishing and enforcing requirements for the decontamination, decommissioning, and reclamation of sites, structures, and equipment used in conjunction with tailings by-product materials (in this case, uranium mill tailings).

The TVA is subject to Executive Order 12088 (ref. 2), Office of Management and Budget Circulars A-78 and A-81, and Executive Order 11752 (ref. 3), all of which relate to the prevention, control, and abatement of environmental pollution in Federal facilities, as well as certain provisions of the Clean Air Act, as amended;[4] the Clean Water Act, as amended;[5] the Solid Waste Disposal Act, as amended;[6] and the Safe Drinking Water Act amendments to the Public Health Service Act;[7] all of which relate to the applicability of various Federal, State, interstate, or local air, water quality, and solid waste standards. TVA is also subject to the requirements of Office of Management and Budget Circular A-95 (ref. 8), which ensures that major projects are coordinated from the point of view of community impact and land use planning with State and local agencies, and is required to ensure that any action it takes conforms with the policies and guidelines of Executive Orders 11988 and 11990, which concern floodplain management and wetland protection.

Table 1.1 identifies the permits, licenses, or approvals that will be required to perform this decommissioning in addition to NRC licensing action; the granting or approving authority; and any remarks regarding the status of these permits, licenses, or approvals.

Table 1.1. Applicable permits, licenses, or approvals[a]

Permits, licenses, or approvals	Granting or approving authority	Status
Approval for disposal of nonradiological demolition solid wastes (i.e., roofing, lumber, blocks, brick, metal, etc.)	State of South Dakota, or local authority	Approvals will be pursued upon identification of waste types, estimated quantities, and disposal site selection
Approval for disposal of domestic or municipal-type solid wastes (i.e., paper, garbage, glass, etc.)	State of South Dakota or local authority	Approvals to be obtained
Approval for disposal of miscellaneous nonradiological "hazardous" and/or "problem" solid waste (i.e., oils, grease, solvents, polychlorinated biphenyls, caustics, etc.)	Environmental Protection Agency (EPA), State, and/or local authority	Approvals will be pursued upon identification of waste types, estimated quantities, and disposal site selection
Section 404 (dredge and fill permit)	U.S. Army Corps of Engineers	Undetermined at present
401 Certification (dredge and fill permit)	State of South Dakota	Undetermined at present
Historical clearance	State Historic Preservation Officer	Clearance secured
	Advisory Council on Historic Preservation	Need not expected
Threatened and endangered species consultation	U.S. Fish and Wildlife Service (Department of Interior)	Completed
Prevention of Significant Deterioration of Air Quality Preconstruction Review (fugitive dust)	EPA Region VIII[b]	Will be submitted as applicable
National Pollution Discharge Elimination Standards permit	EPA Region VIII	Permit application will be submitted as applicable following finalization of design and mitigation plans
Approval of plans and specifications for water pollution control facilities	South Dakota Department of Environmental Protection	To be submitted as applicable following finalization of design and mitigation plans

[a] BLM-TVA land negotiations are not a part of the permitting process.

[b] Authority could be State of South Dakota, Department of Environmental Protection, Office of Air Quality, if State Implementation Plan revisions incorporating the Prevention of Significant Deterioration provisions of the Clean Air Act Amendments of 1977 are approved prior to permit issuance.

1.4 NEED FOR ACTION

Congress has found (PL 95-604, November 8, 1978, cited as the Uranium Mill Tailings Radiation Control Act of 1978) that uranium mill tailings located at active and inactive mill operations may pose a potential and significant health hazard to the public if not properly controlled. Protection of the public health, safety, and welfare requires that every reasonable effort be made to provide for the stabilization, disposal, and control of such tailings in a safe and environmentally sound manner to prevent dispersal of tailings, to minimize radon diffusion into the environment and to prevent or minimize other environmental hazards from such tailings.

Title I of the act cited above requires that remedial action be taken at 22 abandoned and unlicensed tailings sites to ensure the safe and environmentally sound stabilization of tailings and residual radioactive materials.

The Edgemont Uranium Mill, although a licensed facility, has not operated since August 1974. The mill and tailings on the site thus present a similar potential health hazard to the public as do those on many of the abandoned sites for which remedial action has been mandated by Congress.

Title II of the Uranium Mill Tailings Radiation Control Act of 1978 authorizes the NRC, after the effective date of the act, to enforce on new licenses or relicensing actions decontamination, decommissioning, and reclamation standards for uranium mill and mill tailings sites.

The applicant's source material license (SUA-816) is on timely renewal and was amended to require submission of a decommissioning plan for the Edgemont mill and associated tailings. The Tennessee Valley Authority has committed to comply with the NRC branch position on performance objectives for tailings management[9] and the NRC guidelines for facility decontamination.[10]

Because TVA no longer proposes to mill uranium at this site, the expeditious disposal and stabilization of mill tailings and contaminated material in a safe and environmentally sound manner is in the public interest.

1.5 RESULTS OF THE SCOPING PROCESS

In accordance with the guidelines developed by the Council on Environmental Quality (CEQ) in 40 CFR Part 1501.7, the NRC utilized a scoping process to identify the significant issues concerning this proposed project.

During the review of the applicant's environmental report (ER), the NRC staff identified major areas of concern that would require careful assessment in the subsequent Environmental Impact Statement. The NRC also issued a Federal Register notice requesting comments by interested parties on the project and set a public scoping meeting to be held October 25, 1979, in Edgemont, South Dakota.

Prior to the scoping meeting, these primary issues were identified by the NRC staff:

1. Radioactive waste disposal alternatives should be considered in detail, with the prime consideration being the disposal of such wastes in a manner that would prevent potential human exposure during the foreseeable future.

2. Potential short- and long-term adverse effects from the project should be examined and mitigating measures should be implemented to eliminate such adverse effects insofar as possible.

3. During project operations, adequate monitoring capability should be installed so that any unforeseen safety or environmental problems could be rapidly identified and additional mitigating measures could be instituted to eliminate or reduce the problem to the greatest degree reasonably achievable.

In addition, the staff planned to discuss, in the DES, measures to be taken by the applicant to comply with applicable local, State, and Federal regulations in sufficient detail to ensure that such requirements would be met.

At the public scoping meeting, the applicant summarized the proposed project, and comments were solicited from the attendees. The staff also requested additional written comments. The following specific generic issues were raised at the scoping meeting:

1. specific treatment of radiological issues, including

    - present levels of onsite radiation and radon release,
    - present radiation levels from windblown tailings in the Cottonwood community and other offsite locations,
    - increases in radiation release and potential radiation exposure and effects during mill site decommissioning, both to occupational workers and the general public, and
    - the radiation levels expected after decommissioning and reclamation both at the mill and disposal sites;

2. specific treatment of the radioactive wastes disposal plan, including
   - criteria for the disposal site,
   - preparation of the disposal site,
   - depth of burial of tailings and other wastes,
   - preparation of the tailings and wastes for burial,
   - stabilization of the disposal site, and
   - long-term monitoring requirements at the disposal site;
3. specific treatment concerning potential surface and groundwater problems, including
   - condition of the groundwater at the mill site after decommissioning,
   - water requirements for decommissioning,
   - effects of removing slimes only,
   - leaching by groundwater at the mill site,
   - surface water and groundwater flow at the disposal site,
   - groundwater levels at the disposal site,
   - erosion by surface water during decommissioning, and
   - seepage control and monitoring at the disposal site.

More specific suggestions were to discuss the following:

1. eventual disposition of the reclaimed land,
2. air pollution from project operations,
3. time period of project operations, and
4. jurisdictional problems regarding land use.

Written comments received from the Black Hills Alliance requested broad treatment of the following alternatives, which may be summarized:

1. What are the alternatives for decommissioning of the mill?
2. What are the radiological effects?
3. What are the effects on workers?
4. What are the effects on the quality and quantity of water available?
5. What are the effects on aquifers?
6. What are the effects on the local social and economic structure?
7. What are the effects on shallow groundwater under the mill site?
8. What are the effects of alternative monitoring strategies on public-data availability during decommissioning? (Other comments in this letter were not germane to the proposed action.)

The sixth District Council of Local Government submitted written comments related entirely to socioeconomic issues. Sections 3.4 and 4.1.8 and Appendix B, independently prepared by the staff, address these issues.

Written comments were also received from the (1) U.S. Department of Interior, Fish and Wildlife Service; (2) Geological Survey; and (3) National Park Service.

1. The U.S. Fish and Wildlife Service's comments were:

   - Have the consultation procedures specified by the Endangered Species Act Amendments of 1978 (PL 95-632) been followed?
   - Impacts on vegetation from road construction should be considered.
   - A Section 404 Permit from the U.S. Corps of Engineers may be required.
   - The plains top minnow (*Fundulus sciadicus*) is classified as threatened by the State of South Dakota. The applicant should coordinate with the South Dakota Department of Game, Fish, and Parks when restoring the habitat in Cottonwood Creek to preserve tne existence of the plains top minnow.
   - A monitoring program to document the continued existence and possible enhancement of Cottonwood Creek as a habitat for the plains top minnow should be initiated.

2. The U.S. Geological Survey comments were:

   - The need for long-term surface-runoff control, long-term maintenance, and future disposition of the disposal site should be discussed.
   - The degree to which the proposed tailings disposal will achieve postreclamation objectives developed by NRC should be discussed.
   - The locations of private wells should be shown on a map, together with the disposal site, topography, and drainage.
   - Criteria for groundwater monitoring should be specified.
   - More information on windblown tailings should be given.

3. The U.S. National Park Service comments were:

   - The mitigating measures for fugitive dust appear adequate (in the ER), but stringent monitoring was urged.
   - The Fossil Cycad National Monument (ER, Fig. 2.1-1) should be deleted. The monument was abolished in 1956.

The staff has addressed each of the above comments on the Edgemont decommissioning project in the appropriate sections of the DES as noted. No comments were received suggesting disapproval of the project.

REFERENCES FOR SECTION 1

1. Tennessee Valley Authority, *Edgemont Uranium Mill Decommissioning Plan Environmental Report*, Docket No. 40-1341, February 26, 1979. Hereafter in this Environmental Statement, the applicant's Environmental Report will be cited as ER followed by a specific volume, section, page, figure, table, or appendix.

2. "Federal Compliance with Pollution Control Standards," *Fed. Regist.* 43(201): 47,707 (1978).

3. 3A CFR Sect. 240.

4. 42 U.S.C. Sect. 7401 et seq. (1976).

5. 33 U.S.C. Sect. 1251 et seq. (1976).

6. Ref. 4, Sect. 6901 et seq.

7. Ref. 4, Sect. 300f et seq.

8. "Federal and Federally Assisted Programs and Reports: Evaluation, Review, and Coordination," *Fed. Regist.* 38(228): 32,874 (1973).

9. *Nuclear Regulatory Commission Branch Position on Uranium Mill Tailings Management*, May 13, 1977.

10. Nuclear Regulatory Commission, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source, or Special Nuclear Material*, Division of Fuel Cycle — Material Safety, Washington, D.C., November 1976.

2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

2.1 ALTERNATIVE OF NO DECOMMISSIONING ACTION

The staff considers that the alternative of no decommissioning action would place the Nuclear Regulatory Commission (NRC), the applicant, and other associated regulatory agencies in the position of not fulfilling their statutory responsibilities. This alternative is therefore not legally or morally permissible. As a consequence, only alternatives for decommissioning are considered.

2.2 ALTERNATIVES FOR DECOMMISSIONING

2.2.1 Agency considerations for decommissioning

Assuming decommissioning as the reference overall desired action, the primary goal is to return the mill site to productive use. The related required disposal of onsite tailings and other contaminated materials must therefore be accomplished in a manner that protects the health and safety of the public during removal and ensures that such disposal will not result in potential public radiation exposures above applicable standards in the foreseeable future.

2.2.1.1 Decommissioning of onsite buildings

The applicant would have the option of dismantling contaminated buildings and equipment and disposing of such material in the same manner and at the same site as used for final tailings disposal, or he may decontaminate such buildings and equipment to acceptable contamination levels as specified in NRC Regulatory Guide 1.86 (Table 2.1).

The applicant would also be allowed to transfer specific equipment to another licensed facility for further use without full decontamination to unrestricted use category.

2.2.1.2 Mill site land decontamination

As stated previously, the primary goal of mill site land decontamination is to return the mill site to productive use after removal of tailings to a new disposal site. All of the uranium tailings will be removed from the site. It is not known, however, to what extent the soils below the tailings piles have been contaminated by seepage of tailings liquor and what quantity of this contaminated soil may have to be removed. The staff expects that a much lower quantity of contaminated soil will have to be relocated than that projected by the licensee. The staff feels that the exact land cleanup limits to be met should be based on site-specific considerations and on an evaluation of the environmental benefits of moving increasingly lower levels of contamination vs the economic costs of such action. These cleanup limits can only be determined once the exact depth and concentration of contaminated material are known. At the Edgemont site, such a final determination will not be feasible at some locations until tailings are removed from the site. In determining exact cleanup limits, the major consideration will be to ensure that resulting radiation exposures to individuals using the decontaminated land will be within current radiation exposure guidelines and as low as is reasonably achievable. Depending on the cutoff limit ultimately established for removal of contaminated soils for disposal at the new impoundment area, it may be necessary to institute some land use controls at the reclaimed mill site; i.e., residential development of the site would not be permitted.

Table 2.1. Acceptable surface contamination levels

Nuclide[a]	Average[b,c]	Maximum[b,d]	Removable[b,e]
U-nat, ^{235}U, ^{238}U, and associated decay products, dpm α/100 cm^2	5,000	15,000	1,000
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa ^{227}Ac, ^{125}I, and ^{129}I, dpm/100 cm^2	100	300	20
Th-nat, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, and ^{133}I, dpm/100 cm^2	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above, dpm β-γ/100 cm^2	5,000	15,000	1,000

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally, and the entire surface should be wiped.

2.2.1.3 Tailings disposal

The staff evaluated the alternative disposal sites and final disposal and reclamation plans against the following performance objectives developed by the NRC staff to ensure that uranium mill tailings are properly managed and controlled to minimize the potential hazard to public health.

1. Siting and design period:

   - Locate the tailings impoundment area remote from people so that population exposures will be reduced to the maximum extent reasonably achievable.
   - Locate the tailings disposal area so that disruption and dispersion by natural forces is eliminated or reduced to the maximum extent reasonably achievable.
   - Design the isolation area so that seepage of toxic materials into the groundwater system will be eliminated or reduced to the maximum extent reasonably achievable.

2. Decommissioning operations and drying period:

   - Eliminate the blowing of tailings to unrestricted areas during normal operating conditions (including a program of chemical spraying and wetting of tailings surfaces).

3. Postreclamation period:

- Reduce direct gamma radiation from the impoundment area to essentially background levels.
- Reduce the radon emanation rate from the impoundment area to no more than 2 $pCi \cdot m^{-2} \cdot s^{-1}$.
- Eliminate the need for an ongoing monitoring and maintenance program following reclamation.

Before making recommendations, the staff then weighed environmental cost/benefits and economic costs of the various strategies against each other.

2.2.2 Applicant's proposed plan

2.2.2.1 Final disposal site location and required site preparation

Location

The proposed disposal site is located approximately 3.2 km (2 miles) southeast of the city of Edgemont, at the head of an ephemeral drainage that is a tributary of the Cheyenne River, and is located in Sects. 8 and 17, T9S, R3E with minor portions in Sects. 7 and 18, T9S, R2E (Fig. 2.1). The site is east of county road 6N and south of county road 6E. Of the total acreage [104 ha (258 acres)] to be disturbed at the disposal site, about 96 ha (236 acres) are privately owned, 5.7 ha (14 acres) are owned by the State of South Dakota, and 3.2 ha (8 acres) are held by the U.S. Government and are administered by the Bureau of Land Management.

Diversion of runoff

Initial preparation of the proposed disposal site tailings impoundment area will involve the construction of a diversion system of isolation courses to prevent offsite runoff from entering the disposal area and to drain any perched water that may be present in the surficial soils during disposal operations (Fig. 2.2). The area of the drainages is quite small, encompassing about 18.6 ha (46 acres) above the level of the impoundment on the west and northwest sides.

A surface runoff isolation course would be prepared at the northwestern portion of the disposal area to divert runoff to an intermittent drainage to the northwest. Two other isolation courses would be constructed along the western edge of the impoundment area to control offsite runoff from the west. This runoff would be diverted to the southeast and will reenter the drainage channel below the impoundment dike. The isolation courses, which would likely be constructed into the basal shale member, should drain any subsurface perched water at the shale-subsoil interface. A natural drainage divide will prevent offsite runoff from entering the disposal site from the northeast. In addition, a sediment pond would be constructed below the impoundment dike area to control any sediments resulting from construction activities.

Impoundment excavation

After the drainage diversion courses and sediment pond are completed, the impoundment area would be excavated into the shale layer by heavy earth-moving equipment. Approximately 3.8×10^6 m^3 (5×10^6 yd^3) of soil and weathered rock would be removed. This excavation may necessitate the removal of any perched water that may remain in the alluvium.

The overburden removed by this excavation would be used in the construction of the impoundment dike. Some of the overburden also could be used for fill at the mill site upon completion of activities and also for the top cover of the impoundment area. The topsoil and subsoil would be segregated and stockpiled for future use in reclamation and would be contoured and seeded to prevent erosion during storage. Approximately 36 ha (90 acres) would be used for stockpile areas (Fig. 2.3).

Soils and shale that form the base of the impoundment area are reported to have permeabilities on the order of 1×10^{-4} to 1×10^{-7} cm/s (100 to 0.1 ft/year). Should further permeability tests determine that the native soils and shale exposed in the impoundment excavation do not provide adequate seepage control, additional excavation and/or the placement of a clay liner

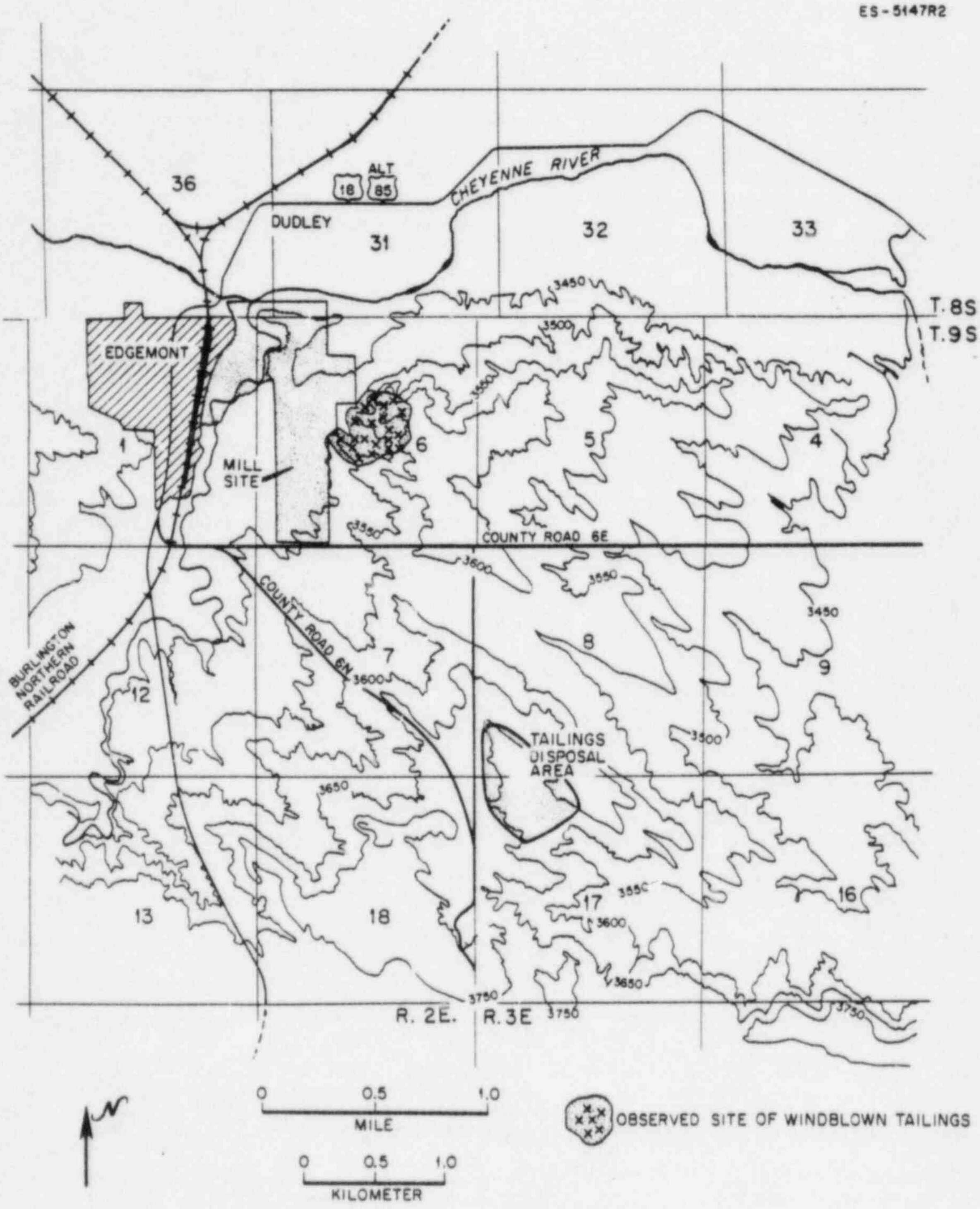

Fig. 2.1. Edgemont mill site and disposal area. Source: Modified from ER, rev. 1, Fig. 2.1-3 and Ford, Bacon & Davis Utah Inc., *Engineering Assessment of Inactive Uranium Mill Tailings, Edgemont Site, Edgemont, South Dakota*, prepared for the U.S. Nuclear Regulatory Commission, Contract No. E(05-1)-1658, January 1980.

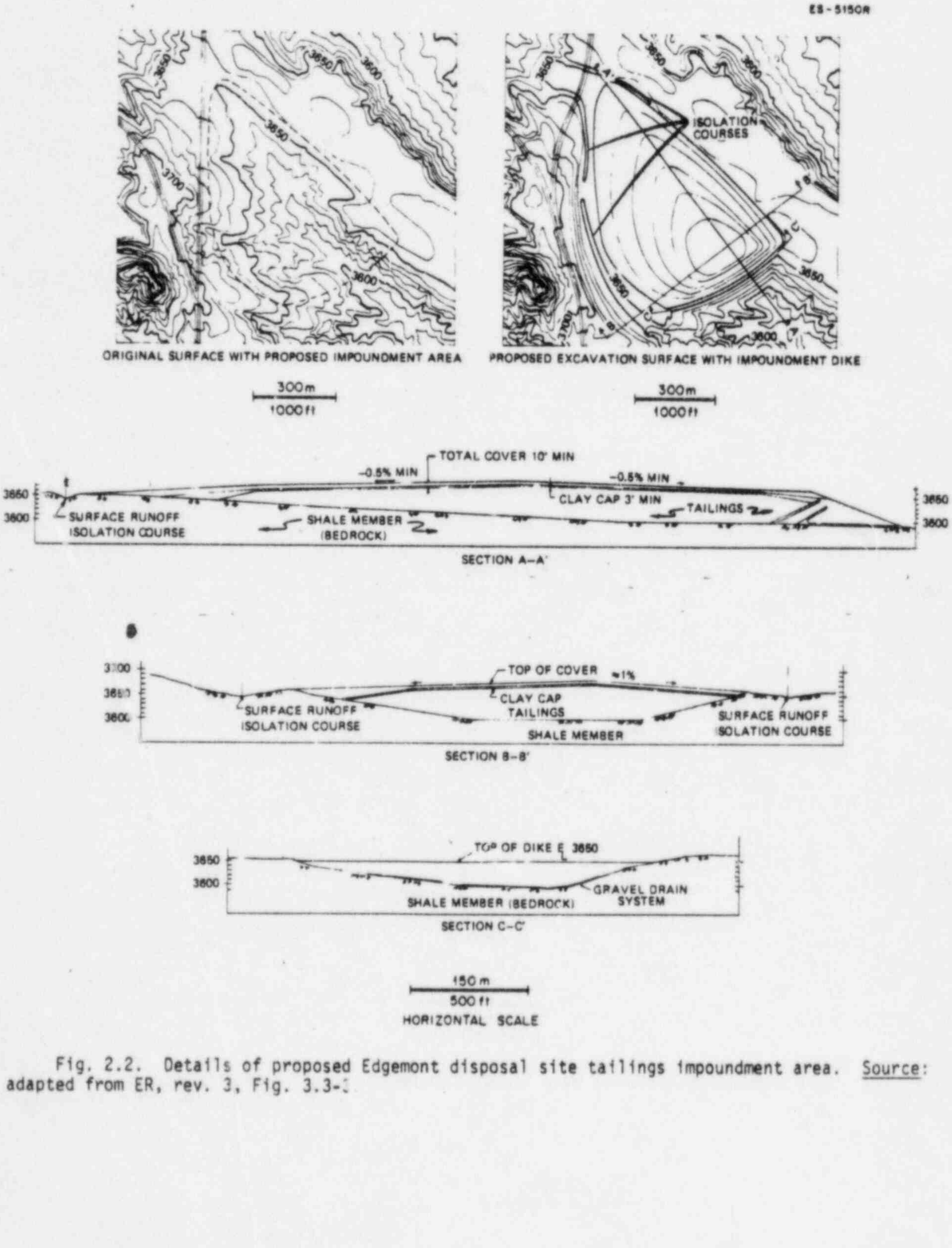

Fig. 2.2. Details of proposed Edgemont disposal site tailings impoundment area. Source: adapted from ER, rev. 3, Fig. 3.3-1

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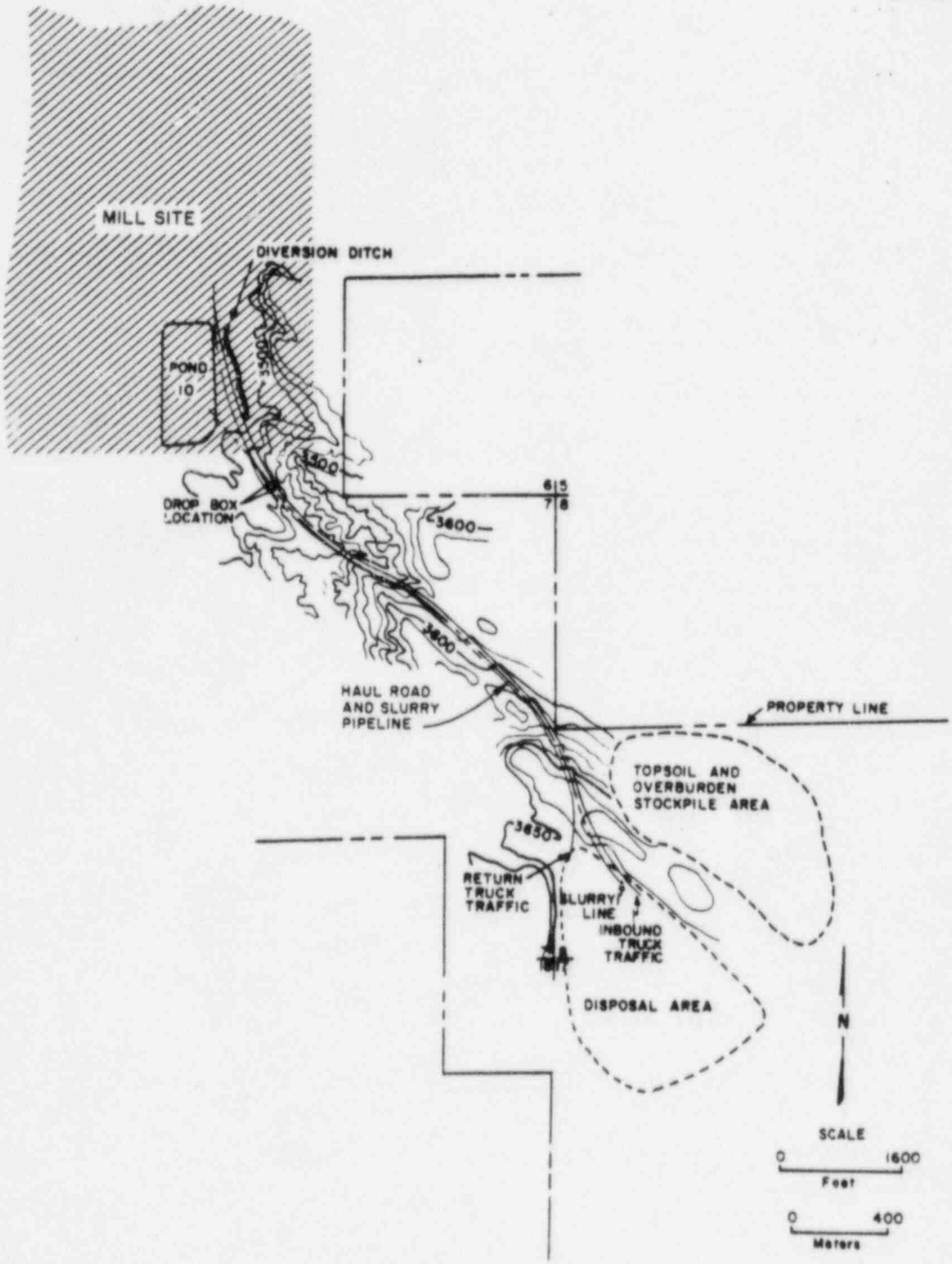

Fig. 2.3. Locations of stockpile areas. Source: ER, rev. 1, Fig. 3.3-4.

over the base and sides of the impoundment will be necessary. Potential borrow areas have been identified as a source of the clay liner material, although the applicant does not presently control such sites.[1] Onsite materials could however be employed for construction of the liner provided they can be shown to be suitable for constructing a liner with a permeability of about 1×10^{-7} cm/s (0.1 ft/year).

Impoundment dike construction

Construction of the impoundment dike would be concurrent with the excavation of the impoundment site. The initial preparation for construction of the dike would include removal of material into unweathered shale and installation of a gravel drain system along the base of the dike area as shown in Fig. 2.4. The drain will be composed of graded sizes of gravel that will filter out soil material and allow for the relief of hydrostatic pressure within the dike. The gravel drain will be constructed within the dike (Fig. 2.4) to remove any water that may enter the dike. To prevent the infiltration of water from the impoundment area, a clay liner with a permeability of about 1×10^{-7} cm/s (0.1 ft/year) will be keyed into the shale bedrock, placed on the upstream face of the dike, and extended along the upstream face of the dike as construction continues.

Material used in the construction of the impoundment dike will be unclassified fill obtained from within the impoundment area. The material will be placed, spread, and compacted in small lifts to ensure proper construction of the dike. The final dike will be about 17 m (55 ft) high and about 549 m (1800 ft) long. The final slope of the upstream face is planned at 4:1, and the downstream face is planned at 5:1. These slopes will be covered with riprap and appropriate filters to protect the embankment from wind and water erosion. Should it be considered necessary for the stability of the dike, the slope could be flattened. The final configuration of the dike may be altered following detailed engineering design studies. The proposed licensing action will require that the final impoundment and dike designs meet the criteria in NRC Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills."

Seismicity

A detailed assessment of the maximum credible earthquake expected at the proposed disposal site over the long term has not been made by the applicant. This would entail compiling a catalog of historic seismic events within a 320-km (200-mile) radius of the site and listing their epicentral distance from the site, magnitude or modified Mercalli intensity, and date of occurrence. From this data, the maximum credible earthquake or earthquakes for desired return periods could be extrapolated. However, previous experience has shown that properly engineered embankments that are constructed of clayey materials that are properly emplaced and compacted can withstand severe earthquakes with no significant damage. On the basis of the low historical seismicity of the region, the absence of capable faults near the proposed site, and the proposed impoundment design, it is highly likely that the proposed disposal site and impoundment system will be able to withstand long-term seismic events without affecting the long-term stability of the impoundment. The applicant will, however, be required to confirm the long-term seismic stability of the impoundment system using procedures described in NRC Regulatory Guide 3.11.

2.2.2.2 Waste transport

Haul road construction

While the disposal site is being prepared, construction of the haul roads will begin. At the mill site, a 17-m (55-ft) two-way traffic haul bed will consist of a subbase of clean sand; a base of coarse, crushed rock; and a final surface of fine, crushed rock. The road will be slightly crowned, with a slope of about 2 cm/m (0.25 in./ft) from the centerline (Fig. 2.5). The haul road at the mill site is for two-way traffic, but separate haul roads will be constructed for one-way traffic to the disposal site and return to the mill site (Fig. 2.3). Each road will be 10 m (33 ft) wide and constructed similar to the mill site haul road (Fig. 2.5).

About 12 ha (30 acres) will be disturbed by the haul road. Topsoil and other removed material will be stockpiled along the route for future reclamation. During construction of the haul road, dust control measures will be implemented. The route will be designed so that curves and

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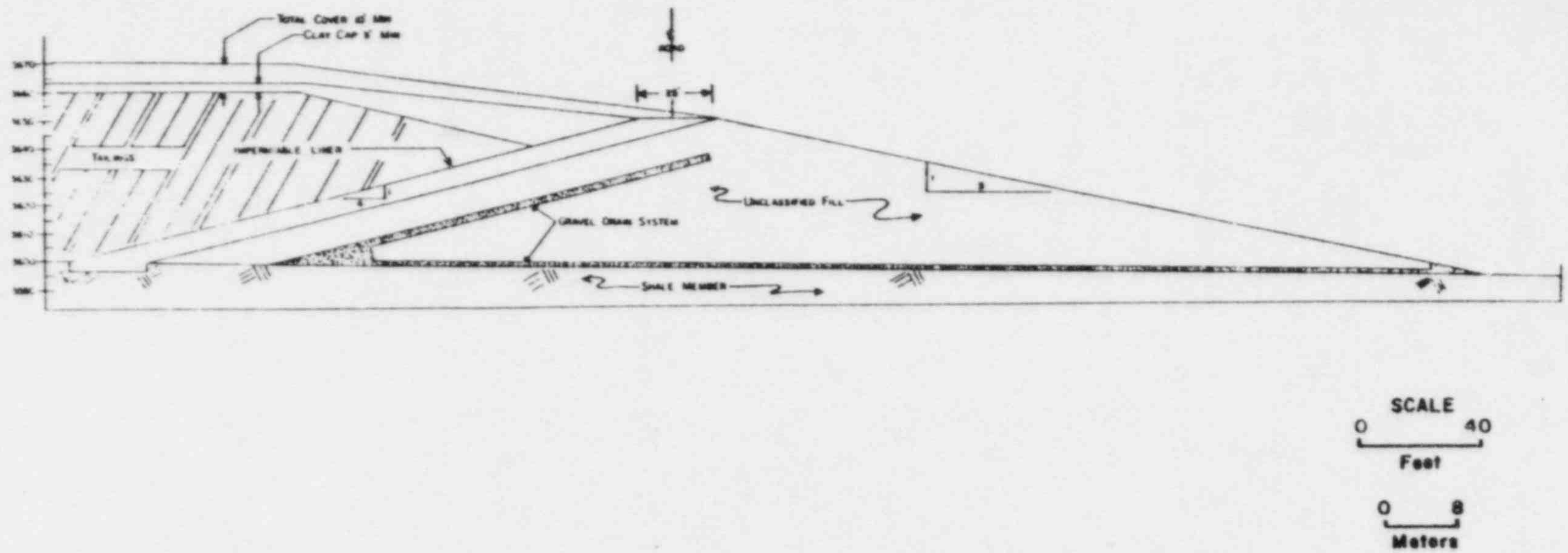

Fig. 2.4. Details of impoundment dike. Source: ER, rev. 1, Fig. 3.3-5.

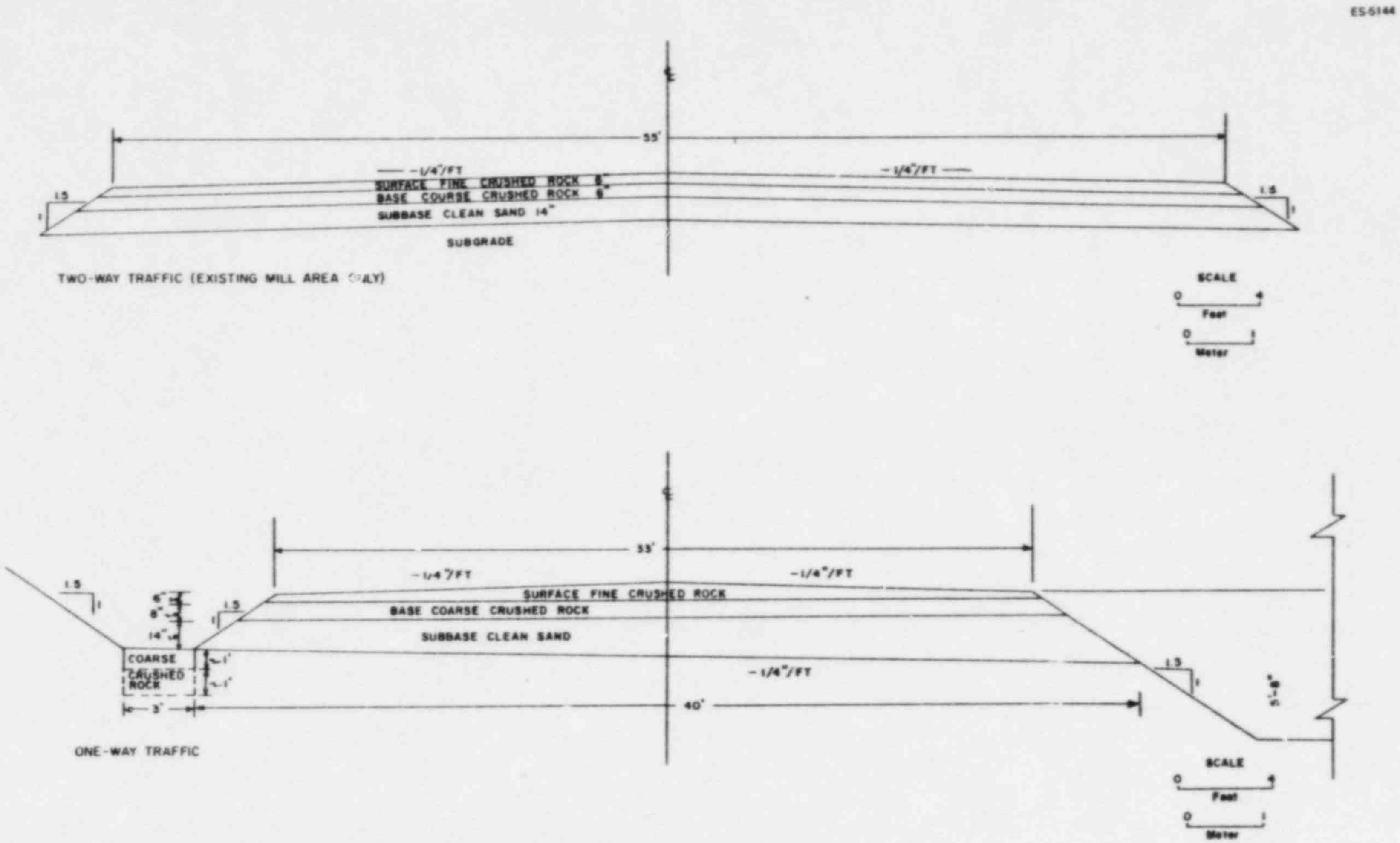

Fig. 2.5. Construction design of haul roads. Source: ER, rev. 1, Fig. 3.4-1.

grades will be as gentle as practical, but some cut and fill may be required. The route will cross a seldom used county road. It is anticipated that some type of underpass/overpass system will be used to route public traffic under or over the haul roads.

No major drainages will be crossed by the haul roads. Runoff from the mill site haul road will be contained on site. To prevent contamination because of runoff from the haul road, a trench drain system will be constructed along the outside of the roads. The divided portion of the haul road is constructed so that the majority of the runoff is in the median drain section of the haul road. All drainage collected by the trench and median drain systems will be directed to Pond 10.

Haul road operation

The projected schedule of operations is discussed in Sect. 2.2.2.4. A fleet of up to twenty 45.5-MT (50-ton) dump trucks will use the haul roads. Vehicle speeds will be maintained at levels determined safe according to road conditions and loads. Average speeds will not exceed 32 km/h (20 mph) for trucks on the haul road. In loading and unloading areas, average speeds will not exceed 16 km/h (10 mph). Road maintenance activities, such as grading, and dust control activities, such as application of water sprays or sealing agents, will be performed as needed.

Slurry pipeline construction and operation

The proposed tailings transport slurry and recycle water pipelines will be constructed between the haul roads (Fig. 2.6). The repulping plant for the pipeline will be located south of the east tailings pile. A 25-cm-diam (10-in.-diam) polyethylene slurry pipeline will be placed along the east side of Ponds 7 and 10 and then proceed southeast of the mill site to the disposal area. The pipeline will be designed to allow for the mobility at the disposal site necessary for planned placement and distribution of the contaminated materials. A 20-cm-diam (8-in.-diam) polyethylene pipeline will recycle water from the decant pond, which should form as tailings settle out of the slurry, to the mill site. The pipelines will be designed so that any spills or ruptures will be contained within the median drain system and be returned to Pond 10 with the runoff from the haul roads. If it becomes necessary to remove a blockage in the slurry pipelines, any material removed will be routed to Pond 10 or to the disposal site.

2.2.2.3 Mill site decommissioning

Prior to the applicant's tailings stabilization efforts in 1976, an undetermined amount of windblown sand tailings was released to an area east of the mill site and in the Cottonwood Community (Fig. 2.1). Initial surveys indicate a contamination of about 31 ha (82 acres) of these neighboring areas. A detailed field study will be conducted to determine the levels of contamination, to identify which portions of the area require cleanup, and to define the quantity of waste materials present which require removal. It is planned that contaminated soils and wastes from offsite cleanup will be disposed of in the tailings impoundment. The area east of the mill site would be decontaminated before construction of the mill area diversion ditch. The Cottonwood Community areas would be cleaned up during the final decommissioning phase.

Diversion ditch

After the cleanup of the windblown tailings east of the mill site, a diversion ditch would be constructed along the eastern perimeter of the mill site (Fig. 2.7). The diversion ditch would intercept the runoff from five natural drainages with a total catchment area of about 71 ha (177 acres), which includes the windblown tailings area. Because the catchment area will first be decontaminated, runoff collected in the ditch will be considered uncontaminated and will be directed to the Cheyenne River floodplain for discharge. The lower reaches of the diversion ditch will be designed for a 100-year flood peak flow of 9.06 m^3/s (320 cfs) and are expected to protect the tailings areas from flooding during the decommissioning operation. The ditch will be gently sloped and vegetated to minimize erosion.

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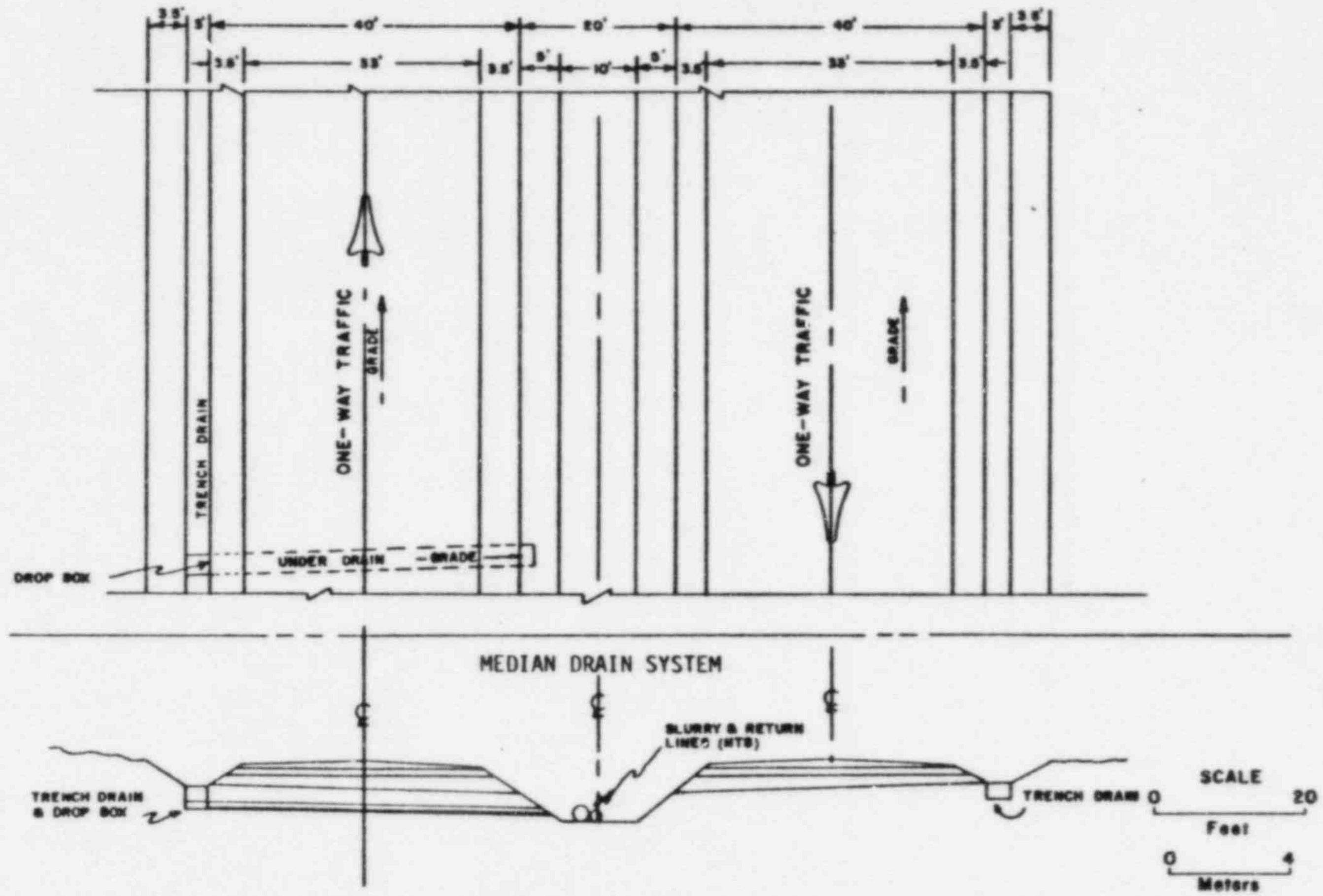

Fig. 2.6. P.ucement oi ... slurry and recycle water pipelines. <u>Source</u>: ER, rev. 1, Fig. 3.4-3.

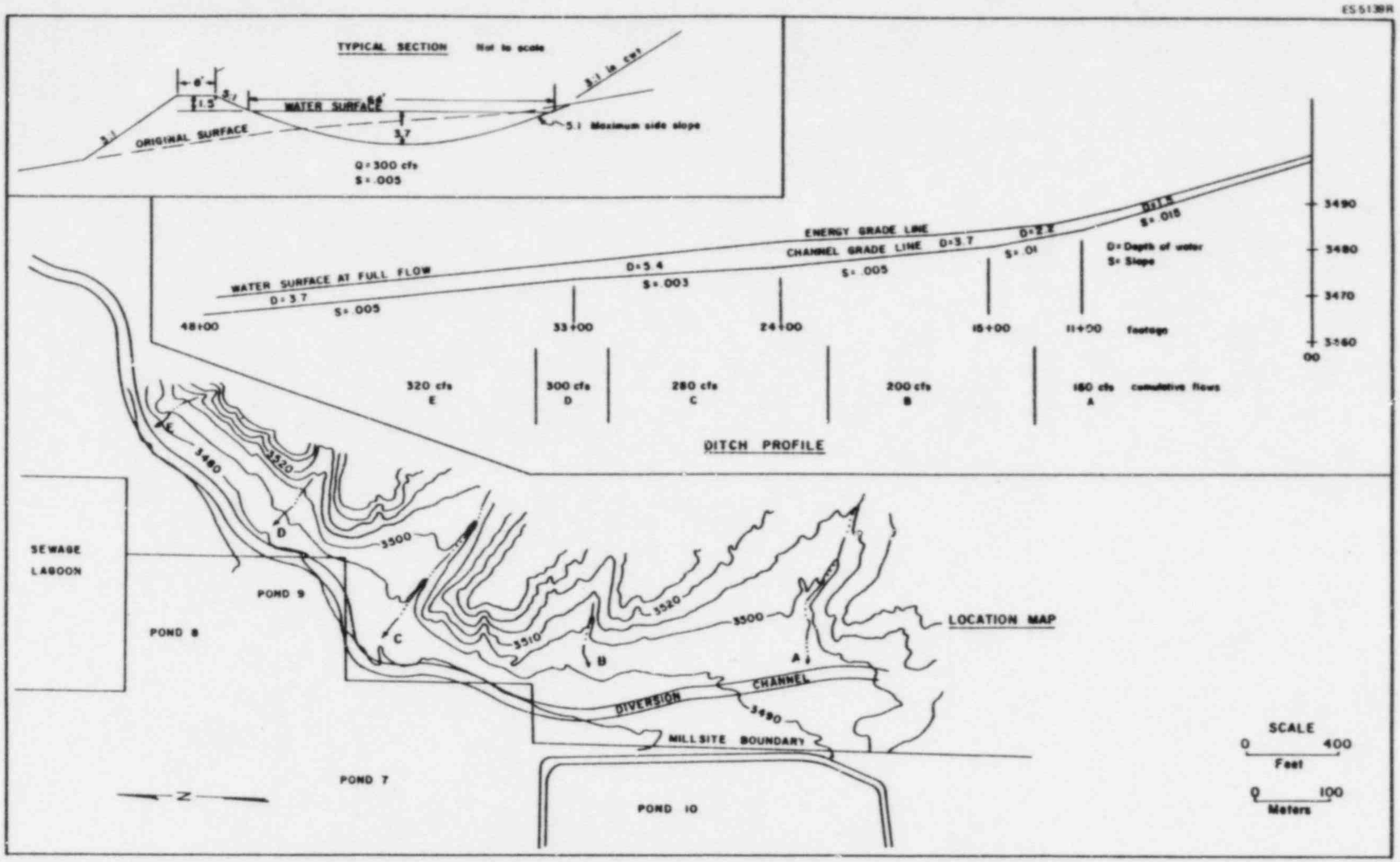

Fig. 2.7. Diversion channel along eastern perimeter of mill site. Source: ER, rev. 1, Fig. 3.5-1.

Structure and equipment disposition

The locations, sizes, and type of construction of the existing structures in the mill complex are listed in Fig. 2.8. The applicant proposes the following disposition plan:

Decontaminate	Demolish
Office building	FeV building
Mobile equipment shop and storage shed	Electric shop
Reagent warehouse	Crusher and sampler building
Scale house	Shaker car building
Carpenter shop	Fly ash pump house
	Lime plant building

The applicant is conducting feasibility and cost-benefit studies to determine whether the main mill building should be demolished or decontaminated and refurbished for other uses.

Items such as motors, pumps, and mobile equipment will be surveyed for radioactive contamination. These surveys and available decontamination methods will aid in determining whether to decontaminate, remove, or dispose of each equipment item. Equipment that can be decontaminated for release may be sold. Usable equipment that cannot be feasibly decontaminated will be considered for use in other licensed facilities. The transport of any existing equipment will be conducted in accordance with applicable regulations on transportation and radiation protection.

Decontamination. Decontamination methods may vary, depending on the level of contamination and the type of structure. Specific procedures will be determined on a building-by-building basis.

In general, the decontamination will proceed from interior to exterior and from top to bottom. Methods may include sandblasting, hydrolasing, and treatment with commercial decontamination agents. Items that cannot be readily decontaminated, such as partitions, insulation, or roofing, will be removed and buried in the impoundment area. During decontamination, radiation surveys will be conducted to identify any areas with unexpectedly high levels of contamination.

Dismantling. Demolition methods may vary from building to building according to structure type, contamination level, and location relative to other buildings and the site perimeter. Specific procedures will be determined on a building-by-building basis.

In general, the demolition will proceed from interior to exterior and from top to bottom. Salvageable items, utilities, insulation, and nonsupporting interior walls will be removed first; then nonsupporting exterior walls, roofing, supporting walls, and, finally, structural supports will be removed. All foundations will be excavated in conjunction with the removal of contaminated soil. All nonsalvageable materials and equipment, whether contaminated or uncontaminated, will be buried in the impoundment area. Concurrent with demolition, radiation surveys will be conducted to identify any areas with unexpectedly high levels of contamination. Some buildings or portions of buildings may require wetting down or the application of fixing agents to prevent dispersal of contaminants.

2.2.2.4 Disposal of tailings and contaminated material

During its 18 years of operation, the Edgemont mill produced about 2.1×10^6 MT (2.3×10^6 tons) of uranium mill tailing solids. Infiltration and leaching subsequent to its closing have caused the contamination of soils and materials underlying and adjacent to the ponds and piles on the site, including parts of the Cottonwood Creek channel (Fig. 2.9). The estimated quantities of materials (including building and mill process materials) to be removed from the mill site to the final tailings disposal impoundment area are listed in Table 2.2. The staff feels that the estimated volumes may be too large, especially those for contaminated subsoils, and that further studies and decommissioning project operating experience may lead to some reduction in these estimates.

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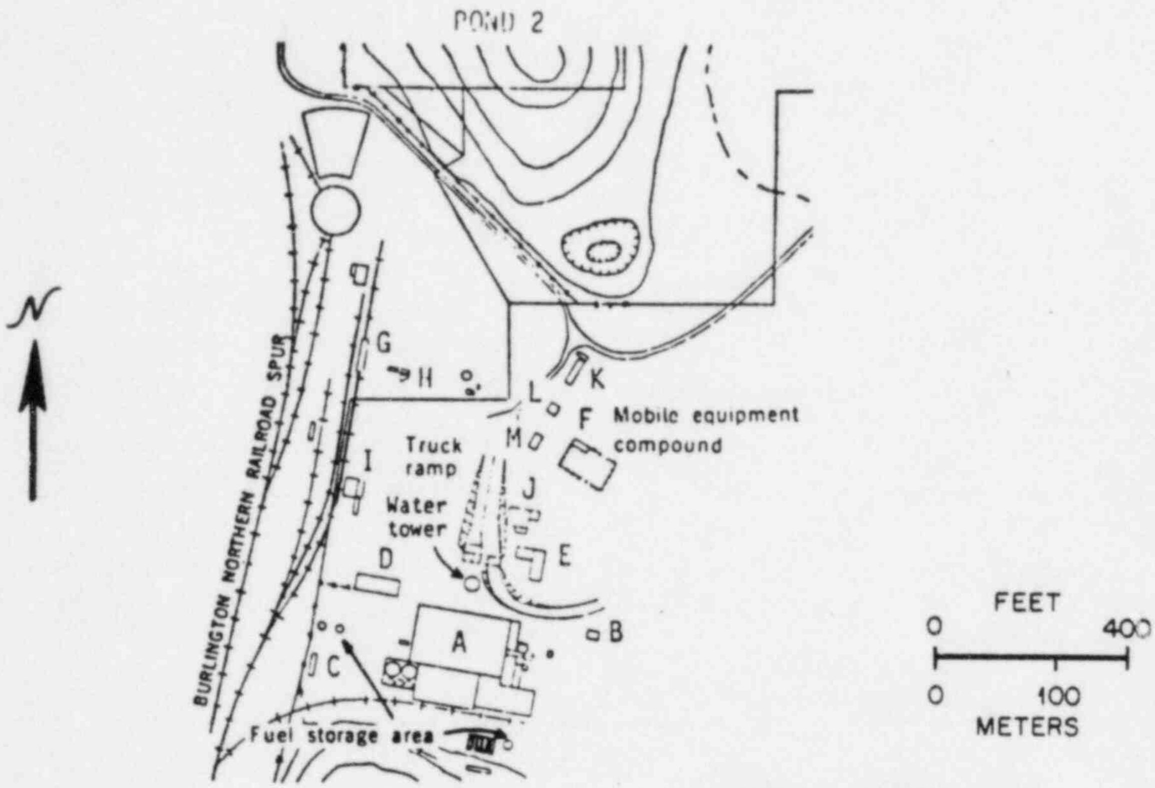

	AREA	CONSTRUCTION
A = MAIN MILL BUILDING	40,000 ft^2	STEEL FRAME
B = "FeV" BUILDING	480 ft^2	STEEL FRAME
C = ELECTRIC SHOP	576 ft^2	WOOD FRAME
D = OFFICE	2,890 ft^2	MASONRY
E = CRUSHER AND SAMPLING BUILDING	1,824 ft^2	STEEL FRAME
F = STORAGE SHED	432 ft^2	WOOD FRAME
G = RAILROAD CAR SHAKER	2,040 ft^2	STEEL FRAME
H = FLY ASH PUMP HOUSE	204 ft^2	WOOD FRAME
I = REAGENT WAREHOUSE	1,120 ft^2	STEEL FRAME
J = MOBILE EQUIPMENT SHOP BUILDING	1,840 ft^2	STEEL FRAME
K = SCALE HOUSE	740 ft^2	STEEL FRAME
L = LIME PLANT	440 ft^2	STEEL FRAME
M = CARPENTER SHOP	720 ft^2	STEEL FRAME

Fig. 2.8. Mill building locations. Source: ER, rev. 1, Fig. 2.2-1.

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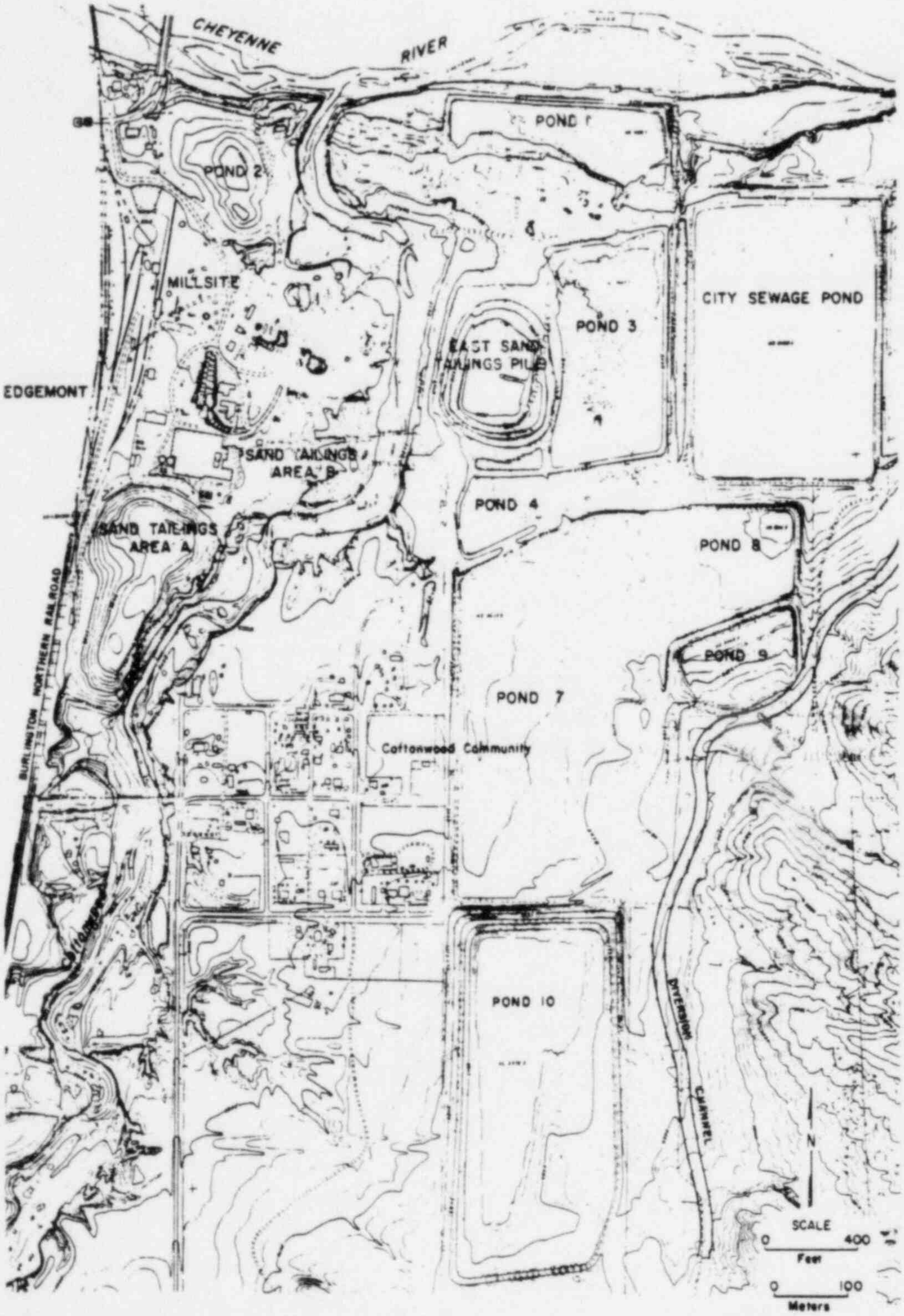

Fig. 2.9. Mill site ponds and tailings piles. Source: ER, rev. 1, Fig. 2.1-2.

Table 2.2. Tailings and related materials present on site

Area	Material	Volume m³	Volume yd³	Weight[a] tons
Pond 1	Sand tailings and slimes	172,000	225,000	371,250
Pond 2	Sand tailings and stabilization cover	123,000	161,000	265,650
Pond 3	Slimes	245,000	320,000	528,000
Pond 4	Sand tailings and slimes	81,000	106,000	174,900
Ponds 7, 8, 9	Sand tailings and slimes	552,000	722,000	1,191,300
	Soil cover	46,000	60,000	99,000
Pond 10	Contaminated dikes and native material	86,000	112,000	184,800
AEC Pile (Area A)	Sand tailings and stabilization cover	169,000	221,000	364,650
Area B	Sand tailings and stabilization cover	90,000	118,000	194,700
East pile	Sand tailings	474,000	620,000	1,023,000
Cottonwood Creek	Creek channel	23,000	30,000	49,500
Subsoil[b]	Contaminated subsoil	914,000	1,195,000	1,971,750
Mill structures	Contaminated structures and equipment	297,000	389,000	641,850
Safety factor (10%)		327,000	428,000	706,200
Total		3,599,000	4,707,000	7,766,550

[a] Assumes an average of 1960 kg/m³ (330 lb/yd³) of material to be moved.

[b] Assumes 1.8 m (6 ft) average for contaminated subsoil below interface and about 502,000 m³/m (200,000 yd³/ft) of contamination.

Source: ER, rev. 1, Table 2.3-1.

Sequence of disposal operations

The basic sequence of proposed disposal operations includes (1) decontamination and/or demolition of mill structures; (2) slurry transport and disposal of tailings sands; and (3) truck transport and disposal of tailings sands, slimes, and contaminated soils. There will be some overlapping of slurry disposal and truck disposal operations as conditions in the impoundment area permit. Figure 2.10 delineates the decommissioning schedule in detail.

In general, the tailings removal will gradually progress from the northwest corner of the mill site to the southeast corner (Pond 10) to minimize recontamination of previously cleaned areas.

Operations will continue as weather conditions permit. Removal operations will cease during extreme weather conditions, such as heavy rainfall or high winds. An onsite supervisor will determine when operations will be discontinued. Freezing temperatures in combination with other extreme weather conditions will restrict the disposal operations to about six months per year. Removal operations will be performed during the working season so that no contaminated material will be exposed during the winter.

Removal by slurry pipeline

The applicant will provide criteria for determining the suitability of materials to be transported in slurry form. It is estimated that about 80% of the tailings at the mill site are suitable for slurry transport. The tailings in Pond 2, the AEC pile, Area B, and the east pile may also be of the proper consistency for transport in slurry form. As cleanup operations continue, other materials meeting the suitability criteria may be transported by the slurry method.

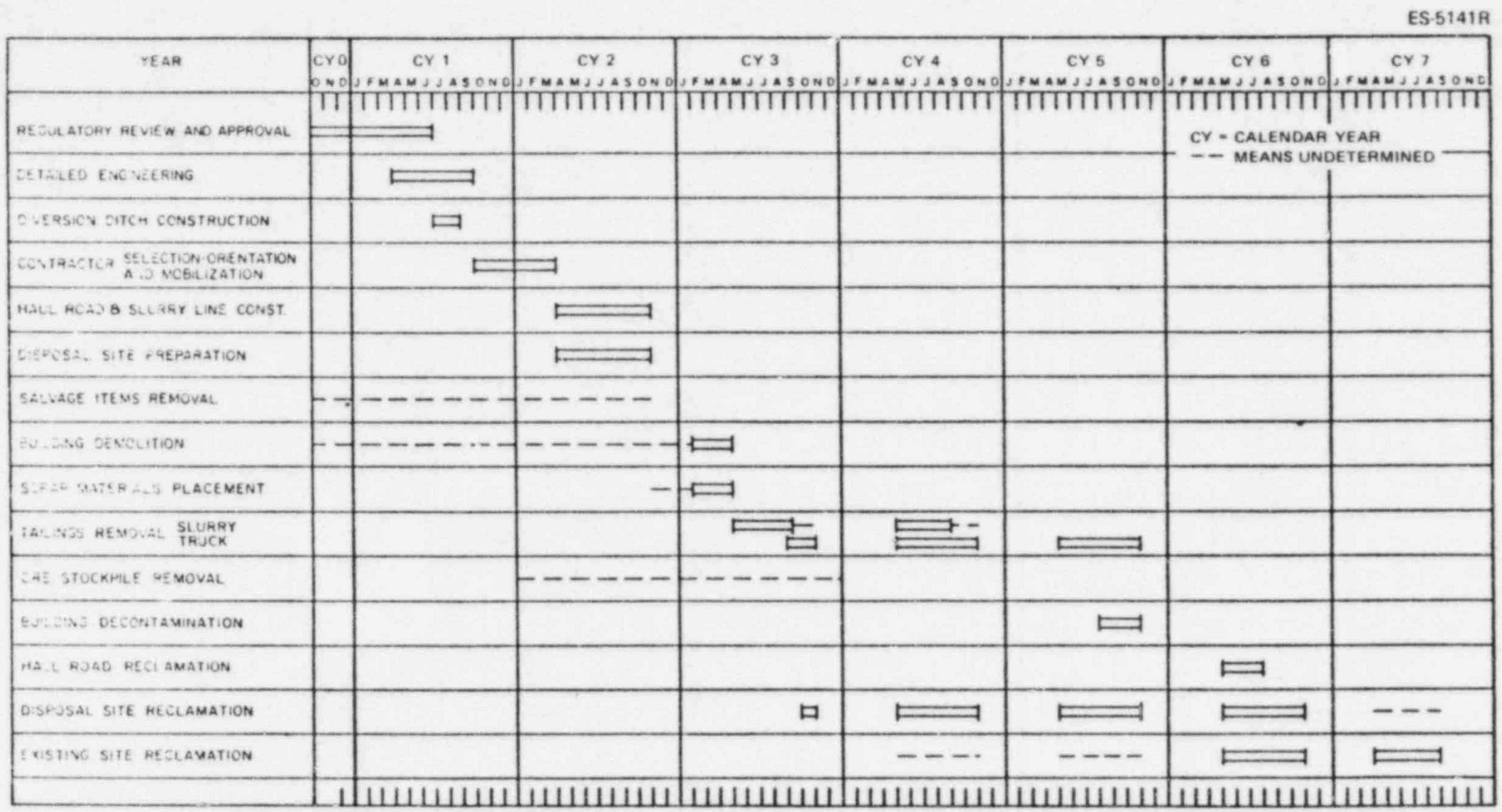

Fig. 2.10. Edgemont decommissioning schedule. Source: ER, rev. 1, Fig. 3.6-2.

Topsoil and stabilization cover material will be removed from Pond 2, the AEC pile, Area B, and the east pile by truck as tailings are transported to the repulping plant near the east pile. Continuous operation of the slurry transport system will necessitate the stockpiling of tailing sands at the pulping plant.

The tailings sand will be mixed with water to a 50-wt % slurry. The design sand input of 285 MT/h (314 tons/h) will yield a flow rate of about 5822 liters/min (1800 gpm) in the slurry pipeline (Fig. 2.11). At the impoundment, the solids will settle out and the liquids will form a pond. A decant barge will be used to recover about 3960 liters/min (1045 gpm) of the liquid, which is then returned by pipeline to the repulping plant (Fig. 2.12). The remaining liquids, about 985 liters/min (260 gpm), are lost to recycle by entrainment in deposited solids, by evaporation, or as pond water inventory. Therefore, as a counter for these losses, an equal amount of makeup water will be drawn from TVA's existing well at the mill site, from Pond 10, and from dewatering sumps around the mill site. The applicant has a water appropriation permit from the State for the onsite well.

Because the majority of the contamination will be concentrated in the tailings, removal of the sand tailings by slurry pipeline will significantly decrease the potential for the release of airborne contaminants along the haul route. The applicant claims that the slurry deposition of sand tailings in the impoundment area, in addition, will fill void spaces in and around the rubble from mill structures and equipment placed in the bottom of the area. This, the applicant claims, will minimize the differential settlement that might threaten the integrity of the final clay cap and overburden cover of the impoundment area. The staff recommends that the applicant evaluate the potential for incomplete filling of void spaces, estimate the magnitude of differential settlement that could result, and identify mitigating measures to prevent failure of the tailings cap and cover due to settlement cracking. In addition, the staff recommends that the applicant establish field procedures for ensuring that all voids are properly filled and that these procedures be submitted for review.

As water drains from the sand tailings deposited by the slurry pipeline, a tailings beach is expected to form. In the event that the slurry is too liquid to form a sloping beach, the staff recommends that small temporary dikes be constructed to prevent broad flowage of slurry and permit establishment of a sloping beach. Once this beach has been established, truck disposal of tailings and contaminated material will commence, proceeding from the impoundment dike in an upstream direction to cover the tailings deposited by slurry pipeline (Fig. 2.12). Material deposited by trucks will be spread and compacted to a density determined acceptable by soils engineering studies. Throughout the slurry disposal operation, the decant pond is expected to proceed in an upstream direction along the leading edge of the deposited tailings. Upon completion of the slurry operation, the decant pond will be pumped to Pond 10 for evaporation.

Treatment of slimes

The milling process separated the solid tailings into two size fractions: sands, which comprise about 80% by weight of the tailings, and slimes, which make up the remainder. The principal contents of Ponds 3 and 7 are slimes. The slimes are generally loose, fine-grained materials with high water contents and very low shear strengths. These properties make them difficult to excavate, handle, and compact with conventional heavy equipment. To overcome this difficulty, the applicant proposes to use the following procedure in the removal of slimes. Excess surface water will be pumped to Pond 10 for evaporation. To increase the evaporation rate, perforated sections of pipe could be used to spray the water over Pond 10 during appropriate climatic conditions. This operation will be directed by an onsite supervisor. The staff believes that the use of spray evaporation could be eliminated if the removal sequence were altered so that slimes recovery occurred simultaneously with the slurry transport of sands, thereby allowing the use of the ponded water as makeup for the slurry system.

Topsoil, stabilization cover material, and dike material removed from other tailings areas would be mixed with the slimes in Ponds 3 and 7 to make them manageable for truck transportation to the impoundment and compaction area. This multiple handling of the slime material is expected to eliminate localized concentrations of slimes and to minimize the potential for differential settlement resulting from slime concentrations. The staff recommends that the applicant develop plans to ensure that the slimes are properly mixed with less compressible materials to permit transport by truck and to minimize differential settlements. Field testing of the mix for compressibility will be required to provide a basis for adjusting the composition of the mix in the field.

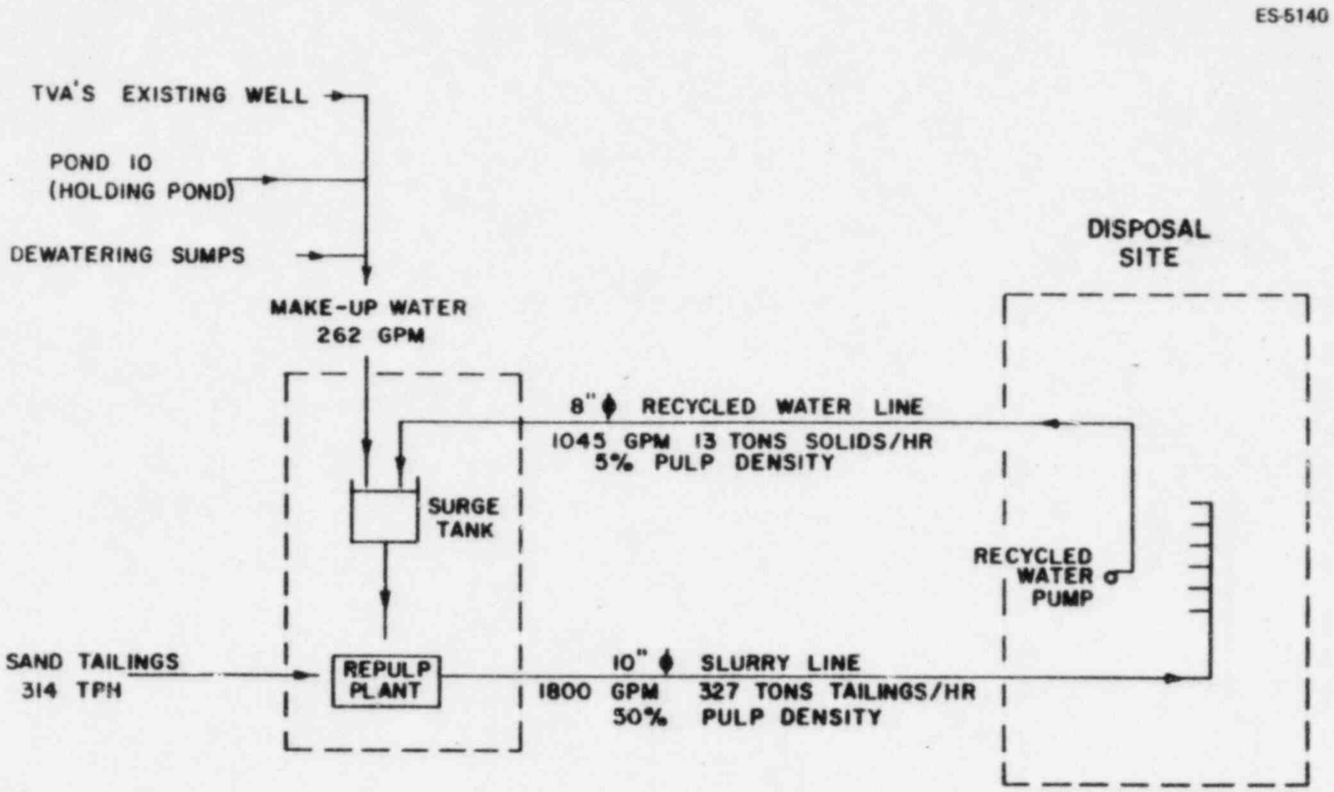

Fig. 2.11. Flow capacity of the slurry and recycle water pipelines. Source: ER, rev. 1, Fig. 3.5-4.

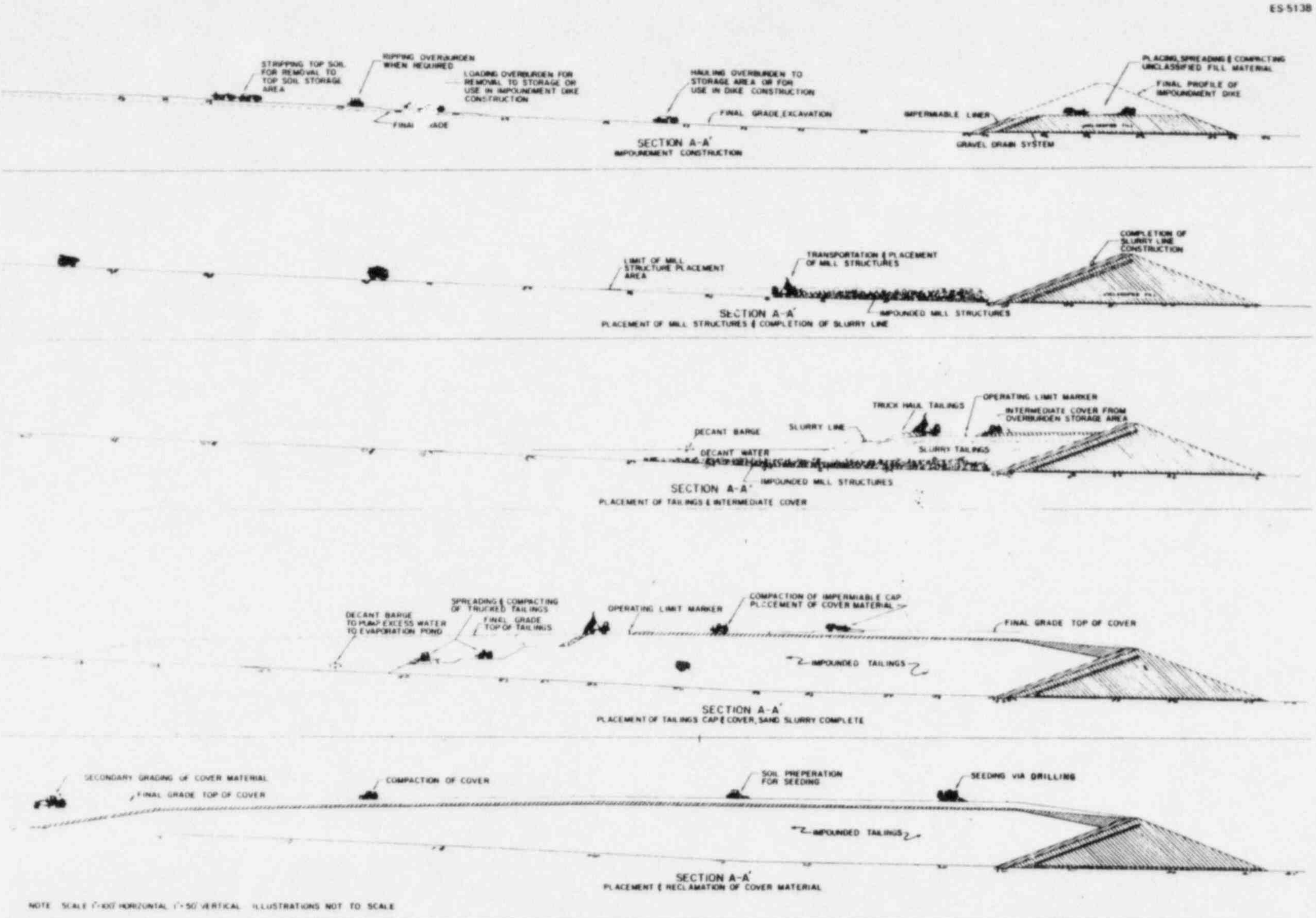

Fig. 2.12. Stages of mill decommissioning at proposed disposal site. Source: Modified from ER, rev. 1, Fig. 3.5-2.

As removal operations in Pond 3 (and possibly Pond 8) progress toward the Edgemont city sewage lagoon, it will be necessary to protect the integrity of the lagoon. To prevent the collapse of the lagoon embankment, sheetpile or another type of containment device will be placed along the exposed side of the lagoon before nearby removal operations begin.

Removal by truck

Trucks of up to 45.5-MT (50-tons) capacity will be used in impoundment operations to transport all materials that cannot be transported by the slurry pipeline system; these materials include building demolition wastes, stabilized slimes mixtures, stabilization cover, dike materials, soil, overburden, and the contaminated alluvium from Cottonwood Creek. Trucks may also haul the tailings sand from the individual piles to the repulping plant.

Truck removal of contaminated material from the mill site to the impoundment area will be over the specially constructed haul roads described in Sect. 2.2.2.2. Water from the onsite well will be used on haul roads, as necessary, to minimize the release of fugitive dust. Contaminated material in the trucks may be watered or sprayed with a suitable material to prevent emissions of fugitive dust during transport. Adverse weather conditions such as high winds, excessive precipitation, or freezing temperatures may temporarily halt the transportation process. Removal operations are expected to continue approximately 6 months per year for 2.5 years.

2.2.2.5 Cleanup of Cottonwood Creek

As cleanup operations proceed from the western portion of the mill site, the removal of contaminated material in and around the Cottonwood Creek channel will be necessary. This phase of the cleanup will require the temporary diversion of the creek. A diversion channel will be constructed of uncontaminated material to divert Cottonwood Creek through the mill site. Figure 2.13 shows the general location of the diversion channel from points A to B. The diversion channel will be constructed to handle runoff from a 100-year flood event. The base of the diversion will be excavated to uncontaminated material. The banks will be excavated outward into existing uncontaminated native materials. However, if the bank material is contaminated, additional soil will be removed and uncontaminated fill material brought in to construct the banks. Uncontaminated fill material will be used as needed to obtain the proper configuration for the diversion channel. During excavation operations, sumps will be used to remove any excess water as discussed in Sect. 2.2.2.4. The diversion channel will be protected from erosion by its careful design and by the use of riprap where necessary.

The channel will be completed from point A to point B (Fig. 2.13) with a temporary dike at each end to prevent floodwaters from entering the excavation. At the time of low flow in Cottonwood Creek, a coffer dam will be constructed at point C to divert the flow of the creek through a pipeline from point D to point E at the Cheyenne River. The pipeline will be designed to accommodate twice the average low flow of the stream. While the flow is being diverted, contaminated material from the creek channel from point F to point G will be removed and the channel stabilized as described above. The flow would then be returned to the decontaminated channel segment (F to G) of Cottonwood Creek.

During the next season at low flow, the coffer dam will again be used to divert the creek through the pipeline. The creek channel between points H and I (Fig. 2.13) will then be cleaned and prepared for flow. Once this is completed, the diversion channel from point A to point B will be connected at the upstream (F-G) and the downstream (H-I) portions of the existing channel. All flow from Cottonwood Creek will then be directed through the diversion channel. Removal of contaminated material to the east of the diversion can then proceed. Once the eastern portion of the mill site has been cleaned, the permanent route for Cottonwood Creek will be prepared. It is expected to follow the original creek channel as closely as practical to form a gently meandering course through the former mill site. When the creek has been reestablished in its permanent channel, any remaining contaminated material will be removed.

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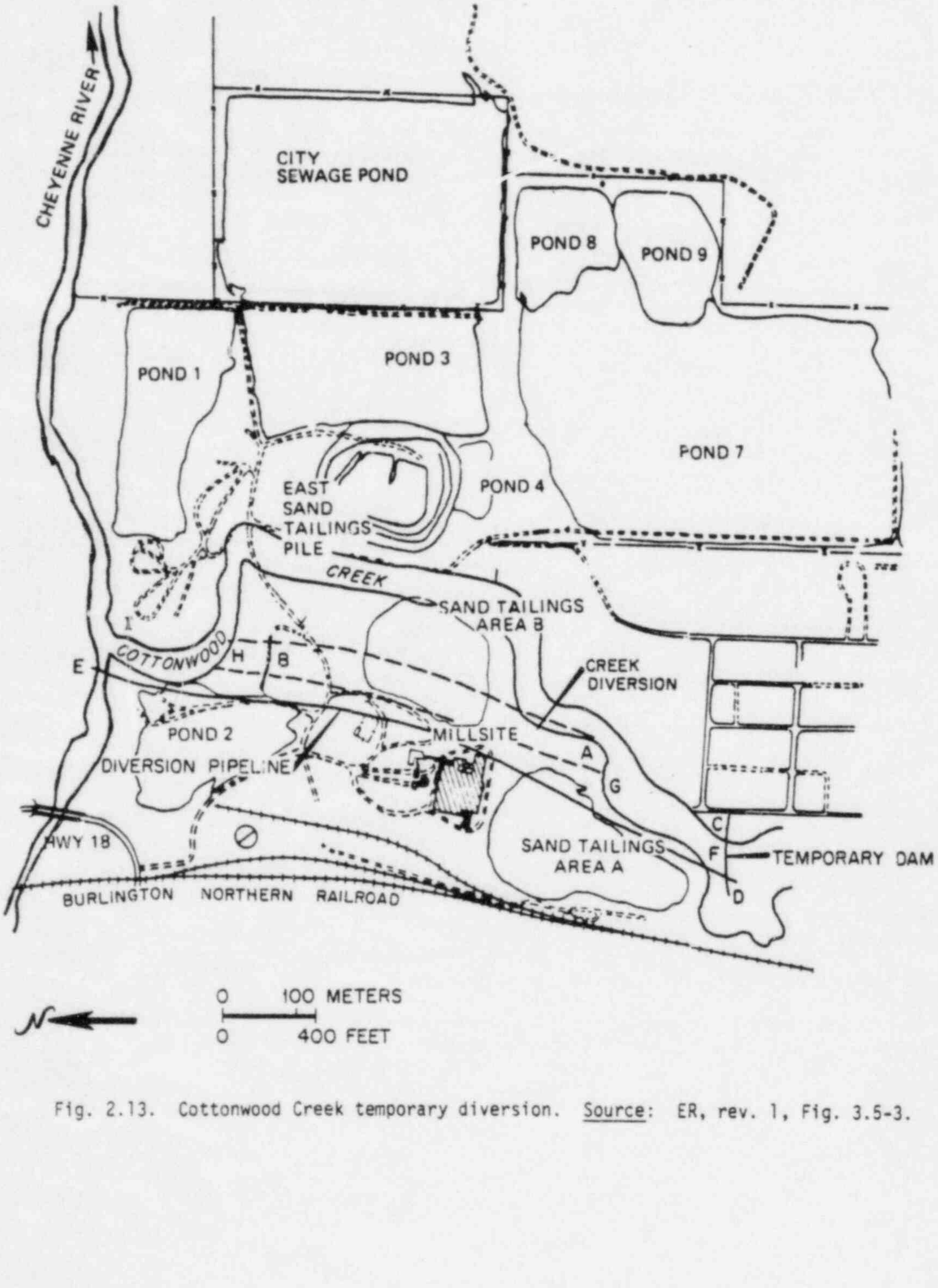

Fig. 2.13. Cottonwood Creek temporary diversion. Source: ER, rev. 1, Fig. 3.5-3.

2.2.2.6 Final mill site removal operations

Pond 10 cleanup

The removal of tailings and the decommissioning of affected areas will generally progress from the northwest to the southeast (Sect. 2.2.2.4). Pond 10, which lies on the southeastern corner of the mill site, will be decommissioned last. Pond 10 was constructed for use as an evaporation pond during the later phases of the mill-operating life, and no tailings sands or slimes were directly deposited in Pond 10. Contamination in Pond 10 will be limited to soil and overburden in the dikes and the pond bottom, some slimes brought in with the water, and contaminated materials in drainage from the haul roads and pipeline corridors.

At the completion of operations, any excess water and contaminated materials in the pond will be mixed with the embankment material surrounding the pond to facilitate handling and disposal. All contaminated materials will then be removed to the impoundment area.

Cottonwood Community

As discussed in Sect. 2.2.2.3, areas of the Cottonwood Community have been contaminated by windblown tailings. Because additional contamination may occur during cleanup operations at the mill site, the applicant proposes to delay survey and cleanup of Cottonwood Community until decommissioning activities on the mill site near completion (ER, rev. 1, p. 2.4-1).

Removal of slurry pipeline and haul road

Concurrent with Pond 10 cleanup activities, the slurry pipeline will be removed. Final disposition of the equipment has not been determined by the applicant, but the major options available at this time include use of the equipment at another licensed facility or disposal in the impoundment area. Contaminated soils on the haul roads and in the drains will be removed to the impoundment.

2.2.2.7 Mill site reclamation

The objectives of the applicant's reclamation plan for the mill site are to (1) provide livestock forage and (2) restore the riparian community of the rechanneled portion of Cottonwood Creek, providing habitat for indigenous wildlife and improving the scenic quality of the creek (ER, Sect. 4.6.3.1). The applicant's plans to meet these objectives, as summarized below, are discussed in Sects. 4.6.3.2 and 4.6.3.3 of the ER.

Site preparation

The entire 86-ha (213-acre) mill site will be recontoured before being revegetated. The applicant plans to obtain fill material from the disposal site. However, depending upon the volume of contaminated soil removed, the amount of excess overburden at the disposal site, and the flexibility of the engineering schedule, additional acreage may be disturbed to acquire the necessary fill material. Any borrow areas will be contoured to blend with surrounding land forms.

To retain water, thereby improving vegetative cover, and to reduce gully formation, the applicant may construct water-spreading bars below drainages originating on the hill east of the site. The reconstructed channel planned for Cottonwood Creek will approximate the predevelopment configuration, with banks graded to a 10° slope.

Before application of soil suitable for plant growth (topsoil), all disturbed areas will be ripped to a depth of 26 to 31 cm (10 to 12 in.) to reduce compaction and increase the soil's water-holding capacity. Topsoil will be applied to a depth of 15 to 20 cm (6 to 8 in.). The applicant states that sufficient materials suitable for use as topsoil exist at the disposal site for reclaiming both the disposal and mill sites. The engineering schedule, however, may not allow the use of this material at the mill site, or more cost-effective areas for topsoil acquisition may be located, but at increased environmental land disturbance as noted above.

Seedbed preparation and seeding

The site will be disked to roughen the surface and reduce compaction caused by topsoil application. The time of seeding will depend upon completion of site and seedbed preparation. If seeding is done during late summer or early fall, a species mixture listed in Table 2.3 will be applied with a drill-type seeder. A 10-m-wide (32-ft) strip along each side of Cottonwood Creek may be planted with a mixture of seed listed in Table 2.3. As discussed below, this understory mixture will be supplemented with shrub plantings during the spring of the second growing season. Native hay mulch may be applied at a rate of 2.2 MT/ha (1 ton/acre) to cover the seed and to aid in moisture retention. The mulch would be anchored with a disk or sheepsfoot roller.

If recontouring is completed before late May, the prepared seedbed will be seeded with 54 kg/ha (48 lb/acre) of barley, rye, or oats. This annual crop should minimize wind and water erosion and provide both organic matter and cover for the reclaimed sites until early fall, when the grass/forb mixture (Table 2.3) can be seeded. This annual crop will be cut to prevent production of seed that would compete with the reclamation mixture. The reclamation mixture will be seeded directly into the existing stubble.

Other areas not immediately available for seeding with the grass/forb mixture because of decommissioning scheduling will also receive the temporary oat, rye, or barley cover crop to minimize wind and water erosion. These cover crops will also be cut to prevent seed formation.

During the second growing season two 2.4-m-wide (8-ft) bands 5 m (16 ft) apart will be plowed and disked along both sides of the reconstructed Cottonwood Creek in preparation for shrub plantings. The shrubs will be overwintered in a lath house for acclimation. Pygmy peashrub (*Caragana pygmea*) and willow (*Salix* ssp.) will be planted at irregular intervals in both bands. Every 20 m (65 ft) will be planted a plains cottonwood (*Populus sargenti*) sapling in place of a willow or peashrub. In the outermost band, Russian olive (*Elaeagnus anqustifolia*), chokecherry (*Prunus virginiana*), and buffalo berry (*Shepherdia argentea*) will be planted at irregular intervals.

Because of the low nutrient content of the soil, the applicant plans to fertilize the seeded areas with 45 to 54 kg/ha (100 to 120 lbs/acre) of nitrogen and 91 kg/ha (200 lbs/acre) of phosphorus. The rates of application will be 50% lower if acrylic or asphalt tacking agents rather than hay mulch are used for erosion control (ER, Sect. 4.6.3.3).

2.2.2.8 Tailings and waste disposal site stabilization

The tailings and wastes in the impoundment will be stabilized against disruption during long-term disposal. Any areas of ponded water remaining after completing deposition of tailings and contaminated materials will be removed or allowed to evaporate. Then the entire impoundment surface will be contoured and compacted. As shown in Fig. 2.2, the impoundment will be capped with 0.9 m (3 ft) of clay which in turn will be covered with unclassified fill to increase the total cover thickness to 3 m (10 ft) or more. The clay and fill will be obtained from onsite excavation or offsite borrow areas.

The cap will be designed to limit the radon-222 flux to 2 $pCi \cdot m^{-2} \cdot s^{-1}$ as specified by the FGEIS on uranium milling.[2] This cover will reduce gamma exposure to essentially background levels. To prevent failure of the cover and subsequent exposure of tailings, the impoundment will be designed and constructed to minimize the risk of differential settlement of the covered tailings. The thickness of the cover also protects the tailings from exposure caused by such things as erosion, root penetration, burrowing animals, and human intrusion.[2] The cover will have a "crowned" surface so that all precipitation will run off into the natural drainages around the impoundment. The establishment of vegetation on the cover (Sect. 2.2.2.9) will provide additional protection against erosion. All embankment slopes will be covered with a suitable thickness of riprap and appropriate filters to provide additional protection against wind and water erosion.

2.2.2.9 Reclamation of disposal site and haul roads

The objectives of the applicant's reclamation plan for the disposal site, haul roads, and borrow areas are to (1) stabilize the tailings and (2) provide livestock forage on all disturbed areas. The applicant's plans to meet these objectives, as summarized below, are discussed in Sects. 4.6.3.2 and 4.6.3.3 of the ER.

Table 2.3. Seed mixtures proposed for revegetation

Species	Quantity[a]	
	kg/ha	lb/acre
Mill site		
Western wheatgrass (*Agropyron smithii* var. *rosana*)	7.5	7
Thickspike wheatgrass (*A. dasystachyum* var. *critana*)	4	4
Slender wheatgrass (*A. trachycaulum* var. *primar*)	4	4
Russian wildrye (*Elymus junceus* var. *vinall*)	7.5	7
Louisiana sagewort (*Artemisia ludoviciana*)	1	1
Sainfoin (*Onobrychis viciaefolia*) or yellow sweet clover (*Melilotus officinalis*)	4	4
Total	28.0	27
Banks of Cottonwood Creek – undergrowth		
Streambank wheatgrass (*Agropyron riparium* var. *sodar*)	11	10
Western wheatgrass (*A. smithii* var. *rosana*)	11	10
Yellow sweet clover (*Melilotus officinalis*)	2	2
Total	24	22
Disposal site and borrow areas		
Western wheatgrass (*Agropyron smithii* var. *rosana*)	7.5	7
Streambank wheatgrass (*A. riparium* var. *sodar*)	7.5	7
Thickspike wheatgrass (*A. dasystachyum* var. *critana*)	4	4
Sand dropseed (*Sporobolus cryptandrus*)	1	1
Blue grama (*Bouteloua gracilis* var. *lovington*)	1	1
Russian wildrye (*Elymus junceus* var. *vinall*)	1	1
Louisiana sagewort (*Artemisia ludoviciana*)	1	1
Sainfoin (*Onobrychis viciaefolia*) or yellow sweet clover (*Melilotus officinalis*)	4	4
Total	27.0	26

[a]Pure live seed.

Source: ER, Tables 4.6-5 and 4.6-6.

Site preparation

Following placement of the clay cap and the overburden at the disposal site, the surface will be ripped to a depth of 26 to 31 cm (10 to 12 in.), and soil suitable for plant growth (topsoil) will be applied to a depth of 15 to 20 cm (6 to 8 in.). The area used to stockpile overburden and topsoil will also be ripped, but it should not require additional topsoil. The final reclaimed surface of the disposal site will have a minimum slope of 1% on the northeast and southwest sides and 0.5% on the northwest and southeast sides.

The roads and drainage channels will be ripped and graded to blend with existing land forms. Topsoil from stockpiles along the route will then be applied to a depth of 15 to 20 cm (6 to 8 in.). Any additional topsoil required may be obtained from the disposal site or borrow areas.

Seedbed preparation and seeding

Methods proposed for this stage of reclamation are identical to those described for the mill site (Sect. 2.2.2.7). The mixture of seed for final reclamation, however, is somewhat different (Table 2.3). A greater diversity of species is planned for these areas, and a substantial percentage of these seed species is suitable for stabilization of drainage areas.

2.2.3 Staff evaluation of the applicant's proposal and other alternatives

The Edgemont Uranium Mill Decommissioning Plan must provide adequate protection of the public and environment both from the short-term effects of waste excavation, transportation, and emplacement and from the long-term effects of mill waste storage. The criteria and performance objectives discussed in Sect. 2.2.1 will be used to measure the effectiveness of the decommissioning action in reducing the environmental impacts of remedial measures and in restoring the mill site to productive use.

Within the framework of the criteria, various alternative decommissioning plans may be formulated. All such plans may be divided into major elements including mill site cleanup, disposal site selection, disposal impoundment design and site preparation, waste transportation, waste stabilization, and site reclamation. Each of these elements may affect the overall viability of the decommissioning plan. Therefore, each of these elements will be examined for its impact upon the viability of the applicant's proposal and other plausible decommissioning plans. The results of the analysis and the staff's recommendations are presented in Sects. 2.2.3.7 and 2.2.3.8.

2.2.3.1 Mill site decommissioning alternatives

Mill site decommissioning involves two general issues: (1) the decontamination and reuse of, or the demolition and disposal of, structures and equipment and (2) disposal of contaminated wastes. The specific issues of mill site reclamation and cleanup of Cottonwood Creek are discussed in Sect. 2.2.3.8. Below, however, are the alternative concepts considered in the decommissioning of the mill structures and equipment.

Alternative A1: Demolition and disposal of all structures and equipment

In this alternative, all equipment would be removed from the mill buildings, and all structures would be demolished using procedures designed to minimize the airborne release of radioactive contaminants. Foundations and footings would be broken up and removed. Contaminated soils would be excavated and removed. All equipment, building materials, and soils with radioactive contamination above the limits in the decontamination criteria would be removed to the tailings and contaminated-materials disposal area. Uncontaminated materials could be sold as scrap or removed to a landfill for disposal.

This alternative is acceptable to the staff.

Alternative A2: Selective decontamination and utilization of buildings and equipment

In this alternative, the office building, water tower superstructure, and mobile equipment shop would be decontaminated for unrestricted use. Each piece of processing equipment would be evaluated for possible use in another mill or decontaminated for unrestricted use in other applications. Efforts would be made to decontaminate the main mill building for unrestricted use. Should such decommissioning prove unfeasible, the main mill building and the remaining support buildings would be demolished as in alternative A1. The decommissioning and continued use of buildings and equipment would provide economic benefits and conserve valuable equipment, while at the same time minimize the volume of such equipment to be buried.

This is the alternative preferred by the staff and essentially that proposed by the applicant.

Alternative A3: Continued restricted use of the main mill building with selective decontamination and utilization of other buildings

For this option, if the complete decontamination of the main mill building proves unfeasible, the applicant suggests that the building still be used for certain types of industrial activities. Care would be required to minimize risks to personnel and to void inadvertent radioactive contamination of the product and effluents of such operations. Restricted industrial use would postpone indefinitely the final decommissioning of the facility. Therefore, monitoring and financial surety arrangements would be required throughout the life of the mill building.

The other structures would be decontaminated or demolished as described in alternative A2. Some process equipment might be retained for further use, and the remaining equipment would be disposed of as in alternative A2.

This proposal is considered by the staff to be unattractive from an economical, environmental, and health and safety standpoint.

2.2.3.2 Alternative methods of tailings disposal

Alternative B1: Grading and stabilization of tailings piles in place on mill site

Alternative B1a. Under this alternative, all rubble and mill debris left on site and the tailings and contaminated materials from sand-tailings area B would be placed in Pond 1 (Fig. 2.9). Some material in the currently steep-banked and unstabilized east sand-tailings pile would be relocated to Ponds 3 and 4 so that all three areas will become short mounds rising no more than 1.5 to 3 m (5 to 10 ft) above the surroundings [average elevation 1056 m (3465 ft)]. The materials in Pond 10, along with its dike, would be removed to the low points of Pond 7.

Alternative B1b. As another option, the tailings and contaminated materials could be consolidated into a smaller number of disposal areas. Also, the materials in Ponds 1, 2, and 10 and in sand-tailings areas A and B would be removed to Pond 7. There would be no change in the planned handling of the east sand-tailings pile or Ponds 3 and 4. The consolidation would reduce the final disposal area from over 40 ha (100 acres) to about 28 ha (70 acres).

Under either option, the disposal areas would be stabilized by adding a cover [0.9 m (3 ft)] of compacted clay, which in turn would be covered with overburden and soil to increase the total cover thickness to 3 m (10 ft). The terrain around the disposal areas would be graded to provide adequate drainage. A permanent runoff diversion ditch would be provided to protect the disposal areas from drainage entering the site from the east. For protection from erosion by normal runoff and the probable maximum flood, riprap would be placed on the banks of Cottonwood Creek and the Cheyenne River adjacent to the disposal areas. Fill materials and soils for disposal area stabilization and reclamation of other impacted portions of the site would be obtained from offsite sources.

The advantages of onsite stabilization include (1) minimized handling of tailings and contaminated materials and thus reduced operational radioactive exposures and emissions, (2) expedited stabilization of the site relative to offsite disposal alternatives, (3) lower costs, and (4) fewer direct impacts on traffic. Depending on whether Alternative B1a or B1b were to be selected, approximately one-half to two-thirds of the 86-ha (213-acre) mill site would be

released for unrestricted use. The stabilized disposal areas will meet the radon-flux- and direct-gamma-radiation limits specified in the FGEIS on uranium milling.[2] However, a major disadvantage with onsite stabilization is the continued presence of radioactive tailings near a population center (Edgemont). Also, continual monitoring and maintenance of the disposal areas would be necessary to offset the erosional effects of Cottonwood Creek and the Cheyenne River as well as to prevent encroachment on the site by human activities. In addition, it is possible that contaminated pond waters could seep through dikes and the unlined pond basins and contaminate nearby surface and groundwaters. As a result, the probability of successful long-term stabilization of the site is highly questionable. Therefore, the staff finds onsite stabilization of tailings and contaminated materials to be unacceptable.

Alternative B2: Offsite disposal of tailings and contaminated materials

Under this alternative, all tailings, contaminated soils and fill, and mill debris would be removed to a specially constructed disposal impoundment located off site. Uncontaminated fill and soil from offsite sources would be used in the reclamation of the mill site. The advantages of offsite disposal include the potential for both isolation of the wastes away from population centers and release of all of the 86-ha (213 acre) mill site for productive use. The offsite disposal impoundment would be designed to meet current NRC regulations for uranium mills,[3] specifically in the areas of maintenance-free, long-term stability and isolation of tailings, tailings-cover design, control of toxic element seepage, and protection from human intrusion. The disadvantages of offsite disposal include costs of site acquisition and preparation, effluents related to material handling, total costs, and increased short-term environmental and health impacts and risks related to the transport of wastes and fill materials required for reclamation.

Despite the potential short-term disadvantages and impacts, the staff feels that a properly designed offsite disposal plan will result in long-term environmental protection significantly superior to that of onsite stabilization. This is thus the alternative preferred by the applicant and endorsed by the staff.

2.2.3.3 Alternative tailings disposal sites

In a preliminary engineering evaluation conducted for the NRC,[4] in 1978, 16 potential disposal sites were identified and studied for suitability for long-term tailings disposal. A later engineering evaluation conducted for the applicant[5] considered nine additional sites, for a total of 25 potential sites within 29 km (18 miles) of the mill site. The locations of the sites are listed in Table 2.4. The criteria used in comparative site evaluations were the NRC performance objectives for disposal of uranium mill tailings, the potential disposal capacity of each site, and disposal costs. Of the 16 sites in the NRC-sponsored study, 12 were eliminated from further consideration because of inadequate site configuration (disposal volume), possibility of encroachment on the site, value of the site for other purposes, adverse surface hydrology (excessive upslope drainage), and scarcity of suitable earth for use as stabilization cover. A reevaluation, conducted for the applicant, similarly eliminated 15 of the 25 sites studied.

In the period since these studies were performed, the estimate of the total amount of wastes (including tailings) requiring disposal has been revised upward, by the applicant, to 7.1×10^6 MT (7.8×10^6 tons) from 2.3×10^6 MT (2.6×10^6 tons) (ER, rev. 1, Table 2.3-1). As a consequence, the applicant found it necessary to eliminate additional sites based on inadequate disposal volume capacity. The staff feels that less material will require disposal than is currently projected by the applicant. However, because final disposal requirements are difficult to establish, the staff recognizes that the site selected must have sufficient flexibility to allow successful isolation of all wastes which could reasonably be expected to be generated in the decommissioning activity, even though the estimates may prove conservatively high.

The applicant has selected two sites for detailed assessments including considerations of radiological impacts, waste transportation impacts, and costs. The staff has included two additional sites (alternatives C3 and C4) for discussion because of their potential amenability to use for complete below-grade disposal, the prime choice for tailings disposal technique as delineated in current NRC Uranium Mill Licensing Regulations.[3] These alternative sites are discussed below.

Table 2.4. Location of alternative tailings sites

Site number	Site location[a]	Distance from Edgemont mill site[b]	
		km	mile
1	Sect. 6, T9S, R3E	1.2	0.75
2	Sect. 8, T9S, R3E	3.2	2.0
3	Sect. 18, T9S, R3E	3.5	2.15
4	Sect. 3, T9S, R2E	5.5	3.4
5	Sect. 6, T9S, R2E	11.3	7.0
6	Sect. 14, T8S, R2E	8.5	5.3
7	Sect. 11, T7S, R1E	17.1	10.6
8[c]	Sect. 1, T7S, R1E	20.0	12.4
9	Sect. 2, T9S, R2E	4.8	2.95
10[b]	East side Rt. 52 near Provo	8.8	5.5
11	Sect. 20, T8S, R3E	8.3	5.15
12	Sect. 18, T8S, R3E	8.8	5.45
13	Sect. 23, T8S, R2E	6.3	4.25
14[b]	Igloo area	16.5	10.25
15	Sect. 20, T7S, R2E	15.3	9.5
16	Sect. 15, T7S, R1E	17.1	10.6
17	Sect. 14, T8S, R2E	~8.8	~5.5
18–25	T11S, R2E and T11S, R3E	Not given	

[a] Ford, Bacon & Davis Utah Inc., *Engineering Analysis of Mill Facility Decommissioning and Long-Term Tailings Stabilization at a Remote Disposal Site, Edgemont Site, Edgemont, South Dakota*, prepared for the Tennessee Valley Authority, Chattanooga, Tenn., January 1979, Appendix E, p. 2.

[b] Ford, Bacon & Davis Utah Inc., *Engineering Assessment of Inactive Uranium Mill Tailings, Edgemont Site, Edgemont, South Dakota*, prepared for the U.S. Nuclear Regulatory Commission, Contract No. E(05-1)-1658, May 1978, pp. 8–10.

[c] Open-pit mine area.

Alternative C1: Site 2, ephemeral drainage basin, Sects. 8 and 17, T9S, R3E (minor portions in Sects. 7, 18, T9S, R3E)

This site, the preferred alternative of the applicant, located about 3.2 km (2 miles) southeast of the city of Edgemont, consists of 104 ha (258 acres) of private, State, and Federal (Bureau of Land Management) lands currently used for grazing. The site is located primarily in Sects. 8 and 17, T9S, R3E (Fig. 2.1). The site lies east of county road 6N and south of county road 6E. No more than six or seven vehicles per day pass near the site.

The portion of the site suggested as a disposal location is at the head of a small ephemeral drainage basin; upstream drainage area is about 18.6 km (46 acres). Surface water within the basin flows predominantly in direct response to precipitation. From this basin, drainage eventually flows eastward into the Cheyenne River. The configuration of the basin is a roughly triangular area open to the southeast. A drainage divide to the north and west separates the site from the Cottonwood Creek watershed.

Total land disturbance at the site would be about 68 ha (168 acres) and 36 ha (90 acres) used for soil- and overburden-stockpile areas. The site is bounded on the north and west by two ridges that could form the abutments of a containment dike. There are no structures on site; however, a small stock-watering pond covering about 0.04 ha (0.1 acre) is located near the southern boundary. Vegetation on the site consists mostly of grasses and sagebrush; there are no trees. The closest residence to the site is a ranch house about 2.4 km (1.5 miles) to the south. There is a barbed-wire fence next to the road along the west side of the site. No population growth that would infringe upon the site is projected for the area. The disposal site offers good conditions for revegetation. Soil cover at the site consists of about 0.15 to 0.6 m (6 in. to 2 ft) of residual fine-grained silts and sands with varying amounts of clays ranging from 15 to 30% by weight. A light brown, silty-clay (weathered shales) subsoil underlies the surface layer to a depth of 0.6 to 1.2 m (2 to 4 ft). A 1.5-m-thick (5-ft) third soil

layer at the site consists of a brown, highly weathered upper zone of shale bedrock strata. The silty clay soils are defined as CL and CH soils by the Unified Soils Classification System.

Bedrock consists of the Greenhorn Formation and the underlying Belle Fourche and Mowry shales, all of which are of Cretaceous Age. The sediments are nearly flat lying with a gentle dip of between 1 and 5° to the south. No fractures (faults or joints) are reported in the vicinity. Permeability of the fine-grained sediments at the site is low, especially in the zone at the soil-bedrock interface. Preliminary site investigations show that the nearest aquifer is at a depth of more than 152 m (500 ft) below the surface. A detailed discussion of the geology of the preferred disposal site (alternate C1) is presented in Sect. 3.7.1.3.

The applicant proposes to construct a partially below-grade impoundment at the site. Construction of a fully below-grade impoundment would require the considerable additional expense of excavating much more unweathered shale, and the additional protection provided would be minimal. The conceptual details of the impoundment design and disposal operations are discussed in Sects. 2.2.2.1 and 2.2.2.8. Excavations at the site would provide sufficient fill material for construction of the impoundment dike and final tailings cover as well as provide some fill for use in mill-site reclamation. If necessary, some clay materials for the impoundment liner (if required) and cap may be obtained offsite.

A major advantage of this site is the favorable topography. The ridges that form the northern and western borders of the site will provide excellent protection against wind erosion because the predominant winds are from the northwest. The gentleness and configuration of the topography provide a sufficiently large impoundment area so that the containment dike can be relatively low in height [17 m (55 ft)]. The site is more than 46 m (150 ft) higher than the probable maximum flood on the Cheyenne River. The drainage area of the site is small enough that runoff across the site should not pose serious long-term erosion or stability problems.

The site is underlain by generally fine-grained soils and a thick sequence of shale bedrock with permeabilities in the approximate range of 1×10^{-4} to 1×10^{-7} cm/s (100 to 0.1 ft/year). This sequence of relatively low-permeability geologic materials should help to protect local groundwater supplies from long-term seepage from the impoundment. However, the staff recommends that the applicant establish procedures for defining foundation permeabilities and acceptable impoundment excavation depths to ensure that the permeability of the entire impoundment foundation area is less than about 1×10^{-7} cm/s (0.1 ft/year). If the foundation or parts of the foundation do not meet this permeability criterion, then a clay liner will be used to ensure that contaminated waters from the tailings do not seep into the groundwater system.

Private haul roads can be constructed between the mill and the disposal site so that contaminated materials will not b[illegible] transported through populated areas, thereby minimizing the potential for accidents and publi[illegible] re to the contaminated materials and eliminating disruption of normal traffic on publi[illegible] Transportation costs are relatively low because of the short haulage distance and ass[illegible] lower fuel consumption. The site location also makes slurry pipeline transport of san[illegible] ngs a feasible alternative — an important part of the proposed course of action, which cou[illegible] rther reduce environmental and health risks due to tailings transport operations and significantly reduce transportation impacts.

Because all mill-site cleanup, waste hauling, and disposal operations will occur downwind (from the prevailing wind direction) from Edgemont, the impacts of fugitive dust will be minimized. In addition, the applicant states that sufficient materials are available for dike construction and cap, cover, and plant growth media.

The disadvantage is that the 34 ha (86 acres) occupied by the disposal impoundment will be withdrawn from unrestricted use. However, after the successful completion of site reclamation, livestock grazing and wildlife uses may be permissible.

The site is preferred by the applicant and considered acceptable by the staf[illegible].

Alternative C2: Site 7, ephemeral drainage basin, Sects. 11 and 14, T7S, R1E

This site is located 17.1 km (10.6 miles) northwest of the Edgemont mill, about 1.2 km (0.75 mile) northeast of the location where the county township road (commonly called road 10) from Edgemont crosses north over the Burlington-Northern tracks south of the old Burdock station. The site, which is in the general vicinity of the area that the applicant has considered for the development of an underground mine and the construction of a uranium mill, is on privately owned land whose mineral rights have been leased by the applicant. Because it is used for grazing, the land has a sparse ground cover of grasses and sage but no trees or bushes. The site is at the head of a drainage basin from which drainage flows south, then eventually west into the Cheyenne River. Two hills form the western boundary of the site and a small ridge forms the northeastern boundary of the site. The use of the site for a tailings disposal area would require at least 28 ha (70 acres) and would necessitate the construction of at least three dikes: two dikes would be required to fill the depression between the hills on the western boundary and one dike would be required to contain the waste at the lower end of the site. These dikes would probably range in height from about 6 to 18 m (20 to 60 ft). There are no structures on the site except several abandoned wells and the wooden remains of a pump system for an old shallow-water well. It would be required to fill these wells with impervious materials before waste impoundment. The closest residence to the site is a ranch house approximately 3.1 km (2 miles) directly south of the site. A small stock pond, about 0.07 ha (0.17 acre) in size, is at the extreme low elevation of the site and in the drainage pattern beginning at the head of the site. Access to the site from the county road is over an unimproved dirt road now being used by uranium exploration crews.

Soils at this site consist of about 0.6 m (2 ft) of a medium brown clayey silt topsoil. The topsoil contains 90% silt-clay and approximately 10% fine sand. Immediately underlying the topsoil to a depth of about 2.6 m (8.5 ft) is a light brown sandy silt containing 75% silt-clay and 25% fine sand. The soils are underlain by a fine-grained gray shale decomposed at the surface to about 0.15 m (about 6 in.). The shale, very friable and dry, contains thin seams of fine sand.

Bedrock at the site is Cretaceous age, and the Skull Creek shale exposed at the surface is underlain by the Fall River sandstone and the Lakota Formation. The Skull Creek shale is approximately 58 m (190 ft) thick at the site and contains minute partings along bedding planes and a low density of fractures normal to bedding planes.[5] No major fractures (faults or joint sets) are reported within the site. Some sandstone dikes have been located in nearby valleys but have not been traced through the site. The extent and permeability of sandstone dikes, if they occur at the site, will have to be determined. The permeability of sandstone dikes is likely to be much higher than that of the surrounding shales. Permeabilities are expected to be low in the soils and weathered-shale zones of the site. The shales could have fairly high permeabilities along horizontal partings, but vertical flow is likely to be low. Flow velocities are expected to be low except where the shales are highly disturbed.

Should this alternative site be selected, the applicant would propose to build an above-grade impoundment. The design concepts discussed in Sects. 2.2.2.1 and 2.2.2.8 would be adapted to the conditions at the site. Excavations at the site should provide sufficient fill material for construction of the dikes and final tailings cover. If necessary, clay materials for the impoundment liner and cap would be obtained off site.

One of the advantages of this site is the limited upslope drainage area and relatively gentle slopes at the site that would minimize the potential for long-term stability problems associated with flooding and water erosion. The construction of a clay liner over the relatively low-permeability soils and shales underlying the site should protect underlying aquifers from long-term seepage from the impoundment. In addition, the site is remote from the Edgemont population center and the reclaimed site would be available for limited use.

A disadvantage of this site is that the impoundment would require dikes at both the head and the lower ends to generate sufficient storage volume. Because diking would be necessary at the head or western end of the impoundment, that dike and the tailings cover would be somewhat exposed to the erosional action of the prevailing winds, which would not be the case for an impoundment situated entirely below the ridge line bordering the basin. More significant negative impacts would however be associated with the transportation of contaminated materials from the mill site to the disposal site, although these would be of a short-term nature. Removal of the estimated 7.1×10^6 MT (7.8×10^6 tons) of contaminated wastes would require about 370,000 trips using 19-MT (21-ton) dump trucks (slurry transport would be unfeasible primarily because of the

distance involved). This extensive transportation impact on public roads and through the town of Edgemont would greatly increase the potential for traffic accidents and radiological exposure to people. Accidents could also cause contamination of local drainages. Other transportation impacts include a slowdown of local traffic and significantly increased fuel consumption and transportation costs. The use of alternative impoundment designs is discussed in Sect. 2.2.3.4.

Primarily because of the significant negative transportation impacts associated with this site, particularly the increased accident potential and increased potential for radiological exposure due to transportation through a population center (Edgemont), the staff concludes that this site is less favorable than the applicant's preferred site (alternative C1).

Alternative C3: Site 8, abandoned mine pits, Sect. 1, T7S, R1E

This site, located 20 km (12.4 miles) northwest of Edgemont, is bounded on the north by the line separating Fall River County from Custer County and on the north and east by the Harney National Forest. This location was the source of much of the uranium ore fed to the Edgemont mill and has large open-pit mines. Of the three large open-pit mines in the vicinity, either Darrow pits 1 and 3 or pit 5 could be used as a disposal location. The pits vary in depth up to 23 m (75 ft) and are ringed by piles of the overburden removed to mine the ore. Only sparse vegetation exists in the pits or on side slopes, and water erosion has created many gullies on the side slopes. No structures are on the site, and the closest residence is a ranch house about 2.9 km (1.8 miles) west of the site. The elevation at the bottom of the pits is about 1170 m (3840 ft) above mean sea level. Access into the bottoms of the pits could be developed by regrading the former ore-hauling routes. Clay for the cap and probable liner and soil for revegetation would have to be obtained off site.

The bedrock at the site of the two abandoned open pits consists of sedimentary formations of lower Cretaceous age. Field observations, reference research, and information provided by the applicant indicate that the formations at the site are, in descending order, the Skull Creek shale, Fall River sandstone, and the Fuson shales of the Lakota Formation. The sediments are primarily interbedded shales of black to light gray, sandstone, and limestones. Bedding is near horizontal and has a projected strike of north-northwest and a dip angle less than 5° to the south.

Fractures at right angles to the bedding planes were sparse and scattered. Partings within the shale layers along foliation planes were common. No major faults were reported within the immediate pit areas.

Erosion of the pit walls was moderate to high, especially where the softer shale sediments were exposed. The pit bottoms were partially filled with erosional wash and debris from scaling and slough. Water runoff from a recent (1978) storm ponded in the lower elevations of the pit bottoms. No groundwater seeps or major flow zones were evident, although some of the sandstone layers contained iron precipitate deposits indicating past groundwater flow.

Relative permeability of the individual formations with respect to outward migration of seepage from the pits was not determined. However, seepage could occur within the sandstones and highly fissile shales or along bedding planes. Therefore, the applicant assumed that a clay liner would have to be constructed in the bottom of the pit and be continued up the sides as disposal operations proceeded.

A definite advantage to the use of the pit is that it would not result in the withdrawal of any additional land for unrestricted use and, in fact, would result in the reclamation of the pit area for limited use such as grazing. Other advantages of the pit site include isolation from populated areas, no maintenance, and a smaller disposal area. Another advantage of the pit site is that much of the wastes could be stored below grade, thereby minimizing the potential for long-term stability problems associated with wind and water erosion. However, the applicant has stated that the volume of the pits is not large enough to contain all of the estimated tailings and contaminated materials.

A disadvantage of this site is the possibility of long-term seepage and spread of contaminants resulting from placement of the contaminants next to permeable geologic formations near the water table. Appropriately designed clay liners could however alleviate this concern to an acceptable degree. Another disadvantage would be the elimination of further mining in the pits. The applicant is considering constructing adits in the pit walls to recover low-grade

uranium deposits. Transportation impacts associated with this site are however the significant disadvantage and are similar to those discussed in Alternative C2. Major transportation impacts include increase in the potential for traffic accidents and radiological exposure to people because of the necessity for hauling wastes through the town of Edgemont and over a significantly greater distance of roads (primarily public) than for site C2.

Primarily because of the significant negative transportation impacts associated with this site, particularly the transportation of large volumes of contaminated materials through a population center and the probability that the pits do not have sufficient capacity to contain the estimated volumes of contaminated materials, the staff concludes that this site is less favorable than the preferred site (Alternative C1).

Alternative C4: Site 3, ephemeral drainage basin, Sect. 18, T9S, R3E

The site is located about 3.6 km (2.25 miles) southeast of the city of Edgemont in Sect. 18, T9S, R3E. The site lies west of county road 6N and immediately to the southwest of alternative site C1.

The site is at the head of a small ephemeral drainage basin and is about 20.2 ha (50 acres) in area. Surface water within the basin flows predominantly in direct response to precipitation. From this basin, drainage flows generally eastward into the Cheyenne River. The site is bounded on the west and southwest by steep cliffs marking the beginning of the adjacent mesa, on the north by a drainage divide that separates the site from the Cottonwood Creek watershed, on the east by a ridge that separates the site from alternative site C1, and is open to the southeast.

The closest residence is a small ranch house about 2 km (1.25 miles) southeast of the site. No population growth that would infringe upon the site is projected for the area.

Soils at the site consist of shallow to moderately deep, well-drained, silty clay loams. Unweathered shale is encountered at depths less than about 100 cm (40 in.). The site is underlain by about 76 m (250 ft) of the lower unit of the Greenhorn Formation, which generally consists of dark gray noncalcareous shale interbedded with thin layers of limestone and clay, as described in Sect. 3.7.1.3. An inactive fault may extend across the western end of the disposal site.

The site is drained by an unnamed ephemeral tributary of the Cheyenne River. The tributary flows into a pond near the western edge of the river's floodplain. An existing small stock pond, about 0.1 ha (0.25 acre), is located near the eastern limits of the site, and a second small pond of similar size is located downstream about halfway to the Cheyenne River. Elevations at the site range from about 1164 m (3820 ft) on the northern watershed divide to 1119 m (3670 ft) below the pond. The drainage area for the site is about 16 ha (40 acres), and annual runoff from the watershed above the site is very low, on the order of 0.51 cm (0.21 in.). The maximum probable flood for the site was estimated to be about 59.5 m^3/s (2100 cfs). Flood peak discharges are generally the result of heavy local thunderstorms.

Groundwater conditions at the site have not been investigated. However, perched water tables may be present near the soil bedrock interface, and potentiometric levels and gradients in the deep aquifers below the site are expected to follow regional trends.

The advantages of this site include isolation from population centers, negligible evidence of flooding, and natural wind protection afforded by the ridges bordering the site. In addition, these ridges would provide natural abutments for the impoundment dike.

One disadvantage of this site is the moderate to high erosion potential due to the relatively steep limestone and shale slopes forming the western and northern borders of the site. Another disadvantage is that because of the relatively small impoundment site area, the impoundment dike would have to be significantly higher than at other sites to contain all of the wastes. In addition, the fault on the west side of the site may pose long-term seepage control or stability problems.

Because of the similarity between this alternative and the preferred alternative (C1) in terms of location and disposal site development, the cost for the impoundment, material transportation, and mill site decommissioning is assumed to be essentially equivalent to that for alternative C1.

Because of the disadvantages described above, the staff concludes that this site is less favorable than the preferred disposal site (alternative site C1).

2.2.3.4 Alternative disposal impoundment designs

Successful long-term isolation of tailings at any site depends on whether the impoundment withstands disruptive influences of water and wind erosion, differential settlement of the tailings and cover material, and natural disasters such as floods and earthquakes. A wide variety of tailings disposal concepts have been examined by the NRC staff for their suitability in long-term management of tailings.[2] Of these, the alternatives for decommissioning the Edgemont mill include above-grade disposal, partially below-grade disposal, below-grade disposal in a mined-out pit, and below-grade disposal in a specially excavated pit.

Alternative D1: Above-grade disposal

This type of impoundment has been widely used in the past. The existing tailings ponds and piles at the mill site are prime examples of simple above-grade impoundments. The terrain of the disposal site determines the configuration of the embankment enclosing the impoundment. Examples include dams across a natural basin and earthen berms constructed on the four sides of an impoundment situated on flat terrain. Diversion ditches, riprap, and similar flood protection measures may be necessary during both waste emplacement and long-term storage periods. The deposited tailings would be stabilized by the placement of a 0.9-m (3-ft) clay cap and additional overburden and soil to increase the cover thickness to 3 m (10 ft). Appropriate grasses, forbes, and shrubs would be planted on the surface to establish sufficient vegetative cover to limit erosion. However, in this case, the steepness of the embankments and the elevation of the impoundment area above the surrounding topography tend to maximize the exposure of the impoundment to the disruptive effects of erosion and natural disasters. Therefore, this type of impoundment may require long-term active care such as maintenance of diversion ditches and repair of erosional damage. The staff finds this alternative unacceptable because extended maintenance and strict land-use controls may be necessary to ensure impoundment integrity. For these reasons, stabilization of tailings in existing impoundments on the mill site (alternative B1) was rejected. In addition, use of this design at the other alternative disposal sites is not considered by the staff to be an acceptable option for similar reasons.

Alternative D2: Site selective/engineered partially below-grade disposal with special design and site features

Although tailings would be deposited partially above grade, judicious selection of the disposal site and careful impoundment design for long-term stability may make this alternative roughly comparable to below-grade disposal concepts (alternatives D3 and D4) in terms of protection against wind and water erosion. The following are general features for this type of impoundment as set forth by the NRC staff.[2]

1. A site is chosen where the upstream drainage area is very small. This would mean, for example, that the impoundment would be near the top of a divide.

2. Site topographic features provide natural shelter of the tailings impoundment area from wind; that is, the face of the impoundment embankment is not exposed directly to prevailing winds.

3. Final reclamation is carried out in such a manner that embankments are contoured to make very gradual slopes.

4. Tailings are covered with reasonably thick soil and overburden materials. The overburden is stabilized with vegetation or rock riprap and cobbles as appropriate to retard any wind and water erosion.

5. The impoundment dike is constructed according to accepted geotechnical engineering standard practices to ensure long-term stability (principles outlined in Regulatory Guide 3.11 are followed).

6. The tailings disposal area is not sited near a geologic fault.

7. Design features combine to cause deposition of sediment on the tailings area from runoff that may cross the impoundment area.

Positive topographical features (minimal upstream drainage, shelter from wind, sediment deposition patterns), establishment of vegetation, and the use of riprap to armor slopes are very important to the effectiveness of this alternative. Therefore, these features must be carefully considered in the site selection, and the impoundment design would seek to exploit them as much as possible.

The proposed disposal site and impoundment design (Sect. 2.2.2.1) display all of these recommended features except those listed in the It n 7. Because of the limited drainage area above the impoundment and limited runoff into the impoundment area, it is not expected that a significant amount of sediment could be accumulated on the impoundment area over the long term. Therefore, rather than creating a depositional condition on top of the impoundment, the staff concluded that it would be more beneficial to minimize surface flows and associated water erosion potential across the impoundment by constructing diversion ditches around the impoundment and by grading its surface to effect positive drainage away from the center. The stabilization cover would consist of 0.9 m (3 ft) of clay; added overburden and soil will make the cover 3 m (10 ft) thick. Seepage control and other stabilization features applicable to this alternative are discussed in Sect. 2.2.3.5.

The main advantage of this alternative is the potential for secure long-term isolation comparable to that obtainable with below-grade disposal but at a lower cost. Additionally, this technique of partially below-grade disposal may avoid the problems of tailings emplacement near or under the groundwater table where the occurrence of a shallow aquifer would affect the feasibility of below-grade disposal. The disadvantages associated with site selective/engineered partially below-grade disposal, with such special siting and design features include the risk of accidental release of tailings because of embankment failure, potential long-term failure of the impoundment resulting from unforeseen changes in natural conditions (such as climate), and necessary passive monitoring and land-use controls to prevent encroachment on the site and disruption by human activities.

Because partially below-grade disposal with special design features can be designed and constructed to provide reasonable assurances of long-term stability against natural forces, similar to below-grade disposal in a mined-out open pit, the staff concludes that this impoundment design would be an acceptable long-term tailings management alternative for the Edgemont site. In the absence of acceptable mined-out open pits in the Edgemont area, site selective/engineered partially below-grade disposal with special design features is the impoundment design preferred by the staff.

Alternative D3: Below-grade disposal in a mined-out open pit

Placement of the tailings, other contaminated materials, and the impoundment cover below the natural-grade elevation will generally isolate the impoundment from natural disruption by surface water and wind. Impoundments adapted from inactive or abandoned mine pits would not require the construction of confining embankments or dams. Such embankments are the principal points of attack for erosive forces and the most likely failure points. The absence of such above-grade structures would therefore render the below-grade impoundment at least as stable as the surrounding natural terrain. This stability is the main advantage of below-grade storage. The possibility of disposal of contaminated materials in open-pit mines in the area is discussed in alternative C3. While such below-grade burial is preferred by the staff, the location, size, and geohydrologic conditions at the open-pit mines in the Edgemont area negatively impact the feasibility of such a technique in several important ways. In order to transport wastes to these mines, contaminated materials would have to be trucked through a population center, thereby increasing the potential for accidents, spillage of contaminated materials, and radiological exposures to people. Whether sufficient storage volume exists in the mine pits for the estimated total quantity of wastes is questionable. In addition, because potentially permeable geologic formations are exposed in the pit walls and the exact level of the water table at the site is at present undefined, a potential may exist for seepage of contaminated liquids into the groundwater system. Installation of a clay liner on the pit bottom and sides would probably be required before pit disposal would be acceptable. Therefore, this alternative disposal design is not considered superior to alternative D2 for the Edgemont decommissioning plan.

Alternative D4: Below-grade disposal in a specially excavated pit

In this alternative, disposal area excavation would ensure that the tailings, other contaminated materials, and the impoundment cover lie below the natural-grade elevation. Therefore, no impoundment embankment would be necessary. This type of impoundment could be constructed at or in the immediate vicinity of the surface impoundment sites considered by the applicant (alternatives C1 and C2). The impoundment configuration would be adjusted to avoid highly sloping terrain and drainage courses. If the shale bedrock alone could not provide adequate seepage protection, a clay liner might be installed in the bottom and on the sides. The advantage of this alternative is the below-grade placement of wastes and cover materials. The major disadvantage of this alternative is the additional costs associated with the excavation of the pit. With an assumed 3.6×10^6 m^3 (4.7×10^6 yd^3) of wastes (ER, Table 2.3-1) and a cost of \$0.92 to \$1.30/m^3 (\$0.70 to \$1.00/yd^3) of material, the construction of a special pit at alternative site C1 would add \$4.3 to \$6.1 million to the cost of the decommissioning. Because a comparable degree of impoundment stability may be obtained with a specially designed partially below-grade impoundment at the same site (as in alternative D2), the added expense of pit construction is not considered justified.

2.2.3.5 Alternative seepage control measures

Alternative E1: Clay liners

If natural hydrogeological conditions of the impoundment base are such that permeabilities greater than about 10^{-7} cm/s are encountered, it would be necessary to emplace clay over portions of or over the entire bottom of the impoundment excavation to inhibit seepage of fluids from the tailings. In that event, the applicant should provide a liner design and material and compaction specifications to ensure that permeabilities of about 1×10^{-7} cm/s (0.1 ft/year) can be obtained for the clay liner. Properties of the clay should be compatible with impoundment fluids to ensure against cracking of the liner or chemical breakdown of the clay minerals.

The installation of clay liners is the seepage control measure preferred by the staff. However, alternative E2 could be employed, provided it can be demonstrated that permeabilities of natural materials exposed in the excavation are uniformly about 1×10^{-7} cm/s (0.1 ft/year). If a liner is needed, detailed plans shall be submitted to NRC prior to installation.

Alternative E2: Excavate impoundment bottom into relatively impermeable soils or bedrock

Under this alternative, the impoundment would be excavated into site soils and/or bedrock to a depth where the permeability has been determined to be about 1×10^{-7} cm/s (0.1 ft/year). Provided the expected maximum groundwater elevation in the area does not intersect the excavation, this alternative would provide reasonable assurances that local groundwater systems would not be contaminated by fluids seeping downward from the tailings. This cannot be determined until the applicant establishes the depth of excavation required for the impoundment.

The major advantage of this alternative is a relatively low cost especially where excavated materials are needed for other uses such as dike, cap, or cover construction. A disadvantage is that soil and bedrock conditions can vary significantly over short distances, and permeabilities measured at one point in the impoundment excavation may not be representative of permeabilities of other points in the excavation. In addition, vertical joints or fractures in soil and rock may go undetected in boring investigations, yet may provide significant pathways for migration of contaminated fluids away from the impoundment.

Therefore, the staff has concluded that this alternative should be used only where it can be demonstrated with a sufficient number of permeability tests and detailed field mapping of the excavation bottom that permeabilities across the entire bottom and sidewalls of the impoundment excavation are uniformly about 1×10^{-7} cm/s (0.1 ft/year). Otherwise a clay liner would have to be installed (alternative E1).

Alternative E3: Dewatering of tailings in place

Under this alternative, the amount of moisture available to carry toxic contaminants away from the impoundments would be minimized by allowing the fluids in contaminated materials deposited

in the impoundment area to form a pond in front of the sand tailings as they are emplaced. These fluids would be allowed to evaporate or would be decanted to a suitable evaporation pond. The staff recommends that measures be employed by the applicant to minimize the amount of fluids contained in the impounded materials before construction of the clay cap and cover.

The design and installation at the base of the impoundment of an underdrain system capable of dewatering the tailings to a greater degree would represent one such method of minimizing the amount of moisture available to allow migration of contaminants from the impoundment to the surrounding environment.

Alternative E4: Solidification of tailings and wastes with cement, asphalt, or other chemical fixants

Various solidifying agents have been suggested for incorporation into tailings so that the resulting solid form would have the desirable characteristics of low leachability and high resistance to the diffusion of radon.[2] The use of such agents on the Edgemont mill tailings would require the reslurrying and probably the neutralization of the tailings.

A common solidifying agent is asphalt, which, if it can be incorporated as an impervious coating on the tailings particles, would retard the diffusion and release of radon to the environment and would effectively prevent the leaching of water-soluble toxicants. A facility for heating and mixing the asphalt with the tailings would be required for implementation of this alternative. About 330 kg (670 lb) of asphalt per metric ton of tailings would be required to produce a suitable mix.[6]

After the selected pretreatments, the tailings could also be mixed with cement to produce, upon setting, a type of low-grade concrete. Properly designed, the same facility could handle the steps of required neutralization and concretion. One part of cement for 20 parts tailings is the estimated minimum. However, a ratio of 1:5 has been shown to yield better strength and leach resistance though at a higher cost.[6]

Commercially available chemical fixants could also be used to solidify the tailings. If this waste stabilization method were implemented, the chemicals would be blended into the tailings slurry and the resulting mixture pumped to an impoundment where solidification would occur within a few days to a few weeks. Either the waste material would be entirely entrapped or the pollutants (primarily heavy metals) would be chemically bound as insoluble complexes.

Although technically feasible and environmentally desirable, solidification of tailings and wastes would be extremely expensive. Assuming a nominal cost of $10.00/MT of tailings (commonly quoted costs range from $7.00 to $36.00/MT of treated wastes),[7] the staff estimates that chemically fixing only the tailings would cost $23 million. Treating the slimes with asphalt or cement would cost between $3.1 and $4 million. These estimates do not include the additional costs in special-material handling and processing. More significantly, the solidified waste would still have to be disposed of in a tailings impoundment because long-term stability after solidification using these techniques has not yet been demonstrated. In the opinion of the staff, potential environmental advantages do not justify the extra economic costs.

2.2.3.6 Waste transportation alternatives

Alternative F1: Conventional highway trucks

In this option, conventional tractor-trailer and end-dump trucks of 33 MT (36 tons) gross weight would haul wastes over existing public roads. To prevent dusting problems and contamination of public roadways with finely divided tailings and dry soil materials, the trucks would be equipped with heavy rubber covers, and washdown facilities would be provided. With an assumed payload of 19 MT (21 tons), trucks would make 370,000 trips hauling wastes from the Edgemont mill site. This number of trips on the public roads serving any of the disposal sites would cause considerable congestion (especially at the crossing of U.S. 18 and at the railroad tracks), present significantly increased risk of traffic accidents, and increase the costs of road maintenance. For disposal sites C2 and C3, nearly 10 million truck miles would be required. About 2 million truck miles would be required for site C1. The staff does not consider this a desirable option and it should therefore be implemented only if ultimately unavoidable.

Alternative F2: Off-road trucks

In this option, wastes would be hauled in off-road trucks of 45-MT (50-ton) or 68-MT (75-ton) capacity. A private haul road would be constructed between the mill site and the disposal area. Dust from hauling operations would be controlled by chemical sealants and water sprays applied to the road. Any spilled contamination on the road surfaces would be removed to the disposal area. Depending upon the size of trucks used, about 105,000 trips would be required. From cost and accessibility standpoints, alternative site C1 is the only disposal site for which this alternative is feasible. Application of off-road trucks at this site would not significantly impact the general public.

Alternative F3: Slurry pipeline

In this option, the sand tailings and some of the contaminated soils would be slurried with water and pumped to the disposal area in a slurry pipeline. Excess water would be decanted from the settled wastes and recycled to the mill site. Wastes not suitable for slurry transport (such as slimes) would be removed to the disposal area by conventional or off-road trucks. Total atmospheric emissions from the decommissioning project would be greatly reduced because of wet handling and deposition of wastes and decreased fossil fuel consumption related to haul-truck operations. As advantages of this system the applicant cites these environmental benefits, along with lower costs similar to those of off-road truck haulage. However, there are no cost advantages for the distant alternative sites C2 and C3 because of the increased costs related to right-of-way acquisition, river and stream crossings, and greater distances involved. In addition, a much greater length of pipeline would have to be monitored and maintained to assure avoidance of potential spills of contaminated materials in the event of pipeline failure or defects. The slurry pipeline is thus considered by the staff to be clearly desirable only for use in connection with site C1.

Alternative F4: Conveyor systems

Conveyor systems would offer environmental benefits similar to those of slurry pipeline transport. However, increased construction costs and operational inflexibility make this alternative less desirable.

Alternative F5: Railroad systems

Railroad transport of wastes could be possible for alternative sites C2 and C3 because of their location near the existing Burlington-Northern tracks at Burdock. This option would probably require the construction of a spur line and waste-handling facilities near the disposal sites and the acquisition of 91-MT (100-ton) hopper cars for transport of the wastes. Trucks or conveyors would be used to move the wastes from the handling facility to the disposal area. The required multiple handling of the wastes would increase the potential for radioactive and particulate emissions. Even though the use of the rail line would reduce the traffic impact of the C2 and C3 alternative sites, the costs of this alternative would be prohibitive.

2.2.3.7 Summary of evaluation of proposed tailings management plan

Tailings management performance objectives

The proposed tailings management plan has been evaluated against the following performance objectives developed by the NRC staff to ensure that uranium mill tailings are properly managed and controlled to minimize the potential hazard to public health.

1. Siting and design period:

   - Locate the tailings impoundment area remote from people so that population exposures will be reduced to the maximum extent reasonably achievable.

   - Locate the tailings disposal area so that disruption and dispersion by natural forces is eliminated or reduced to the maximum extent reasonably achievable.

- Design the isolation area so that seepage of toxic materials into the groundwater system will be eliminated or reduced to the maximum extent reasonably achievable.

2. Decommissioning operations and drying period:

   - Eliminate the blowing of tailings to unrestricted areas during normal operating conditions (including a program of chemical spraying and wetting of tailings surfaces).

3. Postreclamation period:

   - Reduce direct gamma radiation from the impoundment area to essentially background levels.

   - Reduce the radon emanation rate from the impoundment area to no more than 2 $pCi \cdot m^{-2} \cdot s^{-1}$.

   - Eliminate the need for an ongoing monitoring and maintenance program following reclamation.

Comparison of proposal with performance objectives

Siting and design to ensure remoteness from people. The proposed disposal site (Alternative C1) is located about 3.2 km (2 miles) southeast of the city of Edgemont, which is the nearest population center (current population approximately 1800), and about 2.4 km (1.5 miles) north of the nearest residence. Based on the generally favorable site conditions (including natural wind and water erosion protection, depth to major groundwater aquifers, distance from major surface water bodies, low seismicity, etc.), the adequacy of the impoundment system design (embankment stability, cap cover materials, seepage and erosion control, etc.), and the overall ability of the impoundment system to contain the tailings and other contaminated material at the site, the staff considers this site and prepared impoundment design to ensure adequate remoteness from people.

Siting and design to minimize disruption and dispersion by natural forces. Potential interruptions and dispersions from wind erosion, flooding and water erosion, embankment stability, earthquakes, and root and animal penetration would be minimized both by the proposed impoundment design and the natural characteristics of site C1.

1. Wind erosion protection. The proposed disposal site is in a natural basin at the head of an ephemeral drainage. The ridges that form the northern and western borders of the site will shelter the impoundment area from the prevailing winds (generally from the northwest) and should greatly reduce the potential for long-term wind erosion. The impounded materials will be covered with a minimum of 3 m (10 ft) of soil consisting of a 1-m-thick (3-ft) clay cap covered by at least 2 m (7 ft) of unclassified fill. The impoundment surface will be graded and revegetated. Embankment slopes will be covered with a suitable thickness of riprap and appropriate filter material. The natural protection from prevailing winds afforded by the ridges bordering the site, the thick cover of fill materials on the relatively flat impoundment surfaces, and the riprap cover on the embankment slopes should provide adequate long-term wind protection for the proposed tailings impoundment system.

2. Flooding and water erosion protection. The site is at an elevation that is more than 46 m (150 ft) higher than the probable maximum flood on the Cheyenne River; therefore any potential for water erosion at the site from flooding of the Cheyenne River is eliminated. The drainage area upstream from the disposal area is only about 18.6 ha (46 acres). For this reason, the potential for severe water erosion and/or failure of the tailings impoundment system by flooding is considered to be low. In addition, isolation courses will be constructed to divert water approaching the impoundment from the west and northwest. A natural drainage divide will prevent water from entering the impoundment area from the northeast. Grading of the impoundment surface to a gently sloping crown will eliminate areas of surface runoff concentration, remove runoff from the site, and provide significant protection against water sheet and gully erosion. Additional water erosion protection will be afforded by the 3-m (10-ft) thickness of cover material and revegetation of the impoundment area. Adequate water erosion protection of the downstream face of the impoundment dike should be afforded by its relatively gentle slope (5:1) and by the riprap cover and suitable filter materials.

The staff recommends that detailed engineering design studies be performed and that final design plans, cross sections, and material specifications for the proposed isolation courses, diversion systems, riprap, and suitable filter materials be submitted for review to ensure protection of the impoundment against water erosion. In addition, the applicant should provide, through design, assurances that any water that might exit from the gravel drain near the toe of the impoundment dike during disposal operations will be properly collected to prevent erosion of the toe of the dike.

3. Embankment stability. Boring logs supplied by the applicant indicate that silty clay and bentonite seams ranging in thickness from 0.65 to 15.5 cm (0.25 to 6 in.) occur in the shale underlying the disposal site. At the boring locations, the seams ranged in depth from about 3 m (10 ft) to 14 m (45 ft) below the present ground surface. The shale beds in general, and particularly the bentonite beds, may constitute planes of weakness in the impoundment dike foundation and natural dike abutments that could lead to failure of the dike or natural dike abutments during impoundment excavation or after loading with disposal materials. Therefore, the staff recommends that the final design of the impoundment dike and excavation take into account the location, orientation, and continuity of the bentonite and silty clay seams. The shear strengths of these clay seams and other foundation and construction materials should be determined to permit analysis of the long-term stability of the impoundment system. Final impoundment dike design plans should include material specifications, compaction criteria, and field compaction procedures to ensure the long-term stability of the embankment.

The proposed 5:1 slope for the downstream face of the impoundment dike should provide adequate protection against slope failure of the dike. However, the final slope of the downstream face should be determined by detailed engineering design studies that properly consider the foundation conditions below the dike, as discussed in the previous paragraph, and the engineering properties and shear-strength characteristics of the materials that are used in the construction of the dike. In no case should the slope of the downstream face of the dike be steeper than 5:1. Any suitable excavated material in excess of that needed for the proposed impoundment system could be used to flatten that slope and afford additional protection against possible slope failure and erosion. The downstream face will be further protected against erosion by the use of a suitable filter material overlain by riprap as discussed in the previous section.

The applicant should provide specifications for the gravel drain material within the impoundment dike to ensure that a suitable filter is established between the drain system and the unclassified dike fill to minimize the potential for piping failure of the embankment. Similarly, a suitable filter should be established between the impermeable upstream slope liner and the unclassified fill to prevent piping failure in the event cracks develop in the upstream liner.

Excessive differential settlement in the impoundment dike could cause cracking of the clay liner and/or clay cap. Such cracking could lead to erosion or piping failures of the impoundment system. Therefore, the applicant should address the potential for differential settlement within the dike considering unclassified fill and foundation compressibility and compensate for it by appropriate design features.

4. Earthquakes. Previous experience has shown that properly engineered embankments (similar to the proposed impoundment dike), which are constructed of clayey materials that are properly emplaced and compacted, can withstand severe earthquakes with no significant damage. On the basis of the low historical seismicity of the region, the absence of capable faults at the proposed site, and the proposed impoundment design, it is highly likely that the proposed disposal site and impoundment system should be able to withstand long-term seismic events without affecting the long-term stability of the impoundment. However, the applicant should confirm the long-term seismic stability of the impoundment system using procedures described in Regulatory Guide 3.11. In addition, the applicant should submit for evaluation information documenting the capability of the fault located at alternate site C4 immediately southwest of the preferred disposal site.

5. Root and animal penetration. The thickness of the clay cap and cover materials [total about 3 m (10 ft)] should minimize the possibility of penetration of the cap and cover materials by plant roots and burrowing animals.

Siting and design to eliminate/minimize seepage. Recent geologic information (Sect. 3.7.1.2) indicates that the impoundment system will be separated from major underlying confined aquifers by about 170 m (560 ft) of relatively impermeable shales. Therefore, the possibility of contamination of the major aquifers by seepage through the impoundment and underlying geologic material (shales) is considered to be remote. However, because a major performance objective is

to eliminate or minimize seepage from the impoundment system, the potential for seepage from the impoundment was evaluated.

The proposed disposal plan requires excavation of the impoundment site into surficial soils and shales. While the exact depth of excavation has not been established in the applicant's preliminary design plans, it is likely that the impoundment will be excavated into soils and shales with permeabilities ranging from about 1×10^{-4} cm/s to about 1×10^{-7} cm/s (100 ft/year to 0.1 ft/year) or lower. If, as is the current case, the applicant has not and cannot adequately demonstrate that the permeability of the materials in the bottom and sides of the proposed impoundment excavation will be uniformly about 1×10^{-7} cm/s (0.1 ft/year) across the entire site, the staff will require that a clay liner be installed along the bottom and sides of the excavation. The installation of a clay liner that is about 1 m (3 ft) thick across the entire excavation or in any areas where it was not demonstrated that the permeability of natural materials was about 1×10^{-7}cm/s (0.1 ft/year) would ensure that seepage of toxic materials from the impoundment system will be minimized or virtually eliminated and will prevent contamination of local groundwater. If a liner is required, a license condition would be included that would require the applicant to provide test results that ensure that the materials used for the liner would not undergo an increase in permeability characteristics or deterioration of consolidation or stability properties when exposed to tailings impoundment solutions over the long term. In addition, the applicant would develop and submit for review (1) criteria to define foundation conditions that are acceptable for the placement of a clay liner; (2) conditions which will require the use of subdrains and filters; and (3) liner material specifications, compaction criteria, and field compaction procedures.

While the decant system proposed by the applicant will ensure removal of some of the slurried tailings fluids from the impoundment system during disposal operations, much of the tailings fluids will remain at the base of the impoundment area in the sand tailings. Therefore, a license condition would be included that would require the applicant to dewater the tailings to the maximum extent reasonably achievable through the use of an in situ drainage system installed at the bottom of the impoundment to lower the phreatic surface and thus reduce the potential for seepage through the clay liner. Drains would be installed at one or several low points in the impoundment bottom and should be protected by suitable filter materials to ensure that they remain free running. The details of the design and installation of the dewatering system would be submitted to the NRC for review.

Elimination of blowing of tailings during operation. Some of the contaminated materials will be transported by dump truck to the disposal site. Contaminated materials in the trucks will be sprayed with a suitable material to prevent airborne dispersion of contaminated particles during transport. Cover material will be placed on the impoundment area immediately after a sufficient area of deposited tailings reaches final grade to minimize wind blowing of contaminated materials. The staff concludes that these procedures to minimize blowing of tailings during transport by truck and during disposal are generally acceptable. However, the applicant should develop and utilize an active program to control dusting, including periodic inspections to document the effectiveness of the program. To further minimize the potential for blowing of contaminated materials, the staff recommends that tailings not be transported or emplaced during periods of sustained high winds. In addition, the staff recommends that the surface of tailings and contaminated particulate matter at the disposal site be kept moist with water, slurry liquids, or chemical sprays until they can be stabilized by the intermediate cover.

Reduction of radon exhalation rate and gamma radiation following disposal and reclamation. The results of the evaluation of the adequacy of the proposed tailings cover are provided in Appendix D. Calculations indicate that the net gamma radiation from the tailings would be about 3.6×10^{-7} mR/year, which would be insignificant compared to the natural background radiation (153 mR/year). Radon flux from the impoundment would be about 2 $pCi \cdot m^{-2} \cdot s^{-1}$.

Elimination of need for ongoing monitoring and maintenance. After reclamation and a short-term observation and maintenance period for surface cover, the staff expects no further active maintenance will be required for the forseeable future.

It should be noted that, although the above evaluation is against the performance objectives for the tailings management, the applicant's proposed plan would basically satisfy the technical criteria for tailings management in Appendix A of 10 CFR 40, which was issued during preparation of this DES. A detailed evaluation of the proposed plan against these technical criteria, as well as any minor modifications to the plan needed to meet the criteria, will be presented in the FES.

2.2.3.8 Summary evaluation of the overall aspects of the applicant's proposal

The staff considers removal of the tailings and contaminated equipment and soil from the Edgemont mill site and disposal of such material in a manner to ensure long-term stability and isolation from the surface environment without the need for continued maintenance after disposal to be in the public interest and consistent with regulatory policy.

The staff finds that onsite stabilization of tailings is unacceptable because of the proximity of the city of Edgemont and the probability of tailings impoundment erosion at that location over the long term.

Of 25 potential disposal sites studied for suitability for long-term disposal within 29 km (18 miles) of the mill site (Table 2.4), alternative site C1 is preferred by the staff. It has been concluded that a tailings impoundment can be constructed at that site to meet all performance objectives discussed in Sects. 2.2.1.3 and 2.2.3.7. Site C1 contains sufficient storage capacity to contain the present estimate of tailings and other contaminated materials to be removed from the mill site. The staff considers that this estimate may be high but recognizes the difficulty in accurately estimating total volume to be removed. Any other type surface impoundments with special design features [e.g. alternative D2 (Sect. 2.2.3.4)] might require more than one site for disposal. The staff considers this requirement undesirable.

Open-pit disposal was evaluated (alternatives C3 and D3) by the applicant. It appears certain, though not yet formally documented, that sufficient disposal volume is unavailable. Furthermore, the capacity of the pits would be significantly reduced by the installation of liner materials in a manner that would ensure their stability. Therefore this option is no longer considered a viable alternative for this project. The staff does not recommend excavation of a new pit because a comparable degree of impoundment stability may be obtained with careful site selection and impoundment design, as in alternative D2, without the extra excavation expense and the environmental problems concomitant with disposal of the excess excavated material.

The staff presently recommends alternative site C1, the applicant's preferred site. Although both sites C1 and C2 can be engineered to meet the performance objectives, alternative C1 is preferable to alternative C2 because of significantly less severe transportation impacts, less impoundment diking, and less exposure to potential erosion.

The haul road proposed by the applicant, about 2.7 km (1.5 miles) eliminates transportation impacts on the public roads and minimizes the use of fossil fuel. The staff notes that any other site considered viable would result in greater use of fossil fuel and significant transportation impacts on the public roads. The haul road will disturb temporarily about 12 ha (30 acres) of land. It is unlikely that less disturbance would occur at another site.

The staff is of the opinion that the applicant's plans to use a slurry pipeline to transport tailings and other suitable material from the mill site to the disposal site are acceptable. The plans minimize the use of fossil fuel, represent sound economics, minimize the potential for public exposure to windblown contaminated materials, minimize truck transportation requirements, and are cost and energy effective.

With regard to avoiding contamination of ground and surface waters at the mill site, the staff considers the proposed diversion ditch to control runoff from the natural drainage east of the mill to be a necessary and environmentally sound feature. Otherwise, control of sediment transport from the disturbed contaminated materials on the site would be difficult, if not impossible.

Regarding the decontamination of Cottonwood Creek, the staff supports the staged rerouting and cleanup plan as proposed by the applicant. The staff considers that, if considerable expanses of contaminated sediments are identified within the streambed, diversion of the creek flow would be the most practical way to decontaminate the creek channel, with a minimum of sediment entering the Cheyenne River at the mouth of the creek. It is recognized that any method for full decontamination of the creek channel will destroy the aquatic biota in the creek through the mill site in the short-term, but the staff is of the opinion that this action will have significant long-term benefits by returning the creek to unrestricted use. All creek contaminants will be removed to levels determined by NRC in coordination with the State of South Dakota and EPA.

The staff notes that during previous mill operation, although fresh tailings and contaminated groundwater degraded the water quality of Cottonwood Creek, no detectable effects on the Cheyenne River or the Angostura Reservoir were observed.[8] With this past history, the staff is of the opinion that any potential effects of remaining contaminated creek sediment entering the river will be transient and will result in no measurable change in water quality or environmental consequences.

Thus, the staff agrees with the applicant's proposal (Sect. 2.2.3) to reroute, clean up, and stabilize the streambed and provide a restored aquatic habitat in a channel as close to the original creek configuration as feasible.

Regarding details of the proposed Cottonwood Creek cleanup, the applicant's plan for reconstruction of the Cottonwood Creek calls for the banks to be graded to a 10°-slope. Such a slope may be necessary for initial attempts to stabilize the banks, but erosion should be allowed to shape the banks in a natural manner. Areas of the creek expected to receive severe erosion, such as bends, can be stabilized with riprap. Excessive use of riprap, however, should be avoided. Although the plan for revegetating the creek banks generally appears acceptable, the staff recommends that the applicant work in cooperation with the South Dakota Department of Game, Fish and Parks in this area of the cleanup plan. The plan to plow and disk two 2.4-m (8-ft) wide bands along both sides of the creek for shrub plantings does not appear reasonable. Once the banks have been stabilized with the seed mixture as proposed, heavy machinery should not be used on the slopes. The staff suggests that the shrubs and trees be planted by hand. A small roto-tiller would probably be adequate for tilling the soil where the shrubs and trees would be planted. The applicant should consider placing roofing felt or plastic aprons around the shrubs and trees to control growth of competing grasses and shrubs and to conserve moisture.

According to the applicant's original plan for reclaiming the mill site, disposal site, and haul roads, and borrow areas as presented in Sects. 2.2.2.7 and 2.2.2.9, it was reported that sufficient suitable topsoil exists at the disposal site for reclaiming all disturbed areas. However, more recent data indicate that this will not be the case and that quantities are insufficient. Thus, while the staff believes that use of topsoil from the disposal site is environmentally preferable to disturbing additional lands, it appears that opening up new borrow areas for fill and topsoil material will be required. The staff will require adequate documentation and justification of plans to initiate such activity.

The seed mixture proposed for the mill site and banks of Cottonwood Creek (Table 2.4) appears appropriate, considering the proposed use of the land (Sect. 4.1.1.4). The staff feels, however, that the seed mixture to be used to revegetate the disposal impoundment area should not promote livestock grazing because the continued existence of vegetative cover over the impoundment is an integral factor of erosion protection. In selecting the seed mixture for that area, primary emphasis should be on providing self-sustaining vegetation capable of withstanding grazing pressures and effecting long-term erosion protection. As recommended by the U.S. Fish and Wildlife Service (K. D. Keenlyne, U.S. Fish and Wildlife Service, letter to R. A. Scarano, Chief, Uranium Recovery Licensing Branch, Division of Waste Management, NRC, Oct. 27, 1980), the applicant should consider a seed mixture which includes little bluestem (*Andropogon scoparius*), silver sagebrush (*Artemesia cana*), rice grass (*Oryzopsis hymenoides*), and fourwing saltbush (*Atriplex canescens*). These seeds are commercially available, can be planted with other mixtures, and would improve the area's diversity.

The seed mixtures for all areas to be revegetated contain yellow sweetclover (*Melilotus officinalis*). This species is a strong competitor for moisture and may retard the growth of warm season species if its density is too great.[9] Also, excessive seeding rates of small-seeded species such as yellow sweetclover may result in severe competition with grasses, especially if water is limited[10] as it is near Edgemont. Therefore, it may be advisable to broadcast this species after the warm season species have become established. As seeding conditions become more severe (e.g., steeper slopes, south- and west-facing slopes) the rate of seeding should be increased 50 to 100%.[10]

The applicant did not discuss any plans to revegetate the ponderosa pine community east of the mill site. The staff recommends that any portion of this community disturbed as a result of cleanup of windblown tailings be planted with species typical of the area.

To ensure the establishment of a self-perpetuating maintenance-free stand of vegetation, a policy of South Dakota, the applicant should, as described in the ER, (Sect. 5.1.4.1), monitor all reclaimed areas and take all necessary actions to achieve successful vegetation reclamation.

This reclamation should be considered successful when the cover and density of perennial species in the reclaimed areas equal the cover of perennial species at control areas with this condition being met for two consecutive growing seasons.

In summary, the conclusion of the staff is that the applicant's proposal is generally satisfactory and that the project be implemented subject to the monitoring and mitigating measures planned by the applicant and as supplemented by the regulatory agencies involved. Detailed plans and evaluations of each aspect of the decommissioning project will be subject to review and approval by NRC prior to implementation. The applicant will be required to adhere to the monitoring and mitigating measures in Sect. 4 of this statement, and all applicable licensing requirements of the NRC.

The staff concludes that under these restrictions, long- and short-term adverse impacts will be minimal, and the project will improve the local long-term environment and welfare of the public.

REFERENCES FOR SECTION 2

1. Tennessee Valley Authority, "Tennessee Valley Authority Responses to Nuclear Regulatory Commission Questions on Edgemont Uranium Mill Decommissioning Plan Environmental Report," in *Supplement 1: Edgemont Uranium Mill Decommissioning Plan Environmental Report*, Docket No. 40-1341, January 1980.

2. U.S. Nuclear Regulatory Commission, *Final Generic Environmental Impact Statement on Uranium Milling*, Report NUREG-0706, Washington, D.C., September 1980.

3. Uranium Mill Licensing Requirements, Final Rule FR 45(194) 65521-65538 (Oct. 3, 1980).

4. Ford, Bacon & Davis Utah Inc., *Engineering Assessment of Inactive Uranium Mill Tailings, Edgemont Site, Edgemont, South Dakota*, prepared for the U.S. Nuclear Regulatory Commission, Contract No. E(05-1)-1658, May 1978.

5. Ford, Bacon & Davis Utah Inc., *Engineering Analysis of Mill Facility Decommissioning and Long Term Tailings Stabilization at a Remote Disposal Site, Edgemont Site, Edgemont, South Dakota*, prepared for the Tennessee Valley Authority, Chattanooga, Tenn., January 1979.

6. M. B. Sears et al., *Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle in Establishing 'as Low as Practicable' Guides: Milling of Uranium Ore*, Report ORNL/TM-4903, vol. 1, Oak Ridge National Laboratory, Oak Ridge, Tenn., May 1975.

7. U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to Operation of Plateau Resources Limited Shootering Canyon Uranium Project*, Report NUREG-0504, Docket No. 40-8698, February 1979.

8. U.S. Environmental Protection Agency, *Environmental Evaluation of Mines Development, Inc.*, Uranium and Vanadium Milling Operation at Edgemont, South Dakota, Report PB-256, April 1973.

9. S. G. Long, Ed., *Characteristics of Plants Used in Western Reclamation*, Ecology Consultants, Inc., Fort Collins, Colo., 1978.

10. C. W. Cook, R. M. Hyde, and P. L. Sims, *Revegetation Guidelines for Surfaced Mined Areas*, Colorado State University Range Science Department, Science Series No. 16, Fort Collins, Colo., 1974.

3. THE AFFECTED ENVIRONMENT

3.1 CLIMATE

3.1.1 General influences

The climate of southwestern South Dakota, where Edgemont is located, is characterized by low precipitation, high evaporation rates, abundant sunshine, low relative humidities, and moderate temperatures of extensive diurnal and annual variations.[1,2] The general climate of the project area is semiarid, continental, or steppe; and the winter season is dry.[3,4]

Storm systems originating in the Pacific Ocean, after releasing most of their moisture over the Coastal and Cascade ranges and Rocky Mountains, produce only light precipitation in the Black Hills area. Heavier precipitation occurs when these systems reintensify east of the Rocky Mountains and interact with moist air that is already present or that moves by advection into the area from the southeast. Isolated summertime convective storms may also produce heavy, localized precipitation — primarily over and adjacent to the Black Hills.

Local topography in the area should not influence synoptic scale airflow to any great extent. The adjacent Black Hills, however, are a major barrier to airflow and may cause some airflow variation in the general region.

Temperatures are reasonably represented by data from nearby Ardmore, South Dakota, located approximately 35 km (22 miles) south-southeast of the Edgemont properties. Table 3.1 presents mean monthly, mean annual, and mean daily maximum and minimum temperatures for the Ardmore station for 42 years of record.

Temperatures greater than or equal to 32°C (90°F) are estimated to occur on an average of 60 d/year.[2] The extreme maximum temperature reported for Ardmore is 46°C (114°F).[2] Migrating high-pressure systems moving southward out of Canada frequently influence the area. These systems, combined with elevations of about 1067 to 1158 m (3500 to 3800 ft) MSL, a northern continental location, and infrequent cloud cover, contribute to an average of 198 d/year with temperatures less than or equal to 0°C (32°F). The lowest temperature on record for Ardmore is -38°C (-37°F).[2]

Freezing temperatures generally do not occur after mid-May or before the last of September.[1] However, there are large variations in freeze dates from year to year.

3.1.2 Winds

Long-term wind information is not available for the immediate area. The nearest National Weather Service (NWS) stations with such data are at Rapid City, South Dakota, and Scottsbluff, Nebraska, which are more than 105 km (65 miles) northeast and 160 km (100 miles) south of Edgemont respectively. Table 3.2 presents monthly and annual mean wind speeds and directions for these two stations.

The NWS data from Scottsbluff, Nebraska, considered by the staff to be more representative of site conditions than the Rapid City, South Dakota, data, indicate that the general airflow in the region is most frequently from the west-northwest, with a secondary maximum from the east-southeast. Wind speeds are relatively high, with a mean of 4.8 m/s (10.7 mph). The area-specific wind data is reasonably consistent with the NWS information. However, in the area-specific wind data, the average wind speed during the three-year measurement period is lower by a considerable amount than that observed over the longer term NWS period.

Table 3.1. Monthly and annual mean and mean daily maximum and minimum temperatures for Ardmore, South Dakota (1919–1960)

Time segment	Mean [°C (°F)]	Mean daily maximum [°C (°F)]	Mean daily minimum [°C (°F)]
January	–6.8 (20)	0.9 (34)	–14.4 (6)
February	–4.1 (25)	3.8 (39)	–11.6 (11)
March	0.8 (33)	8.3 (47)	–7.1 (19)
April	7.0 (45)	14.9 (59)	–0.8 (30)
May	12.9 (55)	20.7 (69)	5.2 (41)
June	18.6 (65)	26.6 (80)	10.4 (51)
July	23.3 (74)	32.4 (90)	14.3 (58)
August	22.1 (72)	31.3 (88)	12.7 (55)
September	15.9 (61)	25.6 (78)	6.6 (44)
October	8.8 (48)	18.0 (64)	–0.1 (32)
November	1.1 (34)	9.1 (48)	–6.8 (20)
December	–4.8 (23)	2.8 (37)	–12.2 (10)
Annual	7.9 (46)	16.2 (61)	–0.3 (31)

Source: ER, Table 4.1–1.

Table 3.2. Monthly and annual mean wind speeds and predominant wind directions at Scottsbluff, Nebraska, and Rapid City, South Dakota

Time segment	Scottsbluff, Nebraska		Rapid City, South Dakota	
	Mean speed [m/s (miles/h)][a]	Predominant Direction[a]	Mean speed [m/s (miles/h)][a]	Predominant direction[b]
January	4.7 (10.6)	WNW	4.7 (10.5)	NNW
February	5.1 (11.5)	WNW	4.8 (10.8)	NNW
March	5.5 (12.3)	WNW	5.6 (12.5)	NNW
April	5.8 (12.9)	NW	5.9 (13.2)	NNW
May	5.4 (12.1)	ESE	5.5 (12.4)	NNW
June	4.7 (10.6)	ESE	4.8 (10.7)	NNW
July	4.2 (9.4)	ESE	4.4 (9.9)	NNW
August	4.1 (9.2)	ESE	4.6 (10.2)	NNW
September	4.2 (9.5)	ESE	4.9 (11.0)	NNW
October	4.4 (9.8)	NW	5.0 (11.1)	NNW
November	4.6 (10.4)	NW	4.9 (10.9)	NNW
December	4.8 (10.7)	WNW	4.6 (10.4)	NNW
Annual	4.8 (10.7)	ESE	5.0 (11.1)	NNW

[a] Based on 24 years of record.
[b] Based on 13 years of record.
Source: ER, Table 4.1-3.

3.1.3 Precipitation

Maximum precipitation amounts occur during late spring and early summer primarily as a result of the interaction of moist air from the Gulf of Mexico with frontal systems moving across the region. Summertime convective thunderstorm activity also contributes substantially to the precipitation totals during the summer months. Monthly and annual precipitation data from Edgemont (Table 3.3) indicate that approximately one-half of the annual precipitation falls during May, June, and July. Most of the winter precipitation is snow. Based on snowfall records for Ardmore over a nine-year period, the annual average snowfall is approximately 94 cm (37 in.).[2]

Based on records from the NWS station at Rapid City, located about 105 km (65 miles) northeast of Edgemont, it is estimated that precipitation of 0.25 mm (0.01 in.) or more occurs on an average of 90 d/year.[5-7]

Table 3.3. Mean monthly and annual precipitation for Edgemont, South Dakota, 1949–1957

Month	Amount		Years of record
	mm	in.	
January	9	0.3	9
February	11	0.5	9
March	23	0.9	9
April	30	1.2	9
May	73	2.9	9
June	67	2.6	9
July	48	1.9	8
August	29	1.1	8
September	28	1.1	8
October	19	0.7	8
November	10	0.4	9
December	9	0.3	9
Annual	356	14.0	

Source: ER, Table 4.1-2.

The mean annual relative humidity for the area is estimated to be about 52%.[5,7] However, afternoon humidities in the warmer months are often lower than 30%.

3.1.4 Storms

Tornadoes are infrequent in western South Dakota. Of those reported, most occurred in the afternoon and early evening hours during the summertime thunderstorm season. Only nine tornadoes were reported from 1955 through 1967 within a 1°-rectangle (latitude and longitude) that includes the Edgemont area.[8] Thus, the estimated probability of a tornado striking a point within the Edgemont area in any given year is 0.0006,[8,9] which means that the estimated mean recurrence interval for a tornado at any point within the Edgemont area is about 1650 years.

Thunderstorms, relatively frequent in southwestern South Dakota during the summer months, occur on the average of 40 to 45 d/year.[7,10] Hail associated with these thunderstorms generally occurs on an average of 4 to 6 d/year.[10] Extreme winds of short duration generally accompany these thunderstorms, and maximum short-duration rainfalls generally are associated with the more intense thunderstorms.

3.2 AIR QUALITY

The Environmental Protection Agency (EPA) has designated the project area, located in the Black Hills–Rapid City Air Quality Control Region, as an attainment area for sulfur dioxide and total suspended particulates (TSP), indicating that these pollutants are within the Federal air quality standards.[11] The EPA has designated carbon monoxide, ozone, and nitrogen dioxide in this region as "Cannot Be Classified or Better Than National Standards."[11] The only significant nonradiological air pollutant expected to be associated with the proposed action will be TSP.

The applicant has not monitored the existing air quality at the mill site. A TSP monitor was installed about 22 km (14 miles) northwest of the site in April 1979. Results from 17 months indicate that the annual geometric mean for TSP at this location is about 27 μg/m³; the highest recorded value of 146 μg/m³ occurred on May 21, 1980. Wind speeds in the region are highest in March, April, and May (ER, Table 4.1-3). Data on TSP from State monitoring stations are available for communities in the region. The nearest station, Hot Springs, reported annual geometric means of 54, 45, and 44 μg/m³ in 1976, 1977, and 1978, respectively; maximum recorded values for these years were 168, 211, and 132 μg/m³, respectively. The Federal secondary standard and State of South Dakota ambient air quality standard for TSP is 60 μg/m³ as the annual geometric mean, with a maximum concentration of 150 μg/m³ allowed once yearly. Background concentrations of

other pollutants (sulfur dioxide, carbon monoxide, nitrogen dioxide, hydrocarbons, and photochemical oxidants) are all expected to be low in the Edgemont area because of low population density and lack of industrial development.

3.3 TOPOGRAPHY

The mill site is located immediately south of the confluence of Cottonwood Creek and the Cheyenne River, about 4.8 km (3 miles) southwest of the foothills of the Black Hills mountains. The topography of the area is characterized by flat bottomlands and alluvial terraces and gently rolling hills. Elevations at the mill site range from about 1066 m (3500 ft) at the southeastern corner of the site to about 1042 m (3420 ft) along the Cheyenne River, which forms the northern boundary of the site, and along Cottonwood Creek, which flows through the western portion of the site.

Immediately north of the mill site the topography is characterized by about 3.2 km (2 miles) of gently rolling hills followed by rugged northwest-southeast-trending ridges. The topography south of the mill site is characterized by relatively broad, flat bottomlands and alluvial terraces along Cottonwood Creek and northwest-southeast-trending ridges and valleys. About 3.2 km (2 miles) south of the mill site, a line of cliffs marks the beginning of a relatively flat mesa.

The proposed disposal site is located about 3.2 km (2 miles) southeast of the confluence of Cottonwood Creek and the Cheyenne River. The actual site is located at the head of an ephemeral drainage with site elevations ranging from about 1122 m (3680 ft) at the western boundary to about 1096 m (3595 ft) at the southeastern boundary. The disposal site and immediate vicinity is characterized by northwest-southeast-trending ridges and valleys. The cliffs and mesa begin about 0.8 km (0.5 mile) southwest of the proposed disposal site.

3.4 DEMOGRAPHY AND SOCIOECONOMIC PROFILE

The Edgemont mill site is adjacent to and within the town of Edgemont, South Dakota, in the west-central section of Fall River County, approximately 20.9 km (13 miles) by highway east of the Wyoming–South Dakota border, 43.5 km (27 miles) southwest of Hot Springs, the county seat for Fall River County, and 137 km (85 miles) southwest of Rapid City (Fig. 3.1). South of the mill site and west of some of the tailings ponds is a residential area called Cottonwood Community, which has a population of about 75. The Burlington-Northern Railroad borders the site in the west and separates the site from Edgemont's commercial district. Residential areas are west and north of the site across the Cheyenne River. The north area, known as Dudley, has a population of about 60. Except for an Edgemont city sewage pond, the land immediately east of the site is undeveloped (Figs. 3.2 and 3.3). The proposed site for long-term disposal of the Edgemont mill tailings is approximately 3.2 km (2 miles) southeast of the mill site (Fig. 3.3).

Because of the proximity of the communities to the mill and disposal sites and because they are the only communities within reasonable distance that possess amenities such as schools, retail districts, and utilities usually sought by in-migrants,[12] the staff has concluded that Edgemont and Hot Springs will absorb the majority of the socioeconomic impacts resulting from this proposed project. Therefore, the socioeconomic descriptions and impact analyses focus on these communities and the surrounding regions in Fall River County.

3.4.1 Population

Edgemont and Hot Springs are relatively small municipalities; their 1980 populations were approximately 1500 and 4700, respectively. The towns are located in sparsely populated Fall River County, which had an estimated population in 1980 of 8400 and a population density of only about 1.9 persons/km^2 (4.8 persons/sq mile); therefore, the majority of the county's inhabitants (about 6200 of 8400) live in these two communities.* Very little slack exists in the labor

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*The Fall River County estimate was obtained from J. Ray, Bureau of the Census, and was based on 1980 Census data (personal communication, Mar. 12, 1981). The total land area for Fall River County was assumed to be approximately 4510 km^2 (1740 sq miles) and was based on acreage estimates developed by the South Dakota State Planning Bureau (ER, Table 4.3-1).

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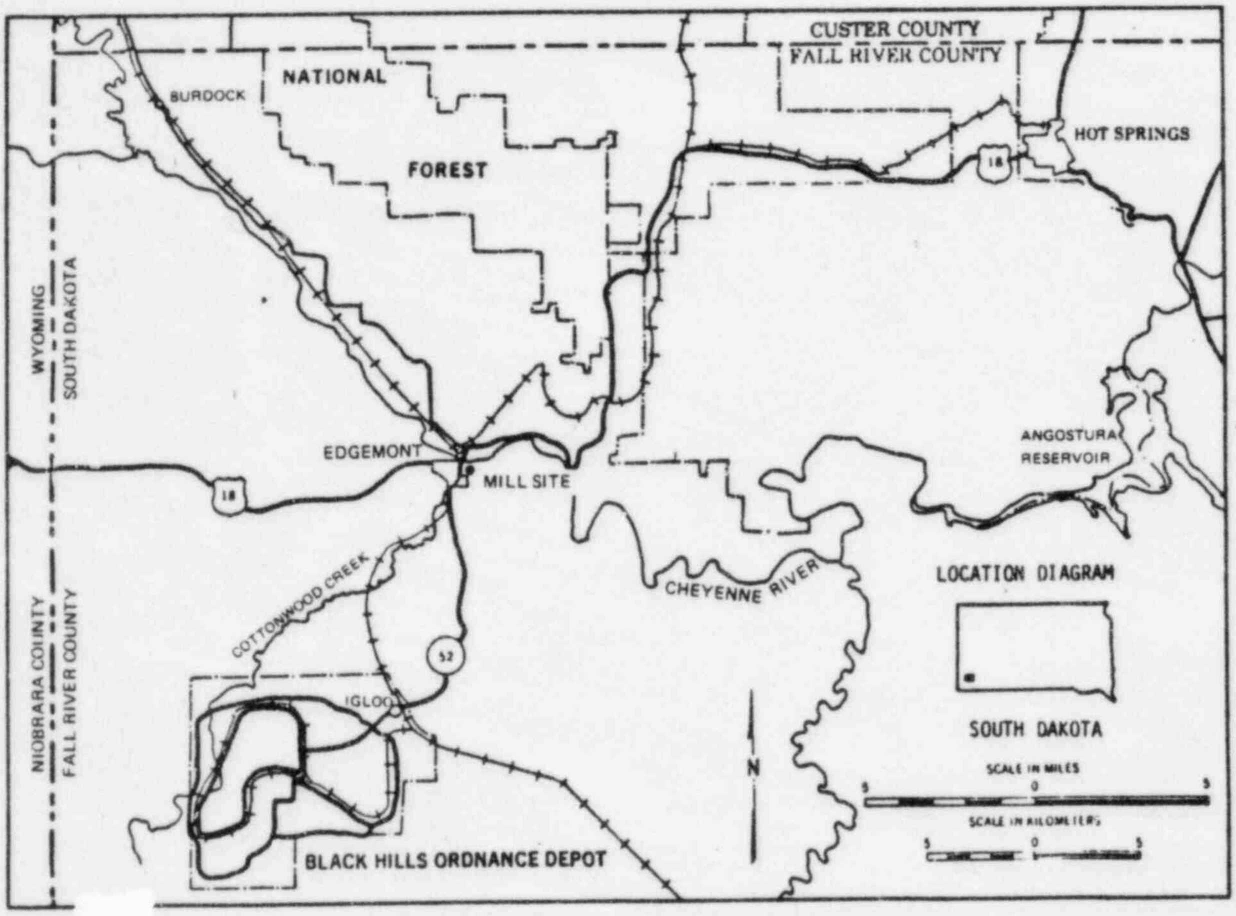

ɜ.1. The regional location of the Edgemont mill site. Source: ER, Fig. 2.1-1.

markets — unemployment rates are low (Sect. 3.4.2) — indicating that population levels would be highly correlated with variations in employment opportunities. These communities are, therefore, very susceptible to the "boom/bust" syndrome; that is, an influx or outflow of any important industry significantly alters employment and, consequently, population trends. Populations have fluctuated dramatically in the past. For example, Edgemont, although experiencing a boom-town growth pattern in the 1970s when population doubled because of expanding energy-related development in and around its boundaries, had previously undergone almost the same sudden increase in the 1950s and an equally precipitous decline by the end of the following decade[13] (Table 3.4). This abrupt reversal in the 1960s was caused primarily by the closing in 1968 of the Black Hills Army Ammunitions Depot in Igloo. This closing caused "serious social and economic disruption, high unemployment, and high outmigration [sic]" (ref. 12, p. 3). Additionally, Edgemont's population decreased significantly in 1980 (from about 2000 to 1500) caused by a decrease in railroad-related employment. Hot Springs's population has fluctuated also, but not as severely as Edgemont's (Table 3.4).

The conclusion from the above observations is that historical trends are not very helpful in predicting the future populations of Hot Springs and Edgemont. However, population projections have been developed (Table 3.5). These forecasts, which are based on known industrial commitments, assume that a large influx of industry will occur in the early 1980s and will result in steep, rapid population expansions. After reviewing these projections, the staff has concluded that although the projections are necessarily inexact, they adequately gauge potential trends; that is, for example, Edgemont's population could conceivably more than double by the mid-1980s.

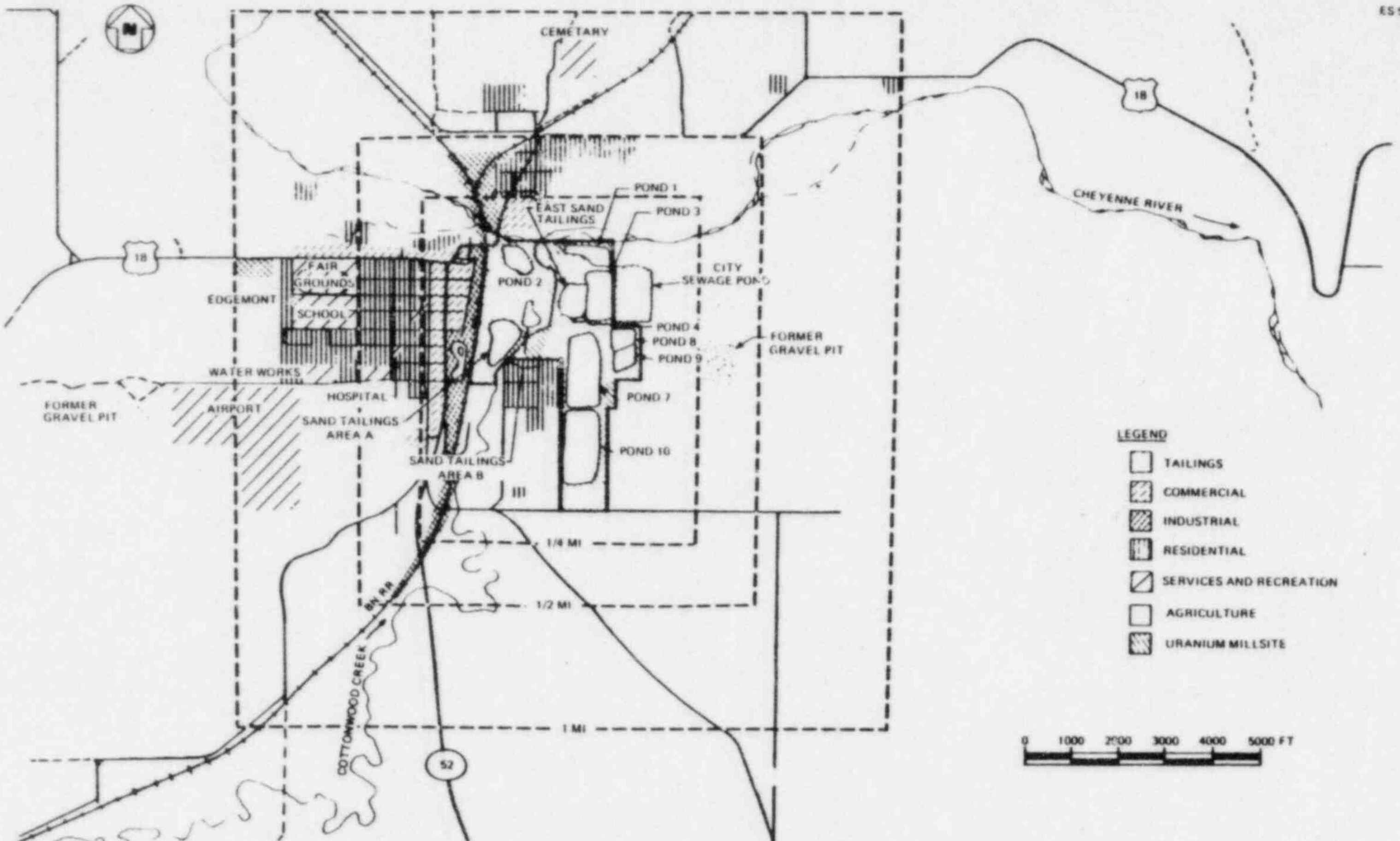

Fig. 3.2. Land use in the Edgemont area. Source: Ford, Bacon & Davis Utah Inc., *Engineering Assessment of Inactive Uranium Mill Tailings, Edgemont Site, Edgemont, South Dakota*, prepared for U.S. Nuclear Regulatory Commission, May 1978, Fig. 4.3.

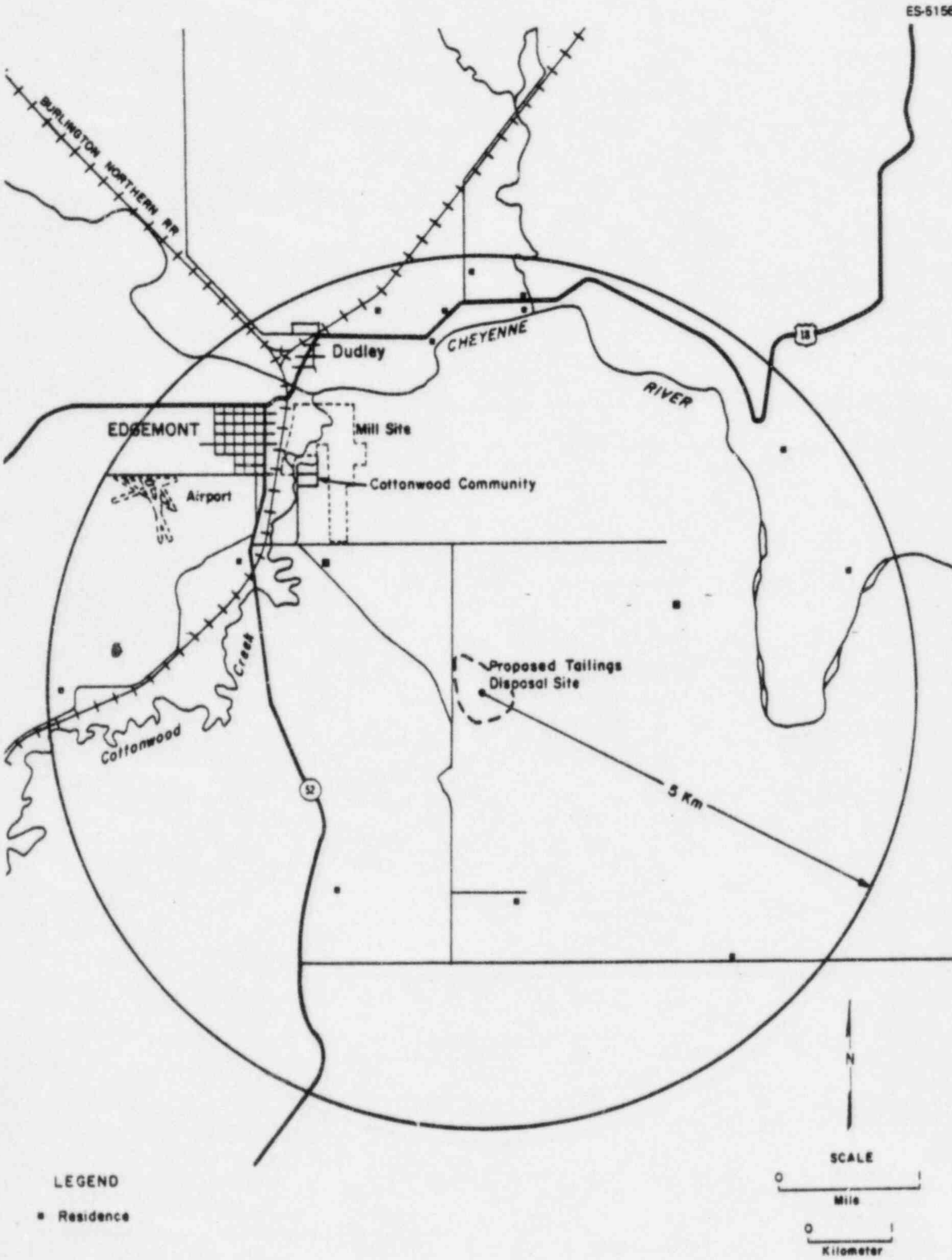

Fig. 3.3. Location of proposed tailings isposal site and Edgemont mill. Source: ER, Fig. 3.3-1.

Table 3.4. Historical population levels and trends for Hot Springs, Edgemont, and Fall River County

Year	Edgemont		Hot Springs		Fall River County	
	Population	Percentage change	Population	Percentage change	Population	Percentage change
1940	1002[a]					
1950	1185[b]	+18	5030[c]			
1960	1772[b]	+50	4943[c]	−2		
1970	1174[b]	−34	4434[c]	−10		
1973			4561[c]	+3	8100[d]	
1975	1800[a] 2000[b]	+38[e]	4670[c]	+2	8000[d]	−1
1976			4797[f]	+3	8300[d]	+4
1977			4759[g]	−1	8344[g] 8700[d]	+3[e]
1979	2200[f]		5000[f]	+5		
1980	1471[h]		4731[h]		8431[h]	

[a]Undated document prepared by John Krueger, Edgemont City Planner; original source, U.S. Census Bureau.

[b]Sixth District Council of Local Governments, "Edgemont Recreation Assessment," Rapid City, S.D., April 1979; original source, U.S. Census Bureau.

[c]Sixth District Council of Local Governments, "Hot Springs Outdoor Recreation Assessment," Rapid City, S.D., March 1979; original source, U.S. Census Bureau.

[d]Computerized tabulation entitled "Personal Income By Major Sources 1972–1977," a component of the Regional Economic Analysis, prepared by the Bureau of Economic Analysis, April 1979.

[e]Percent change calculated by taking the average of the population estimates and comparing this composite to the previous population estimates.

[f]Sixth District Council of Local Governments, "Fall River County 601 Designation Application," Appendix B Rapid City, S.D., June 18, 1979. The original source for the 1979 Edgemont estimate was John Krueger, Edgemont City Planner. The 1976 Hot Springs estimate was derived from a special 1976 U.S. Census tabulation; the 1979 estimate was based on this 1976 figure.

[g]Catherine O'Brien, Bureau of the Census, personal communication.

[h]John Ray, Bureau of the Census, personal communication (1980 census data).

Table 3.5. Population projections for Edgemont and Hot Springs[a]

Year	Edgemont			Hot Springs
	Low	Medium	High	
1982	3388[c]	5102[d]	5700[e]	7374,[d] 7504[b]
1984	4070[c]	4289[c]	4725[c]	
1987	3750[c]	4200[c]	5375[c]	
1990	3600[c]	4000[c]	4950,[c] 5700[e]	8041[b]
1995	3600[c]	4000[c]	4500[c]	
2000	3600[c]	4000[c]	4500,[c] 5700[e]	8637[b]

[a]The wide variations in projections are indicative of the difficulties encountered when dynamic economic conditions have been and continue to be prevalent in a region.

[b]Sixth District Council of Local Governments, "Hot Springs Outdoor Recreation Assessment," Rapid City, S.D., March 1979.

[c]Undated document prepared by John Krueger, Edgemont City Planner.

[d]Sixth District Council of Local Governments, "Fall River County 601 Designation Application," June 18, 1979.

[e]Sixth District Council of Local Governments, "Edgemont Recreation Assessment," April 1979; original source, *Public Service and Community Facility Impact Analysis – Fall River County, 1978*, prepared by the same agency. The 1990 and 2000 projections are based on a stable operational employment level of various energy related industries.

3.4.2 Housing

During the late 1960s and early 1970s, a severe housing surplus existed in Fall River County. The 1970 housing census indicated that

> the housing stock of Fall River County . . . was quite large relative to demand. A large number of units were standing empty, a situation which had persisted for some time and resulted in few new homes being built. [From 1962 to 1976, only three houses were built in Edgemont.] . . . [L]ow rents and resale values resulting from the oversupply [apparently tended] . . . to discourage maintenance and improvements. Thus, although a relatively large stock of housing was present, it was aging and its quality was an important and increasing problem. (ref. 12, Appendix F, p. 3)

The housing surplus during this period was caused by out-migration brought about by declining employment opportunities (Sect. 3.4.1). However, in the last five years the housing market has considerably tightened. A housing boom is already occurring because of current energy developments; for example, the county's stock of housing and mobile homes increased by 323 and 336, respectively, from 1970 to 1978, an increase of 10% and 188%, respectively.[12] Therefore, as is usually the case for low-population-density areas that are experiencing rapid development of energy resources, the housing of potential in-migrants may be a critical problem in Edgemont and Hot Springs. Although projecting housing needs is tenuous at best, possibly acute housing shortages may occur in Edgemont and Hot Springs as the population of the county increases during the 1980s. Because the cost of building and financing individual permanent housing units has increased dramatically in recent years, it is anticipated that the housing demand will be for mobile and modular homes and rental properties.[12]

Based on staff discussions with local officials, the status of and the barriers to housing development in Edgemont and Hot Springs are as follows.

3.4.2.1 Edgemont

As of March 1981, there were 486 residential units in Edgemont: 158 renter-occupied and 328 owner-occupied units. Seventy-two multifamily rental dwellings were available (19 of these were vacant), and 45 single-family units were vacant. These relatively high vacancy rates contrast sharply with the near-zero rates recorded in early 1980 and are a result of the population decrease that occurred in 1980. From 1977 to 1979, the following units were added to the housing inventory: 45 houses (none constructed in 1980), 45 apartments (20 constructed in 1980), a 25-unit trailer park, and 26 older homes (for purchase or rent). One local developer has opened an 8.1-ha (20-acre) planned residential development for single-family and multifamily dwellings, only 3.3 ha (8 acres) of which have been developed.

3.4.2.2 Hot Springs

The Hot Springs housing inventory, as of June 1979, is summarized in Table 3.6. Although the present recession and rapidly increasing interest rates temporarily increased vacancies in permanent housing and brought construction to a standstill during the first months of 1980, the Hot Springs housing market is expected to be expanded but still strained in the early 1980s. Rental properties especially are expected to be in short supply, although several apartment complexes have been completed recently, and the Century House (Evans Hotel) is being restored to provide 85 units of low-income housing for the elderly.[14] The 1970 housing census indicated that there were 1042 people living in group quarters in Hot Springs. Most of these resided in the local Federal and State medical care facilities (Sect. 3.4.4).[15] Vacant lots are available for additional housing; however, individual building lots are not available for placement of mobile homes because community regulations restrict mobile homes to approved mobile home parks.

3.4.3 Employment

Compared with national figures, the unemployment rates in Fall River County and elsewhere in South Dakota have been very low; for example, the 1979 annual average unemployment rates were, for the county and the State, respectively, only 2.0 and 2.7%. By comparison, the national rate

Table 3.6. Housing inventories for Hot Springs

Housing types	Hot Springs[a]
Residential	
Permanent (single family)	1063
Temporary (mobile homes)	125
Other (multifamily dwellings)	305
Commercial	

[a]Sixth District Council of Local Governments, "Fall River County 601 Designation Applications," Rapid City, S.D., June 18, 1979.

was ~6.0%.[16] The 1978 rate of 1.5% for the county was even lower, and the 1978 State rate of 3.1% was the second lowest recorded (only the Nebraska rate was less). By February 1980, however, the county unemployment rolls had increased to such an extent that 4.1% of the labor force was actively seeking work; by January 1980, the State rate had climbed to 4.2%. Although higher, these percentages are still considerably below the 6 to 8% being currently reported by a recessionary national economy.

County ment estimates for several job categories are presented in Table 3.7. A large perc the work force (35% in 1977) is government employees. In 1977, about half of the govern. ployees worked for the Federal government; the other half were employed by State and loca. governments. Of the approximately 16% of the work force agriculturally employed in 1977, more than 60% were proprietors. Retail trade and services employment ranked third and fourth, respectively.

Table 3.7. Full- and part-time employment by type and by industrial classifications for Fall River County (1972 and 1977)

Job description	Employment levels		Total employment (%)		Percentage change 1972–1977
	1972	1977	1972	1977	
Proprietors					
Farm	353	339	11.4	9.7	−4.0
Nonfarm	294	323	9.5	9.2	+9.9
Total	647	662	20.9	18.9	+2.3
Wage and salary employees					
Farm	174	204	5.6	5.8	+17.2
Nonfarm	2268	2633	73.4	75.3	+16.1
Mining	94	97	3.0	2.8	+3.2
Construction	15	149	0.0	4.3	+893
Manufacturing	90	84	2.9	2.4	−6.7
Transportation and public utilities	122	134	3.9	3.8	+9.8
Wholesale trade	19	25	1.0	1.0	+31.6
Retail trade	322	495	10.4	14.1	+53.7
Finance, insurance, and real estate	57	79	2.0	2.3	+38.6
Services	331	335	10.7	9.6	+1.2
Government	1218	1235	39.4	35.3	+1.4
Total	2442	2837	79.1	81.1	+16.2
Total employment	3089	3499	100.0	100.0	+13.3

Source: Computerized tabulation entitled "Employment By Type and Broad Industrial Sources," prepared as part of the Regional Economic Information System, Bureau of Economic Analysis, April 1979.

3.4.4 Economics

3.4.4.1 Overview of the regional economy

For decades, the economy of Fall River County, which was originally settled by homesteaders after the discovery of gold in the Black Hills, has been based (1) on transportation (essentially the Burlington-Northern Railroad), (2) on agricultural activities (ranching and farming), and (3) on the extraction of mineral resources (primarily uranium).[17] As discussed in Sect. 3.4.3, the government employs the largest percentage of the county's work force. Also, because of the proximity to several tourist attractions, tourism is also a major source of income.

Edgemont was founded as a railroad town, and its economy is still heavily dependent on the activities of the Burlington-Northern Railroad. Sheep raising has traditionally been an important industry in the vicinity of Edgemont; however, farmers have recently been switching to cattle.[17] Lignite was mined near Edgemont until the 1930s; and, in the 1950s, uranium mining and milling significantly boosted the local economy.[12]

Tourism, agriculture, and governmentally sponsored medical services form the economic base for Hot Springs. The Veterans Administration Medical Center in Hot Springs, the largest veterans hospital complex in the State, had 449 full-time, 52 part-time, and 47 other employees (consultants) on its payroll as of Mar. 30, 1979. The center's 1979 budget was nearly $12 million, of which about $9 million was designated for salaries and the rest for supplies and services.[14] Additionally, the State Veterans Home employed about 106 persons (99 full time) and had an operating budget of almost $1.5 million. [A commercial hospital and privately operated intermediate-care nursing home are also located in Hot Springs and together employed about 90 persons in 1979.[14]]

Primarily because of an expectedly large and rapid influx of energy-related industry, the economies of Edgemont and Hot Springs and, therefore, the county are predicted to prosper as manifold expansions in employment and population occur.

3.4.4.2 Income

Comparative descriptive statistics indicate that, although increasing steadily through time, the personal per capita incomes of residents of South Dakota and Fall River County have consistently lagged behind national averages (Table 3.8). For example, average per capita earnings in South Dakota were estimated to be $6841 in 1978, 14.9% above that recorded in 1977, and 37% better than that calculated for 1975.[18] However, when compared with the nation and with other states, South Dakota has ranked in the lower fourth. The national average was $7810 in 1978, placing the State 35th among all the states, a marginally better showing than in 1975 and in 1970 when the State ranked 37th and 40th, respectively. While slightly higher than that of South Dakota, the per capita income of the county has increased along with that of the State.

Estimated average annual earnings for Fall River County for several job categories are summarized in Table 3.9. Except for the possibly inflated figures for construction, the results are as anticipated. As expected, farm earnings fluctuated erratically from year to year; and mining, transportation, and utilities have consistently been relatively high-paying industries.

3.4.4.3 Finance and taxes

Two banks and one savings and loan company are located in Hot Springs with total assets of $762 million and $165 million, respectively, as of December 31, 1978.[14] Edgemont has one bank but no savings and loan institution. The primary source of income for the county and the municipalities is property taxes. Relevant tax and spending statistics for these entities are summarized in Table 3.10.

3.4.4.4 Community services and public facilities

As in most relatively lightly populated regions where development of mineral resources is expanding rapidly, the two largest cities of Fall River County, Edgemont and Hot Springs, are experiencing and will continue to experience some difficulties in meeting community service

Table 3.8. Per capita personal income for the United States, South Dakota, and Fall River County (1960–1978) and percentage change (1972–1977)

Year	Income (current $)[a]		
	United States	South Dakota	Fall River County
1960	2201[b]	1758[b]	
1970	3893[b]	3108[b]	
1972	4493	3847	3984
1973	4980	4948	5135
1974	5428	4753	4793
1975	5861	4995	5693
1976	6397	5043	6203
1977	7026	5953	5400
1978	7810[b]	6841[b]	
	Percentage change		
1972–1977	56.4	77.8	35.5

[a]Sixth District Council of Local Governments, "Public Investment Plan, Fifth Stage," Rapid City, S.D., June 1979. All estimates are in current dollars; that is, inflationary trends have not been accounted for.

[b]U.S. Bureau of the Census, *Statistical Abstract of the United States*, 100th ed., U.S. Government Printing Office, Washington, D.C., 1979, Table 730, p. 446.

Table 3.9. Estimated annual income per labor force participant by job type and industry for Fall River County, 1972 and 1977[a]

Job categories	1972	1977	Percentage change
Proprietor earnings			
Farm	16,966	−3,572	−121
Nonfarm	7,602	10,437	37
Employee earnings			
Mining	8,681	13,959	61
Construction	54,400[b]	19,128[b]	−65
Manufacturing	8,067	10,869	35
Transportation and public utilities	10,697	17,724	66
Wholesale trade	8,684	11,840	36
Retail trade	6,571	7,378	12
Finance, insurance, and real estate	8,000	11,772	47
Government	7,142	10,173	42

[a]These estimates were developed by dividing the total reported personal income for each job category by the total employees recorded for each classification. The income figures are from, respectively, computerized tables entitled "Personal Income By Major Sources 1972–1977" and "Employment By Type and Broad Industrial Sources 1972–1977," prepared by the Bureau of Economic Analysis as part of its Regional Economic Information System.

[b]Because these income estimates seem exorbitantly high, the staff believes that either the employee estimates are understated or the incomes reported are biased upward.

Table 3.10. Recent property valuations, mill levies, and budgets for Fall River County, Hot Springs, and Edgemont

	Fall River County	Hot Springs	Edgemont
Approximate property market valuations,[a] $			
1979	95,994,000	26,139,000	10,527,910
1978	89,178,000	23,661,000	8,028,00
1978 mill levies[a]			
Nonschool	18.89[b]	32.45	25.30
School			
Nonagriculture		49.11	49.02
Agriculture		33.11	33.02
Total city budgets,[c] $			
1975		1,138,086 (385,106)[d]	182,425
1976		1,319,600 (522,289)	224,550
1977		1,335,891 (599,370)	266,317
1978		2,425,056 (1,661,744)	279,300
1979		1,760,188 (937,588)	258,650

[a] Earl Fisher, Tax Assessor, personal communication, October 24, 1979.

[b] Levy for areas *not* in Hot Springs and Edgemont. The levy for these municipalities is 18.84.

[c] Sixth District Council of Local Governments, "Hot Springs Outdoor Recreation Assessment," Rapid City, S.D., March 1979; and "Edgemont Recreation Assessment," Rapid City, S.D. April 1979.

[d] Amounts within parentheses are the self-supporting portions of the budgets.

requirements. To forecast accurately their needs for additional facilities is difficult. Whereas a large industrial development could produce a need for expanded facilities and staff, the unexpected phasing out of another source of employment could relax facility requirements.

Education

The Hot Springs Independent School District (No. 23-2) encompasses about 1660 km^2 (640 sq miles), of which about 440 km^2 (170 sq miles) are in Custer County, and includes Hot Springs, the two small population centers of Buffalo Gap and Oral, and the rural areas around Hot Springs.[14] Statistics for the Hot Springs district are in Table 3.11. As of April 1981, some crowding existed at the Hot Springs elementary school: three classes were in modular classrooms (B. Lynch, Business Manager, Hot Springs School District, telephone conversation with S. Martin, Apr. 1, 1981).

Table 3.11. Hot springs school district statistics as of September 1980

Expenditures per pupil ~$1933

	Number	Enrollments	Full-time equivalency staff
High school grades 9–12	1	318	22.8
Middle school grades 6–8	1	237	14.5
Elementary school grades K–5			
Hot Springs	1	435	21.5
Maitland	1	5	1
Buffalo Gap	1	23	2
Oral	1	23	2
Totals	4	486	26.5
Special education		14	3

The Edgemont District (No. 23-1) serves all but the eastern part of Fall River County. Edgemont has consolidated all schools at one location. The average grade size is about 35, and the district hired a special education instructor for the 1980-1981 school year (S. Doerr, Edgemont School District Superintendent, personal communication, Apr. 2, 1981). Enrollment and teacher statistics are summarized in Table 3.12.

Table 3.12. Edgemont school district statistics as of March 16, 1981

Expenditures per pupil, ~$1270.

	Enrollments	Full-time equivalency staff
High school grades 9–12	129	8.2
Grades 4–8	167	7.4
Grades K–3	169	7.4

Medical services

In the past, access to medical personnel and facilities has been poor for residents in the Edgemont area because there were no resident medical doctors, dentists, optometrists, or hospital facilities. To obtain care, some residents traveled as far as New Castle, Wyoming, 107 km (67 miles) distant. However, this situation considerbly improved during 1980. A formerly vacant hospital in Edgemont is now used for outpatient medical (including emergency) treatment. Edgemont now has a resident dentist and a resident physician's assistant; also a physician from Custer, South Dakota, and a physician from Lusk, Wyoming, commute to Edgemont once a week. A pediatrician from Rapid City provides bimonthly services, and an optometrist and two mental health counselors provide their services once a week (J. Krueger, Edgemont City Planner, personal communication, Apr. 2, 1981). The local volunteer fire department has one ambulance and provides emergency service for Edgemont and the western portion of Fall River County.

Although there are extensive Federal facilities in Hot Springs, only one civilian hospital, the Southern Hills General Hospital, is in the area. This 50-bed, short-term facility is also in Hot Springs and has a low occupancy rate of about 30%. This rate is misleading because 25 beds are actively being utilized (M. S. Flesner, Assistant Administrator, Southern Hills General Hospital, personal communication, Apr. 2, 1981). The hospital staff consists of four full-time physicians, a courtesy staff of 21 specialists who commute from Rapid City, and an active auxiliary of community volunteers. The hospital has a shared service contract with the veterans hospital for such therapy as ultrasound and nuclear medicine (M. S. Flesner, Assistant Administrator, Southern Hills General Hospital, personal communication, Apr. 2, 1981). Attached to the hospital is a 50-bed, intermediate-care nursing home. Both the hospital and the nursing home are privately owned and operated by the Lutheran Hospitals and Homes Society. Also four general practitioners (one is a surgeon), two dentists, and two optometrists are in Hot Springs.

Fire and police protection

The Edgemont police force consists of four full-time patrolmen, two dispatchers, and two patrol cars; the county sheriff's department protects the noncity areas in the vicinity. Fire protection is provided by a 40-member volunteer fire department. Its basic fire-fighting equipment consists of two 1900-L/min (500-gpm) pumpers; a 3800-L (1000-gal), 946-L/min (250-gpm) pumper for rural service; two four-wheel drive, 946-L capacity (250-gal) trucks for grass fires; a 7600-L (2000-gal) tanker and 1100-L/min (300-gpm) high-pressure pump for rural fires; a salvage truck with smoke extractor; and a portable electric generator (R. V. Bossche, Chief, Edgemont Volunteer Fire Department, personal communication, Mar. 24, 1980). The department also has an emergency ambulance. The fire insurance rating for Edgemont is eight on a scale of one (best) to ten (worst).

The Hot Springs Police Department has a paid staff of six officers, a two-man reserve, and two patrol cars; dispatchers are shared by the city and the county sheriff's department. The volunteer fire department is headed by a chief and two assistants and has a staff of about 50 (H. Walker, Chief, Hot Springs Volunteer Fire Department, personal communication, Mar. 24, 1980). The department's equipment is similar to that of Edgemont and includes an emergency ambulance. Fire insurance classification for Hot Springs is seven.

Water supply systems

Edgemont's water is obtained from five deep free-flowing wells. The maximum pumping capacity is $\sim 3.8 \times 10^6$ L/d (10^6 gpd). The average daily usage varies according to population changes. In 1979, when Edgemont's population was about 2000, the average usage was about 1.9×10^6 L/d (5×10^5 gpd). The population declined in 1980 to about 1500; therefore, the average usage has probably decreased to about 1.5×10^6 L/d (4×10^5 gpd). Because the filtering capacity of the system is limited to $\sim 1.9 \times 10^6$ L/d (5×10^5 gpd), peak summer demands, which have been as high as 3.8×10^6 L/d, are difficult to satisfy without imposing restrictions and/or bypassing the filter system. Restrictions have been imposed in the past, and residents have cooperated in decreasing their consumption during specified time periods. About $260,000 was spent from funds provided by a Local Public Works Grant to finish a partially completed storage reservoir that has a capacity of about 10.4×10^6 L (2.75×10^6 gal) and will also serve as a cooling pond to lessen the adverse heat effects on the distribution system. [The water is very hot — 53°C (128°F) — and is high in minerals, which damage water mains and valves.] Housing and Urban Development Community Block Grants totaling $350,000 have been used for the last three years to upgrade distribution lines. An application for additional funds for this purpose through the Federally sponsored 601 Energy Impact Assistance Program was recently rejected. According to J. Krueger, Edgemont City Planner (personal communication, Apr. 2, 1981), Edgemont's water system, which has been improved during the last few years, is adequate for a population of about 1500. However, if the population increases beyond 1500, then the system may become strained, shifting improvement timetables. For example, some of the wells would have to be recased sooner than would be necessary with a population less than or equal to 1500.

The Hot Springs water system, which is city-owned and -operated, was purchased from the Hot Springs Water Company in 1975.[14] Water supplying the system comes from springs 4.0 km (2.5 miles) northwest of the city. The storage and pumping capacity are adequate for a population of about 6500; however, the system, like that of Edgemont, is severely limited by an old, undersized distribution network. Approximately $1.7 million ($1.25 million from revenue bonding) was recently used to construct a concrete storage facility with a capacity of 7.6×10^6 L (2×10^6 gal), construct a booster pump station, and renovate 4.8 km (3 miles) of distribution line. These projects were completed in 1978. In 1979, using about $200,000 of a Housing and Urban Development (HUD) block grant, new water mains were installed in the Coldbrook neighborhood. In 1980, a main north-south distribution line was installed in the business district. This installation cost ~$700,000 and was funded via special assessment bonds (J. Scheltens, Hot Springs City Engineer, personal communication, Apr. 30, 1980).

Sewage

Edgemont's collection, discharge, and wastewater treatment facilities are adequate for a population of 1500. However, the wastewater treatment facility, a stabilization lagoon, is designed for a population of 1500 and would therefore be undersized if Edgemont's population increases. Additionally, the lagoon does not meet the requirements established for a National Pollutant

Discharge Elimination System (NPDES) permit. The city has purchased land adjacent to the existing lagoon to be used for future wastewater treatment facility expansions: sufficient land is available for a facility sized to treat the sewage for a population up to ~6500. Edgemont has been mandated by EPA to expand the lagoon to a size sufficient for a population of 1800 by 1985 to satisfy NPDES requirements. Therefore, the city plans to add an additional cell by 1985. As the population increases beyond 1800, additional cells will be added (J. Krueger, Edgemont City Planner, personal communication, Apr. 2, 1981).

The Hot Springs wastewater treatment facilities are old and inadequate: a portion of the city is still using septic tanks. Plans for upgrading the system were funded and approved. However, because of unanticipated short-term increases in demand caused by currently expected energy-related expansions in employment and population, EPA has approved the commencement of a reevaluation study (J. Scheltens, Hot Springs City Engineer, personal communication, Apr. 3, 1981).

Solid waste

Both Hot Springs and Edgemont collect solid wastes and use landfills for disposal.

Transportation

U.S. Highway 18 and State Highway 52 are the major roads to Edgemont. Highway 18, the primary link between Edgemont and Hot Springs, is currently being upgraded in the Edgemont area. International Parks Highway 385 also passes through Hot Springs, providing a north-south route. Continental Trailways and the Burlington-Northern Railroad provide, respectively, bus and rail service for both Edgemont and Hot Springs. Continental Trailways offers direct connections northward to Rapid City via Custer and southward to Lusk and Cheyenne, Wyoming, and to Denver, Colorado. The Omaha-Rapid City bus line also serves Hot Springs, providing one bus north and south each day to Chadron, Nebraska, and then east to Omaha. No commercial airlines serve Hot Springs or Edgemont. The nearest airport providing commercial service is at Rapid City. Both Hot Springs and Edgemont have municipal airports capable of handling small aircraft. The Edgemont airport has a sod runway. The Hot Springs airport has a 1370-m (4500-ft) asphalt runway, a 1160-m (3800-ft) sod runway, and two hangars equipped to provide fuel.

Utilities

The Black Hills Power and Light Company and the Peoples Telephone and Telegraph Company supply, respectively, electrical power and telephone service for both Edgemont and Hot Springs.

Recreation

Edgemont has two major recreational areas, a municipal park and a school/fairground complex (a park platted in Cottonwood has never been developed).[13] The municipal park has a small fishing pond, picnic facilities, and playground equipment. The school/fairground complex consists of a playground, indoor recreational facilities, the city's only ballfield, a tennis court, and an outdoor basketball court located on the school grounds. In addition, a privately owned swimming pool is available for public use. The fairgrounds are used primarily for an annual fair. Because Edgemont's park and recreation system is limited, the city has expanded its budget for improvements to be made during the next five years.[13]

Table 3.13 contains an inventory of the outdoor recreational facilities in and around Hot Springs [within a 24-km (15-mile) radius] and includes Evans Plunge, a privately run indoor pool fed by several local warmwater springs.[14]

From a regional perspective, tourism and hunting (primarily for antelope, mule deer, and turkey) are major activities. Outstanding tourist attractions include the Black Hills National Forest, Buffalo Gap and Thunder Basin National Grasslands, Wind Cave National Park, Jewel Cave National Monument, Mount Rushmore National Memorial, Custer State Park, and the Angostura Recreation Area.

Table 3.13. Hot Springs outdoor recreation areas

Area	Size (ha)	Size (acres)	Description
Municipal parks			
Butler Park	12	29	Playground equipment, 4 rest rooms, 3 tennis courts, 2 outdoor basketball courts, and 1 lighted and 2 unlighted softball fields
Cold Brook Park	0.4	1	No facilities
Riverside Park	0.6	1.5	Playground equipment and picnic tables
Centinnial Park	0.6	1.5	Green area with lighted fountain and parking
Chautauqua Park	3	8	Picnic area with picnic tables, running water, and fire boxes
Kidney Springs Park	0.2	0.5	Green area with restored gazebo
Southern Hills Golf Course	36	88	Nine-hole, irrigated, grass-green course
Veterans Administration Medical Center Park	0.8	2	One baseball diamond
School system			
Hot Springs High School and Middle School	6	15	Lighted football field, cinder track, two tennis courts, and gym
Hot Springs Elementary School	2.4	6	Playground equipment
Private facilities			
Evans Plunge			Indoor swimming facility with hot spring water
Hot Springs 24-km (15-mile) recreational areas			
Cold Brook Reservoir			Fishing, camping, hiking, and boating
Fall River Archery Club			Archery range
Cottonwood Springs Creek Dam			Picnicking, camping, playground, and hiking
Hot Springs Gun Club			Trap range
Angostura State Recreation Area			Picnicking, camping, fishing, swimming, boating, and water skiing
Cascade Springs			Picnicking, fishing, and swimming
Larive Lake			Swimming and camping
Wind Cave National Park			Hiking

Source: Sixth District Council of Local Governments, "Hot Springs Outdoor Recreation Facilities," Rapid City, S.D., March 1979.

3.5 LAND

3.5.1 Land use

The principal land use in Fall River County is rangeland (85%). The remainder consists mostly of forest (11%) and cropland (3%). Although sheep grazing is important in some areas, rangeland is used predominantly by cattle. Generally, from 2.7 to 3.9 ha (6.6 to 9.5 acres) are required to support one cow or five sheep for one month per year in grasslands; and from 4.1 to 5.1 ha (10 to 12.5 acres), in pine forests (ER, Sect. 4.6.1.1). Range condition in the vicinity of the project area is generally good, but intensive grazing does occur in some areas, particularly near water. Crop production is usually limited to native hay, alfalfa, or grain. Hay crops generally yield less than 3.4 MT/ha (1.5 tons/acre), and wheat crops usually yield less than 3 m^3/ha (35 bu/acre) (ER, Sect. 4.6.1.1.1). Other crops occasionally grown in the county include irrigated corn, dry-land barley, and oats. None of the lands in the area are classified as prime or unique farmlands as defined by the Soil Conservation Service.[19]

The Tennessee Valley Authority (TVA), which controls mineral rights on 4.1×10^4 ha (1.01×10^5 acres) in Fall River and Custer counties, South Dakota, and in Weston and Niobrara counties, Wyoming, proposes to begin in the 1980s the mining of uranium/vanadium ore deposits at two sites within 24 km (15 miles) of Edgemont.[20] Both underground and surface mining methods will be used.

The existing mill complex, consisting of several tailings disposal areas and process buildings, has not operated since 1974. Presently, land use at the mill site has a nonuse status. The immediate surrounding land is used in a variety of ways. Cottonwood Community, a residential area, is located south of the site. The Burlington-Northern Railroad to the west forms a narrow industrial strip separating the mill from the commercial district of Edgemont. Except for the city sewage pond adjacent to the site, undeveloped land lies east of the site. The Cheyenne River parallels the northern boundary of the site. Farther north [0.37 km (0.25 mile)] is Dudley, another small residential area.

The proposed disposal site is used primarily for grazing. No structures are on the site, but a small [0.04-ha (0.1-acre)] stock-watering pond is located near the southern boundary. The nearest residence is about 2.4 km (1.5 miles) northwest of the site (ER, Sect. 4.3.1.1).

3.5.2 Historical, archaeological, and scenic areas

3.5.2.1 Historical

No sites currently listed in the National Register of Historic Places are located within the Edgemont Uranium Mill and proposed disposal site. Other than the marked location of the Cheyenne and Deadwood Stage, which passes adjacent to the Edgemont Uranium Mill, no Register sites are located near this facility and the disposal site. No sites or structures potentially eligible for addition to the Register were judged to exist within or immediately adjacent to the areas associated with this project.

3.5.2.2 Archaeological

Archaeological surveys were conducted for this decommissioning plan which took place on September 22 and November 16, 1978, and December 20, 1979, and were performed by a TVA staff archaeologist. These surveys were conducted in compliance with the National Historic Preservation Act (NHPA) of 1966, Executive Order 11593 of 1971, and other applicable legislation.

A file record search was initiated for previously known archaeological sites at the South Dakota Archaeological Research Center, Ft. Meade, South Dakota. A literature search was also conducted in the National Register of Historic Places for archaeologically significant sites. No previously recorded reported sites were discovered in either source of information.

The location of the mill site is at the confluence of Cottonwood Creek and the Cheyenne River. The major portion of this area is in the floodplain adjacent to these two permanent streams. This locality might have had a fairly high potential for prehistoric occupation. However, there has been prior disturbance that approaches total alteration of the original surface. The nature of this disturbance is in the form of the previously constructed settling ponds and tailings piles. As such, the potential for discovering undisturbed archaeological materials at this locality is essentially nonexistent.

The proposed disposal site occupies parts of the southwest one-fourth of Sect. 8 and northwest one-fourth of Sect. 17, T9S, R3E, plus small portions of Sects. 7 and 18, T9S, R3E. The approximate center of the area is 3200 m (approximately 2 miles) from the nearest point on the Cheyenne River and 2800 m (1.7 miles) from Cottonwood Creek. The disposal site is considered to have a low to moderate potential for supporting an archaeological site. A single isolated biface fragment was recorded for one of the ridges within the disposal site area. A no-effect determination has been granted for this property by the South Dakota State Historic Preservation Officer (J. J. Little, South Dakota Historic Preservation Officer, personal communication with M. D. Ramsey, TVA, Oct. 17, 1979). If archaeological remnants are discovered during site operations, TVA will be required to notify State and Federal authorities and protect the archaeological resources as instructed.

3.5.2.3 Scenic

No scenic or natural areas were identified on the disposal site. The only feature in the vicinity proposed for special scenic designation is Red Canyon–Fourmile Creek Drive extending from U.S. Highway 18 east of Edgemont to U.S. Highway 16 west of Custer. This road, located several miles from the site, is proposed by the South Dakota Department of Transportation for inclusion in the Federal scenic roads and parkways plan (ER, Sect. 4.3.2.1).

3.6 WATER

3.6.1 Surface water

3.6.1.1 Hydrology

All streams in the Edgemont area – most of which are ephemeral – flow into the Cheyenne River. Surface water features for the Edgemont decommissioning area, which is within the Cheyenne River watershed, are shown in Fig. 3.4. The mill site is on the Cheyenne River at the mouth of Cottonwood Creek. The Cheyenne River begins about 185 km (115 miles) west of Edgemont, flows from east to west along the northern boundary of the site, and drains an 18,500-km^2 (7140-sq-mile) area above Edgemont which includes portions of Wyoming, Nebraska, and South Dakota. The river course approximates the boundary between the Black Hills and the Missouri Plateau sections of the Great Plains Physiographic Province (ER, Sect. 4.2). About 54 km (34 miles) downstream from Edgemont, the Cheyenne River is impounded for irrigation and flood control by the Angostura Reservoir.

The average discharge of the Cheyenne River at the Edgemont station (Highway 18 bridge north of town) over a 35-year period was 2.8 m^3/s (97 cfs or 70,600 acre-ft/year), which is equivalent to 0.48 cm (0.19 in.) of annual runoff from the watershed.[21] The average annual flow for 20 water years (1949 through 1968) ranged from a minimum of 0.37 m^3/s (13 cfs) in 1961 to a maximum of 12.3 m^3/s (434 cfs) in 1962.[21] Sustained flow was recorded during only eight of the years from 1947 through 1977.[22] Flows of the Cheyenne River are influenced by many small reservoirs (9320 in 1965), which may have the potential for decreasing the future flow rate of the river (ER, Sect. 4.2).

During periods of high spring flow, the Cheyenne River channel is completely filled to a depth of 2 to 3 m (7 to 10 ft). Flooding may cause extensive scouring of substrata. During the summer and autumn, little or no flow occurs, and large quantities of silt may be deposited in the channel. At these times the stream channel is braided because debris on the floodplain causes flow in small, intermeshed channels. The State of South Dakota has classified the Cheyenne River as a warmwater, semipermanent, fish-life-propagating stream, which is characterized by riffle and pool habitats.

Cottonwood Creek, which flows through the mill site, drains an area of approximately 388 km^2 (150 sq miles). The stream channel in the vicinity of the mill site, tailings area A, and the east sandpile (Fig. 3.5) was straightened during mill operation. Because no historical flow records are available for Cottonwood Creek, the applicant determined flow characteristics of the stream by using techniques developed by the U.S. Geological Survey (USGS)[23,24] (Table 3.14). The average flow, which TVA estimated to be 0.065 m^3/s (2.3 cfs), is equivalent to an annual runoff of 0.53 cm (0.21 in.). The State of South Dakota has classified Cottonwood Creek as a perennial stream that exhibits fluctuations in flow. Although of lesser magnitude, fluctuations in streamflow of Cottonwood Creek are similar to those of the Cheyenne River. Like the Cheyenne River, Cottonwood Creek is characterized by riffle and pool habitats.

Mill site

The Cheyenne River channel in the vicinity of Edgemont is braided and has a broad floodplain. Flood stages can reach the level of the base of the tailings in ponds 1 and 2. The riverbed in the reach containing the tailings is at elevations between 1040 and 1041 m (3412 and 3416 ft) MSL. The base of the tailings in this reach is near 1044 m (3425 ft). A flow of 390 m^3/s (13,800 cfs), which is a 25-year flood equivalent, reaching an elevation of 1044 m (3425 ft) was recorded at Edgemont in 1971 (ER, Sect. 4.2). A flood on May 20, 1978, reached an elevation of 1044.8 m (3428.2 ft) at the USGS gage (Fig. 3.5) upstream of the mill site and a peak flow of 793 m^3/s (28,000 cfs). The highest recorded flood (May 1922) was 0.11 m (0.35 ft) higher

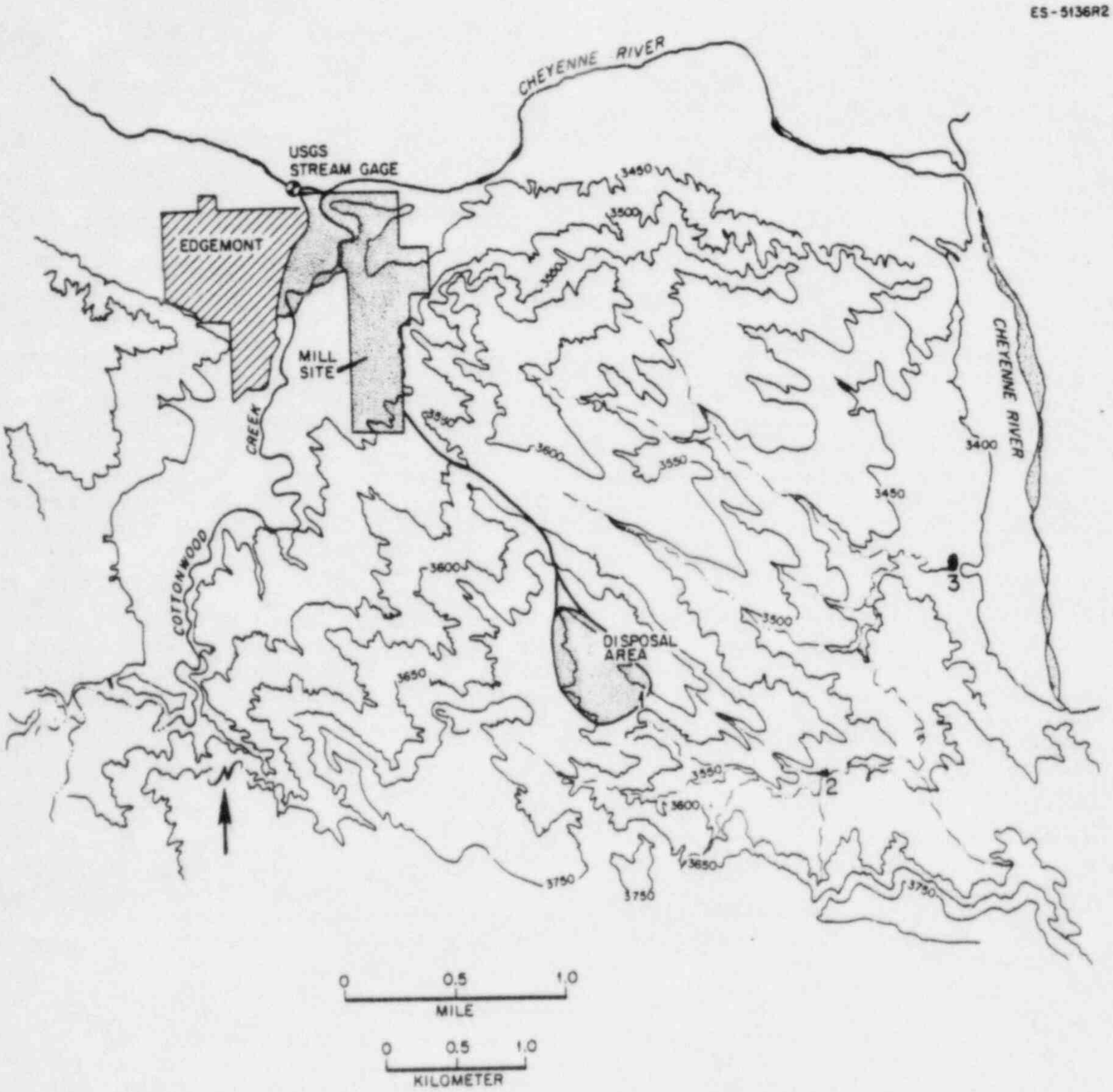

Fig. 3.4. Surface water features for the Edgemont decommissioning area. Single numbers correspond to ponds downstream of the disposal site that are discussed in the text. Source: Modified from ER, Fig. 4.2-1.

and near the 100-year flood level [900 m^3/s (31,800 cfs)] (ER, Sect. 4.2). An estimate of the 500-year flood on the Cheyenne River provided by the USGS indicates a discharge of 1775 m^3/s (62,700 cfs) would reach an elevation of about 1046 m (3432 ft) (ER, Sect. 4.2). A probable maximum flood of 5950 m^3/s (210,000 cfs) could reach an elevation of at least 1047 m (3435 ft) (Table 3.15).[17,25]

Cottonwood Creek, within the reach adjacent to the mine tailings, has cut through the Cheyenne River alluvium and upper bedrock to reach levels of 1041 to 1046 m (3414 to 3430 ft).[24] A theoretical USGS technique[6] was used to estimate 25- and 100-year flood levels for Cottonwood Creek. This technique yielded estimates of approximately 102 m^3/s (3600 cfs) for the 25-year flood and about 222 m^3/s (7850 cfs) for the 100-year flood. Water levels at the site for the

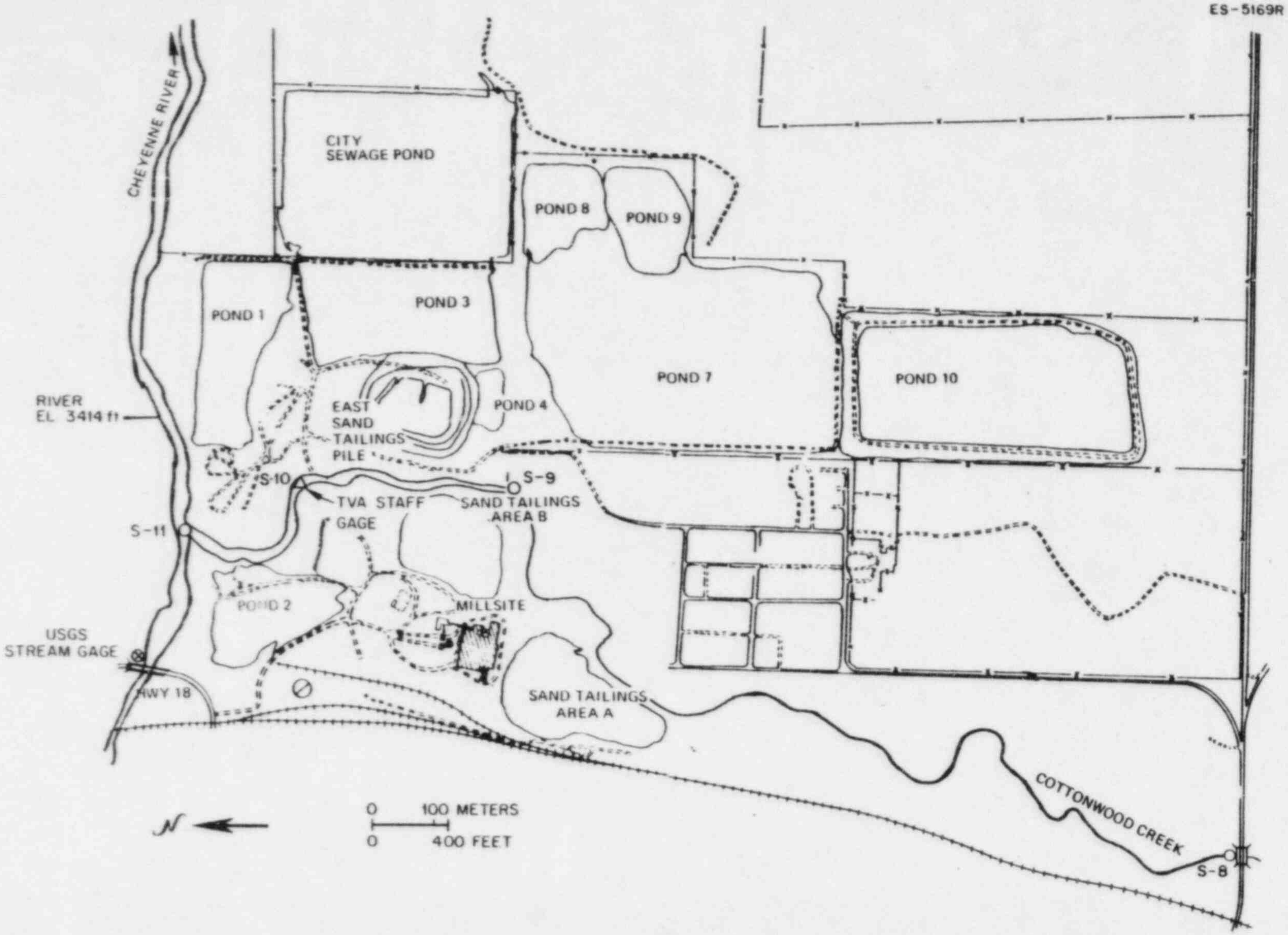

Fig. 3.5. Surface water features of the Edgemont mill site Source: ER, Fig. 4.2-2.

Table 3.14. Estimates of mean annual runoff – drainage area parameters[a] for watersheds above selected locations in the vicinity of the proposed disposal site for the Edgemont Uranium Mill

Selected location[b]	Drainage area		Maximum 24-hr – 2-year rainfall		Water content of snow, March 1–16, (25-year recurrence interval)[c]		Mean annual discharge					
	km²	miles²	cm	in.	cm	in.	m^3/sec	cfs	m^3	acre-ft	cm	in.
Edgemont Uranium Mill site												
Cottonwood Creek	388	150	4.8	1.9[d]	3.6	1.4	0.066	2.3	2.08×10^6	1,690	0.08	0.21
Cheyenne River	18,500	7,140					2.76	97.4	87.04×10^6	70,570	0.07	0.19
Disposal site												
Containment dike	0.52	0.2	4.8	1.9	3.6	1.4	0.00009	0.003	2.7×10^3	2.2	0.08	0.21
Pond near Cheyenne River	11.4	4.40	4.8	1.9	3.6	1.4	0.002	0.072	64.1×10^3	52	0.09	0.22

[a]Significant parameters based on regression analysis as defined by O. J. Larimer, *A Proposed Steamflow Data Program for South Dakota*, U.S. Geological Survey Open File Report, 1970.

[b]Refer to location maps (Figs. 3.4 and 3.5).

[c]Based on U.S. Weather Bureau Technical Paper No. 50 (1964).

[d]Based on U.S. Geological Survey stream gage records for the Cheyenne River at Edgemont Station.

Source: Modified from ER, Table 4.2-1.

Table 3.15. Flood peak discharge at selected locations in the vicinity of the proposed disposal site for the Edgemont Uranium Mill

Selected location[a]	Drainage		Discharge									
			2-year		10-year		100-year		50-year		Max. probable[b]	
	km^2	$miles^2$	m^3/s	cfs	m^3/s	cfs	m^3/s	cfs	m^3/s	cfs	m^3/s	cfs
Edgemont Uranium Mill site												
Cottonwood Creek	388	150	10.7	379	60.3	2,130	217	7,680	159	5,600	1,982	70,000
Cheyenne River	18,500	7,140	86.4	3,050	292	10,300	900	31,800	663	23,400	5,940	210,000
Disposal site												
Containment dike	0.52	0.2	0.28	10	2.5	90	10.8	380	7.4	260	102	3,600
Pond near Cheyenne River	11.4	4.40	1.6	55	11	300	44.5	1,570	31.4	1,110	424	15,000

[a] Refer to location maps (Figs. 3.4 and 3.5).
[b] Reconnaissance-level estimates only.
Source: ER, Table 4.2-2.

100-year flood should not exceed 1049 m (3440 ft) MSL.[17] Physical transport of tailings due to flooding of the Cheyenne River or Cottonwood Creek is possible.

The Cheyenne River and Cottonwood Creek are both gaining streams during most of the year; thus, they are, in part, recharged by unconfined groundwaters in the vicinity of Edgemont. Wells located within the floodplain are recharged by the flow of floodplain surface waters or by the entering groundwater.

Additional sources of surface flow at the site are from the (1) Edgemont secondary sewage treatment outfall line, which may be intermittent depending on system breakdown, (2) city wells, (3) mill fire safety tank, (4) potential seepage from tailings ponds on site, and (5) direct and ponded precipitation runoff. Runoff from an area of about 125.5 ha (310 acres) east of mill tailings ponds 7 through 10 contributes to standing water in the ponds.

Disposal site

The preferred disposal site (Fig. 3.4) is drained by an ephemeral, unnamed tributary of the Cheyenne River. The tributary ends in a man-made pond near the western edge of the river's floodplain at point 3 (Fig. 3.4). Another small man-made pond (Fig. 3.4, point 2) of about 0.1 ha (0.25 acre) is located approximately halfway between the disposal site and the Cheyenne River. A small stock pond of about 0.8 ha (2 acres), which is located at the southern limit of the disposal site (Fig. 3.4, point 1), is impounded by an earth dam about 64 m (210 ft) long, 4.6 m (15 ft) high, and 7.6 m (25 ft) wide at the crest.[25] Most of the runoff from the disposal site is probably contained by this pond. Any overflow from this pond not contained by ponds at points 2 and 3 (Fig. 3.4) could reach the Cheyenne River.[25] Runoff characteristics at points 1 and 2 (Fig. 3.4) are based on techniques developed by the Water Resources Division of the USGS[23,24,26] (Tables 3.14 and 3.15). Annual runoff for the disposal area, although variable, averages approximately 0.53 cm (0.21 in.). More than half the runoff generally occurs during May, June, and July as the result of snowmelt and heavy rainfall. The range of flood peak discharges that could be expected at selected locations in the vicinity of the preferred disposal site is indicated on Table 3.15. Watershed elevations for the disposal site range from about 1165 m (3820 ft) at the highest point on the western watershed divide to about 1091 m (3580 ft) near the proposed dike at the lower boundary of the disposal site (Fig. 3.4, point 1). The disposal site elevation is well above the projected elevation of the 500-year flood [1046 m (3432 ft)] (ER, Sect. 4.2).

3.6.1.2 Water quality

This section describes the nonradiological surface water-quality characteristics of streams affected by the decommissioning of the Edgemont mill.

Water quality in both the Cheyenne River and Cottonwood Creek is influenced by spring runoff and reduced flow during late summer and early fall. During the spring those constituents influenced by runoff, such as suspended solids, color, nutrients, and iron, are increased. During the late summer and early fall, streamflow is predominantly from groundwater that enters the streambed through seeps, springs, and flowing wells (ER, Sect. 4.2).

The South Dakota temperature standards for the Cheyenne River [32.2°C (90°F)] were exceeded in August 1973 and June 1974 (ER, Sect. 4.2). The chemical water quality of both the Cheyenne River and Cottonwood Creek ranges from good to poor. Mean concentrations of barium in both streams and maximum concentrations of arsenic in the Cheyenne River exceed the EPA "National Interim Primary Drinking Water Standards"[27] for finished drinking water (Tables 3.16 and 3.17). Chloride, iron, manganese, and sulfate concentrations in both the Cheyenne River and Cottonwood Creek exceed concentrations identified by the EPA "Proposed Secondary Drinking Water Standards."[28] None of the values discussed above exceed quality criteria for protection of aquatic biota. Conductivity in the Cheyenne River and Cottonwood Creek is above irrigation criteria, and ammonia nitrogen in Cottonwood Creek is above warmwater semipermanent stream criteria according to South Dakota water-quality standards.[29] High chemical oxygen demand exists in the Cheyenne River in the project vicinity. Historically, dissolved oxygen concentrations in both water bodies have been greater than the minimum State standards.[29] Values for pH range from 6.5 to 8.9 (Table 3.18). Alkalinity and hardness values are sufficiently high in both the Cheyenne River and Cottonwood Creek for the water in the streams to be considered very hard. Dissolved solids are also high in both streams. Turbidity and suspended solids in Cottonwood Creek increase downstream through the mill site.

Table 3.16. Summary of chemical surface water quality for the Cheyenne River and Cottonwood Creek in the vicinity of the Edgemont Uranium Mill, South Dakota

Parameter	No. of samples	Observed concentrations		
		Maximum	Minimum	Mean
		Cheyenne River (S-4)[a]		
Aluminum, µg/liter	3	400	<[illegible]	<300
Ammonia nitrogen, mg/liter	19	0.35	<0.01	0.11
Arsenic, µg/liter	6	53	<2	<13
Barium, µg/liter	5	14,000	<100	<2,900
Beryllium, µg/liter	2	<10	<10	<10
Biochemical oxygen demand (5-day), mg/liter	37	3.0	0.5	1.4
Boron, µg/liter	7	1,300	240	500
Cadmium, µg/liter	7	8	0	2
Calcium, mg/liter	61	650	67	370
Chemical oxygen demand, mg/liter	2	150	16	83
Chloride, mg/liter	66	1,190	30	410
Chromium (total), µg/liter	10	42	0	<9
Cobalt, µg/liter	2	11	<5	<8
Conductivity, µmhos	93	7,690	590	3,980
Copper, µg/liter	9	50	3	20
Fluoride, mg/liter	31	0.8	0.2	0.6
Iron (total), mg/liter	38	80	0.02	5.8
Lead, µg/liter	9	27	0	11
Lithium, µg/liter	3	280	120	210
Magnesium, mg/liter	61	301	22	126
Manganese (total), µg/liter	37	4,150	70	490
Mercury, µg/liter	7	0.9	0.1	<0.3
Molybdenum, µg/liter	9	<100	2	<80
Nickel, µg/liter	7	80	5	<40
Nitrate plus nitrite nitrogen, mg/liter	18	0.64	<0.01	0.18
Organic nitrogen, mg/liter	23	4.1	0.08	1.0
Phosphorus (total), mg/liter	59	1.9	0.0	0.2
Potassium, mg/liter	56	25	1.2	10
Selenium, µg/liter	7	3	<1	<2
Silica (total), mg/liter	25	12	3.9	8.4
Silver, µg/liter	5	10	0	6
Sodium, mg/liter	58	1,310	110	530
Strontium, µg/liter	2	4,700	1,600	3,150
Sulfate, mg/liter	63	3,720	350	1,730
Tin, µg/liter	1	<100		
Titanium, µg/liter	2	<1,000	<1,000	<1,000
Vanadium, µg/liter	9	<500	3.3	<200
Zinc, µg/liter	9	420	<10	80
		Cheyenne River (S-6)[b]		
Aluminum, µg/liter				
Ammonia nitrogen, mg/liter				
Arsenic, µg/liter	1	<5		
Barium, µg/liter				
Beryllium, µg/liter				
Boron, µg/liter				
Cadmium, µg/liter				
Calcium, mg/liter				
Chemical oxygen demand				
Chloride, mg/liter				
Chromium (total), µg/liter	2	<5	<5	<5
Cobalt, µg/liter				
Conductivity, µmhos	22	5,500	545	3,925
Copper, µg/liter	2	70	<10	<40
Fluoride, mg/liter				
Iron (total), mg/liter	2	0.40	0.14	0.27
Lead, µg/liter	2	13	<10	<12
Lithium, µg/liter				

Table 3.16 (continued)

Parameter	No. of samples	Observed concentrations		
		Maximum	Minimum	Mean
Cheyenne River (S-5)[b] (continued)				
Magnesium, mg/liter				
Manganese (total), μg/liter				
Mercury, μg/liter				
Molybdenum, μg/liter	2	<100	<100	<100
Nickel, μg/liter	2	<50	<50	<50
Nitrate plus nitrite nitrogen, mg/liter				
Organic nitrogen, mg/liter				
Phosphorus (total), mg/liter				
Potassium, mg/liter				
Selenium, μg/liter				
Silica (total), mg/liter				
Silver, μg/liter				
Sodium, mg/liter				
Strontium, μg/liter				
Sulfate, mg/liter				
Tin, μg/liter	1	<100		
Titanium, μg/liter				
Vanadium, μg/liter	2	<500	<500	<500
Zinc, μg/liter	2	60	10	40
Cheyenne River (S-6)[c]				
Aluminum, μg/liter	3	1,100	200	700
Ammonia nitrogen, mg/liter	2	0.05	0.01	0.03
Arsenic, μg/liter	5	90	<2	<20
Barium, μg/liter	5	15,000	<100	3,100
Beryllium, μg/liter	2	<10	<10	<10
Boron, μg/liter	4	820	260	520
Cadmium, μg/liter	5	4	<1	<2
Calcium, mg/liter	5	490	220	340
Chemical oxygen demand	2	240	19	130
Chloride, mg/liter	5	890	75	420
Chromium (total), μg/liter	6	18	<5	<7
Cobalt, μg/liter	2	27	<5	<16
Conductivity, μmhos	4	6,100	1,490	3,790
Copper, μg/liter	6	50	<10	30
Fluoride, mg/liter	5	0.61	0.43	0.52
Iron (total), mg/liter	6	5.00	0.11	1.36
Lead, μg/liter	6	21	<10	14
Lithium, μg/liter	3	180	150	170
Magnesium, mg/liter	5	190	69	130
Manganese (total), μg/liter	5	3,900	50	1,100
Mercury, μg/liter	4	<0.2	<0.2	<0.2
Molybdenum, μg/liter	6	<100	<100	<100
Nickel, μg/liter	4	100	<50	<60
Nitrate plus nitrite nitrogen, mg/liter	2	0.56	0.10	0.33
Organic nitrogen, mg/liter	2	3.60	0.31	2.00
Phosphorus (total), mg/liter	2	2.80	0.07	1.40
Potassium, mg/liter	3	25	9.6	18
Selenium, μg/liter	5	4	<1	<2
Silica (total), mg/liter	3	8.8	2.1	6.1
Silver, μg/liter	3	10	<10	<10
Sodium, mg/liter	5	910	170	560
Strontium, μg/liter	2	4,600	2,000	3,300
Sulfate, mg/liter	5	2,700	640	1,590
Tin, μg/liter				
Titanium, μg/liter	2	<1,000	<1,000	<1,000
Vanadium, μg/liter	6	<500	<100	<200
Zinc, μg/liter	6	100	<10	50

Table 3.16. (continued)

Parameter	No. of samples	Observed concentrations		
		Maximum	Minimum	Mean
Cheyenne River (S-7)[d]				
Aluminum, μg/liter	2	1,700	<200	1,000
Ammonia nitrogen, mg/liter	2	0.01	0.01	0.01
Arsenic, μg/liter	2	4	<2	<3
Barium, μg/liter	2	230	<100	<160
Boron, μg/liter	1	140		
Cadmium, μg/liter	2	8	<1	<4
Calcium, mg/liter	2	510	470	490
Chemical oxygen demand	2	19	5	12
Chloride, mg/liter	2	160	150	160
Chromium (total), μg/liter	2	<5	<5	<5
Cobalt, μg/liter	2	<5	<5	<5
Conductivity, μmhos	2	3,000	2,770	2,880
Copper, μg/liter	2	40	20	30
Fluoride, mg/liter	2	0.82	0.66	0.74
Iron (total), mg/liter	2	0.65	0.14	0.40
Lead, μg/liter	2	<10	<10	<10
Magnesium, mg/liter	2	100	100	100
Manganese (total), μg/liter	2	100	20	60
Mercury, μg/liter	2	0.6	<0.2	<0.4
Molybdenum, μg/liter	2	100	100	100
Nickel, μg/liter	1	<50		
Nitrate plus nitrite nitrogen, mg/liter	2	1.60	0.17	0.89
Organic nitrogen, mg/liter	2	0.55	0.03	0.29
Phosphorus (total), mg/liter	2	0.29	0.01	0.15
Selenium, μg/liter	2	2	2	2
Silica (total), mg/liter	1	13		
Silver, μg/liter	1	<10		
Sodium, mg/liter	2	230	140	180
Strontium, μg/liter	2	4,900	4,600	4,750
Sulfate, mg/liter	2	2,200	1,600	1,900
Vanadium, μg/liter	2	<100	<100	<100
Zinc, μg/liter	2	30	10	20
Cottonwood Creek (S-8)[e]				
Aluminum, μg/liter	2	700	<200	450
Ammonia nitrogen, mg/liter	2	0.02	0.02	0.02
Arsenic, μg/liter	5	7	<2	<4
Barium, μg/liter	5	5,100	<100	<1,100
Boron, μg/liter	4	1,600	440	930
Cadmium, μg/liter	5	7	<1	4
Calcium, mg/liter	5	620	280	470
Chemical oxygen demand	2	27	17	22
Chloride, mg/liter	5	300	46	240
Chromium (total), μg/liter	5	8	<5	<6
Cobalt, μg/liter	2	<5	<5	<5
Conductivity, μmhos	5	6,100	3,200	5,010
Copper, μg/liter	5	40	<10	30
Fluoride, mg/liter	5	1.0	0.80	0.93
Iron (total), mg/liter	5	3.1	0.41	1.2
Lead, μg/liter	5	17	<10	14
Magnesium, mg/liter	5	260	20	180
Manganese (total), μg/liter	5	720	140	380
Mercury, μg/liter	5	0.4	<0.2	0.2
Molybdenum, μg/liter	5	<100	<100	<100
Nickel, μg/liter	3	50	<50	50
Nitrate plus nitrite nitrogen, mg/liter	2	0.03	0.01	0.02
Organic nitrogen, mg/liter	2	0.18	0.11	0.15
Phosphorus (total), mg/liter	2	0.02	0.01	0.02
Selenium, μg/liter	5	3	<1	<2

Table 3.16. (continued)

Parameter	No. of samples	Observed concentrations		
		Maximum	Minimum	Mean
Cottonwood Creek (S-8)[e] (continued)				
Silica (total), mg/liter	3	8.0	4.4	5.8
Silver, μg/liter	5	3	<1	<2
Sodium, mg/liter	5	5,600	77	1,500
Strontium, μg/liter	2	5,700	3,700	4,700
Sulfate, mg/liter	5	3,300	1,300	2,600
Vanadium, μg/liter	5	<500	<100	<200
Zinc, μg/liter	5	40	10	20
Cottonwood Creek (S-9)[f]				
Aluminum, μg/liter				
Ammonia nitrogen, mg/liter				
Arsenic, μg/liter	2	<5	<5	<5
Barium, μg/liter	1	100		
Boron, μg/liter	1	1,400		
Cadmium, μg/liter	1	<1		
Calcium, mg/liter	1	240		
Chemical oxygen demand				
Chloride, mg/liter	1	260		
Chromium (total), μg/liter	3	12	<5	<7
Cobalt, μg/liter				
Conductivity, μmhos	2	4,800	3,730	4,270
Copper, μg/liter	3	20	10	10
Fluoride, mg/liter	1	1.3		
Iron (total), mg/liter	3	1.6	0.19	0.75
Lead, μg/liter	3	16	<10	<12
Magnesium, mg/liter	1	150		
Manganese (total), μg/liter	1	360		
Mercury, μg/liter	1	<0.2		
Molybdenum, μg/liter	3	<100	<100	<100
Nickel, μg/liter	3	<50	<50	<50
Nitrate plus nitrite nitrogen, mg/liter				
Organic nitrogen, mg/liter				
Phosphorus (total), mg/liter				
Selenium, μg/liter	1	1		
Silica (total), mg/liter	1	21.0		
Silver, μg/liter	1	<10		
Sodium, mg/liter	1	500		
Strontium, μg/liter				
Sulfate, mg/liter	1	840		
Vanadium, μg/liter	3	<500	<100	<400
Zinc, μg/liter	3	40	20	30
Cottonwood Creek (S-10)[g]				
Aluminum, μg/liter	2	700	300	500
Ammonia nitrogen, mg/liter	2	5.9	5.2	5.6
Arsenic, μg/liter	5	20	<2	<7
Barium, μg/liter	5	4,800	<100	<1,000
Boron, μg/liter	4	1,300	370	850
Cadmium, μg/liter	5	5	<1	2
Calcium, mg/liter	5	410	220	290
Chemical oxygen demand	2	19	13	16
Chloride, mg/liter	5	300	63	230
Chromium (total), μg/liter	6	13	<5	<7
Cobalt, μg/liter	2	<5	<5	<5
Conductivity, μmhos	5	4,600	3,250	3,870
Copper, μg/liter	5	40	<10	30
Fluoride, mg/liter	5	1.2	0.11	0.92
Iron (total), mg/liter	5	2.1	0.15	1.1
Lead, μg/liter	6	12	<10	<10

Table 3.16. (continued)

Parameter	No. of samples	Observed concentrations		
		Maximum	Minimum	Mean
Cottonwood Creek (S-10)[g] (continued)				
Magnesium, mg/liter	5	170	100	130
Manganese (total), μg/liter	5	730	220	450
Mercury, μg/liter	5	0.6	0.2	0.3
Molybdenum, μg/liter	6	<100	<100	<100
Nickel, μg/liter	4	<50	<50	<50
Nitrate plus nitrite nitrogen, mg/liter	2	2.0	0.95	1.5
Organic nitrogen, mg/liter	2	1.8	1.4	1.6
Phosphorus (total), mg/liter	2	0.02	0.02	0.02
Selenium, μg/liter	5	5	2	4
Silica (total), mg/liter	3	19	8.8	12.3
Silver, μg/liter	3	10	<10	<10
Sodium, mg/liter	5	5,400	370	1,400
Strontium, μg/liter	2	4,100	2,900	3,500
Sulfate, mg/liter	5	2,200	840	1,600
Vanadium, μg/liter	6	<500	<100	<200
Zinc, μg/liter	6	80	<10	40
Cottonwood Creek (S-11)[h]				
Aluminum, μg/liter	2	900	500	700
Ammonia nitrogen, mg/liter	1	7.4		
Arsenic, μg/liter	6	10	<2	6
Barium, μg/liter	5	6,600	<100	<1,400
Boron, μg/liter	4	1,300	380	750
Cadmium, μg/liter	5	4	<1	<2
Calcium, mg/liter	5	300	220	260
Chemical oxygen demand	2	46	18	32
Chloride, mg/liter	5	310	78	230
Chromium (total), μg/liter	7	13	<5	<6
Cobalt, μg/liter	2	<5	<5	<5
Conductivity, μmhos	5	3,800	2,800	3,380
Copper, μg/liter	7	60	<10	30
Fluoride, mg/liter	5	1.3	0.11	0.86
Iron (total), mg/liter	7	2.9	0.27	1.5
Lead, μg/liter	7	17	<10	<11
Magnesium, mg/liter	5	160	17	99
Manganese (total), μg/liter	5	1,300	220	560
Mercury, μg/liter	5	0.8	<0.2	0.5
Molybdenum, μg/liter	7	<100	<100	<100
Nickel, μg/liter	5	<50	<50	<50
Nitrate plus nitrite nitrogen, mg/liter	1	2.4		
Organic nitrogen, mg/liter	1	4.0		
Phosphorus (total), mg/liter	1	0.03		
Selenium, μg/liter	5	5	2	3
Silica (total), mg/liter	3	17.0	8.8	11.6
Silver, μg/liter	3	<10	<10	<10
Sodium, mg/liter	5	500	280	400
Strontium, μg/liter	2	3,000	2,700	2,900
Sulfate, mg/liter	5	1,800	960	1,450
Vanadium, μg/liter	7	<500	<100	<300
Zinc, μg/liter	7	50	<10	30

[a] Upstream of U.S. Highway 18 bridge at Edgemont.

[b] About 2.5 km downstream of Edgemont.

[c] About 10 km downstream of Edgemont.

[d] Upstream of State Route 71 bridge at Angostura Reservoir.

[e] Upstream of mill property at the county bridge off State Highway 52.

[f] At mill site pipeline extension bridge.

[g] About 9.1 km (30 ft) upstream of the mill road culvert.

[h] At the confluence with the Cheyenne River.

Source: Modified from ER, Table 4.2-4.

Table 3.17. Summary of water quality standards and criteria

Parameter	South Dakota water quality standards[a]	EPA drinking water standards[b]	NAS–NAE[c]	
			Irrigation water criteria	Livestock watering criteria
Aluminum, µg/liter			5,000	5,000
Ammonia nitrogen, mg/liter	1.0			
Arsenic, µg/liter		50*	100	200
Barium, µg/liter		1,000*		
Beryllium, µg/liter			100	
Boron, µg/liter			750	
Cadmium, µg/liter		10*	10	50
Calcium, mg/liter				
Chemical oxygen demand				
Chloride, mg/liter		250		
Chromium (total), µg/liter		50*	100	1,000
Cobalt, µg/liter			50	1,000
Conductivity, µmhos	2,500			
Copper, µg/liter		1,000	200	500
Fluoride, mg/liter		1.4→2.4*	1.0	2.0
Iron (total), mg/liter	0.2	0.3	5	
Lead, µg/liter		50*	5,000	100
Lithium, µg/liter			2,500	
Magnesium, mg/liter				
Manganese (total), µg/liter		50	200	
Mercury, µg/liter		2*		10
Molybdenum, µg/liter			10	
Nickel, µg/liter			200	
Nitrate nitrogen, mg/liter	50 (as NO_3)	45 (as NO_3)*		
Nitrate plus nitrite nitrogen, mg/liter				100
Organic nitrogen, mg/liter				
Phosphorus (total), mg/liter				
Potassium, mg/liter				
Sodium adsorption ratio	10			
Selenium, µg/liter		10*	20	50
Silica (total), mg/liter				
Silver, µg/liter		50*		
Sodium, mg/liter				
Strontium, µg/liter				
Sulfate, mg/liter		250		
Titanium, µg/liter				
Vanadium, µg/liter			100	100
Zinc, µg/liter		5,000	2,000	25,000

[a] State of South Dakota, Department of Environmental Protection, *Surface Water Quality Standards*, SDCL 46-25-107, 1974.

[b] Standards marked with an asterisk (*) are primary drinking water standards. Unmarked standards are the proposed secondary drinking water standards (40 CFR Part 141, 248 and 40 CFR Part 143, 62).

[c] National Academy of Sciences and National Academy of Engineering, *Water Quality Criteria 1972*, Report USEPA R3-73-033, March 1973.

Source: Modified from ER, Table 4.2-4.

3.6.1.3 Surface water use

The State of South Dakota has classified the Cheyenne River in the vicinity of Edgemont as being suitable for (1) warmwater, semipermanent fish-life propagation; (2) limited contact recreation; (3) wildlife propagation and stock watering; and (4) irrigation.[29] Based upon *Water Quality Criteria*, 1972 (ref. 30), water from the Cheyenne River is unsuitable for continuous irrigation use. The mean concentrations of dissolved solids in the Cheyenne River exceed both established criteria for livestock watering and water-quality standards for South Dakota.

Table 3.18. Summary of physical and bacteriological surface water quality data for the Cheyenne River and Cottonwood Creek in the vicinity of the Edgemont uranium mining project

Stream and mileage	Parameter											
	Water temp. (°C)	Dissolved oxygen (mg/liter)	pH (S.U.)	Total alkalinity as $CaCO_3$ (mg/liter)	Hardness as $CaCO_3$ (mg/liter)	True color (PCU)	Apparent color (PCU)	Turbidity (JTU)	Solids: Dissolved (mg/liter)	Solids: Suspended (mg/liter)	Coliform (No./100): Fecal	Coliform (No./100): Streptococcal
Cheyenne River[a] (S-4)												
Max	29.0	13.1	8.9	433	2770	100	6000	2700	7571	8593	4800	
Min	0.0	0.7	7.0	70	260	5	7	8.4	695	0	0	
Mean	11.5	9.8	8.6	189	1390	30	1200	700	3526	692	480	
No. of samples	100	74	94	63	65	5	5	4	67	41	52	
Cheyenne River[b] (S-5)												
Max	36.0	13.7	8.4						4200	17		
Min	0.0	8.3	6.9						3800	17		
Mean	10.7	10.9	7.9						4000	17		
No. of samples	23	21	22						2	2		
Cheyenne River[c] (S-6)												
Max	26.0	12.4	8.2	180	1900	90	6200	3200	6300	5500		
Min	18.0		6.7	84	880	7	14	11	990	9		
Mean	22.8		7.6	130	1400	30	1400	840	3560	960		
No. of samples	4	1	5	4	5	5	5	4	6	6		
Cheyenne River[d] (S-7)												
Max	20	8.4	8.2	163	1692	10	210	68	2700	120		
Min			8.1	160	1600	5	8	4.4	2500	21		
Mean			8.2	162	1646	8	110	36	2600	70		
No. of samples	1	1	2	2	2	2	2	2	2	2		
Cottonwood Creek[e] (S-8)												
Max	23.0	12.3	7.8	260	2592	30	34	11	5600	53		
Min	18.5		6.5	170	1265	5	19	3.8	2300	5		
Mean	20.5		7.3	230	1931	15	28	6.6	4200	27		
No. of samples	4	1	5	4	5	5	5	4	6	6		
Cottonwood Creek[f] (S-9)												
Max	29.5		7.7	320	1217	8	18		2800	38		
Min	22.0		6.9						2400	11		
Mean	25.8		7.3						2600	23		
No. of samples	2		2	1	1	1	1		3	3		
Cottonwood Creek[g] (S-10)												
Max	25.0	13.5	8.1	230	1700	25	45	20	3800	30		
Min	21.0		7.0	200	686	5	20	7.9	2600	11		
Mean	22.9		7.5	210	1178	15	33	13	3000	27		
No. of samples	4	1	5	4	5	5	5	4	6	6		
Cottonwood Creek[h] (S-11)												
Max	24.5	13.3	8.1	220	1300	50	420	190	3800	390		
Min	18.0		7.2	180	677	6	24	21	2000	16		
Mean	21.9		7.5	195	1053	22	130	67	2800	127		
No. of samples	4	1	5	4	5	5	5	4	7	7		
South Dakota water quality standards[i]	32.2 (23.9)	5	6.3→9.0 (6.5→8.8)	750				50	1500	90	1000	5000
EPA drinking water standards[j]			6.5→8.5		15			5*	500	4*		
NAS–NAE irrigation water criteria[k]			4.5→9.0									
NAS–NAE livestock watering criteria[k]									3300			

[a] Cheyenne River (S-4): 43°18'20", 103°49'17" upstream of US Hwy. 18 bridge at Edgemont, S. D.; data sources: TVA (12/74 through 9/77), U.S. Geological Survey (1/72 through 9/78), and the State of South Dakota (11/72 through 5/77).

[b] Cheyenne River (S-5): 43°18'49", 103°47'16"; ~2.5 km (1.6 miles) downstream of Edgemont, S.D., above Red Canyon Creek; data sources: TVA (12/74 through 6/75) and U.S. Geological Survey (7/73 through 6/74).

[c] Cheyenne River (S-6): 43°17'07", 103°44'21"; ~10 km (6.2 miles) downstream of Edgemont, S.D.; data source: TVA (12/74 through 9/77).

[d] Cheyenne River (S-7): 43°16'23", 103°33'43" upstream of SR 71 bridge at Angostura Reservoir, S.D.; data source: TVA (5/77 through 9/77).

[e] Cottonwood Creek (S-8): 43°17'23", 103°49'26" upstream of mill property at the county road bridge, off State Highway 52; data source: TVA (12/74 through 9/77).

[f] Cottonwood Creek (S-9): 43°18'02", 103°49'00" at pipeline suspension bridge; data source: TVA (12/74 through 9/76).

[g] Cottonwood Creek (S-10): 43°18'11", 103°48'59" approximately 9.1 m (30 ft) upstream of the mill road culvert; data source: TVA (12/74 through 9/77).

[h] Cottonwood Creek (S-11): 43°18'19", 103°49'03" at the confluence with the Cheyenne River; data source: TVA (12/74 through 9/77).

[i] State of South Dakota, Department of Environmental Protection, *Water Quality Standards*, SDCL 46-25-07, 1974.

[j] Standards marked with an asterisk (*) are primary drinking water standards. Unmarked standards are the proposed secondary drinking water standards (40 CFR Part 141.24B and 40 CFR Part 143.62).

[k] U.S. Geological Survey, *Water Resources Data for South Dakota, Water Year 1977*, Water Data Report SD77-1, 1977.

Source: Modified from ER, Table 4.2.3.

Cottonwood Creek is classified by the State for the beneficial use of wildlife propagation and for stock watering and irrigation. The pH values recorded from Cottonwood Creek were within National Academy of Sciences–National Academy of Engineering (NAS-NAE) Criteria for irrigation water, South Dakota water-quality, and EPA drinking-water standards.[27,29,30] Cottonwood Creek met chemical water-quality criteria for livestock watering.[30] However, boron, manganese, and fluoride concentrations in Cottonwood Creek exceeded NAS-NAE criteria for irrigation water.[30]

Surface drainage in the Cheyenne River basin is contained in many instances by many small reservoirs, for example, 9320 in 1965 (ER, Sect. 4.2), with a total capacity above Edgemont of 5.6×10^7 m^3 (4.5×10^4 acre-ft). These reservoirs are used for stock watering and irrigation. The Cheyenne River and Cottonwood Creek in the Edgemont area are also used primarily for stock watering and, to a limited extent, irrigation. Few irrigation permits have been issued for the Cheyenne River above the Angostura Reservoir (John Hatch, Deputy Director, South Dakota Water Rights Department, personal communication, Mar. 20, 1980), which was constructed in the 1950s to provide irrigation water for the area.

3.6.2 Groundwater

3.6.2.1 Regional flow system

Groundwater in western Fall River County occurs both in unconsolidated sediments and in bedrock aquifers. The occurrence of groundwater in bedrock aquifers is largely dictated by the structure and the stratigraphy associated with the uplift of the Black Hills. The regional dip and alternating sequence of sandstones (aquifers) and shales (aquicludes) account for the artesian conditions in some of the bedrock aquifers. The quality of water contained in the bedrock aquifers is highly variable.

Most wells in this area, located in the unconsolidated sediments of quaternary alluvial deposits, occur along the larger drainages and comprise the most important existing and future water supply for the area. Groundwater flow in these deposits is usually controlled by the underlying bedrock configuration and the local topography. Recharge occurs by direct infiltration of local precipitation and streamflow.

The principal bedrock aquifers in the area are the Pahasapa Formation (Mississippian Age), the Sundance Formation (Jurassic Age), and the Fall River and Lakota formations of the Inyan Kara group (Cretaceous Age).[31]

The Pahasapa Formation, a local name for the Madison Formation, consists of a gray massive limestone. Only very deep wells obtain water from this formation in Fall River County. Five wells developed in this formation at depths of more than 700 m (2300 ft) provide water for the city of Edgemont, the Burlington-Northern Railroad, and the mill facility.

The Sundance Formation, which consists of alternating marine sandstones and shales, is used as an aquifer primarily near its outcrop area in the central and northwestern parts of the county.

The Lakota Formation consists of cross-bedded, channel-fill sandstones, shale, and locally occurring limestone. The Chilson member of this formation is the primary water-bearing unit. The Lakota Formation lies unconformably over the Jurassic Morrison Formation, which consists mostly of shale and clay. The Fall River Formation consists of a well-bedded, fine-grained sandstone, with lesser amounts of interbedded siltstone and clay. The Fall River Formation is overlain by the Skull Creek shale of the early Cretaceous Age. The Skull Creek shale is considered an aquiclude. The Fall River Formation is the largest producing bedrock aquifer in Fall River County.

3.6.2.2 Site flow system

Existing site

Unconfined groundwater occurs beneath the existing tailings site in unconsolidated quaternary alluvial deposits ranging up to 9 m (30 ft) thick. Extensive intertonguing of sediments from the Cheyenne River alluvial floodplain and Cottonwood Creek exists beneath the tailing site. A potentiometric surface and flow gradient of the unconfined aquifer at the site is given in Fig. 3.6.

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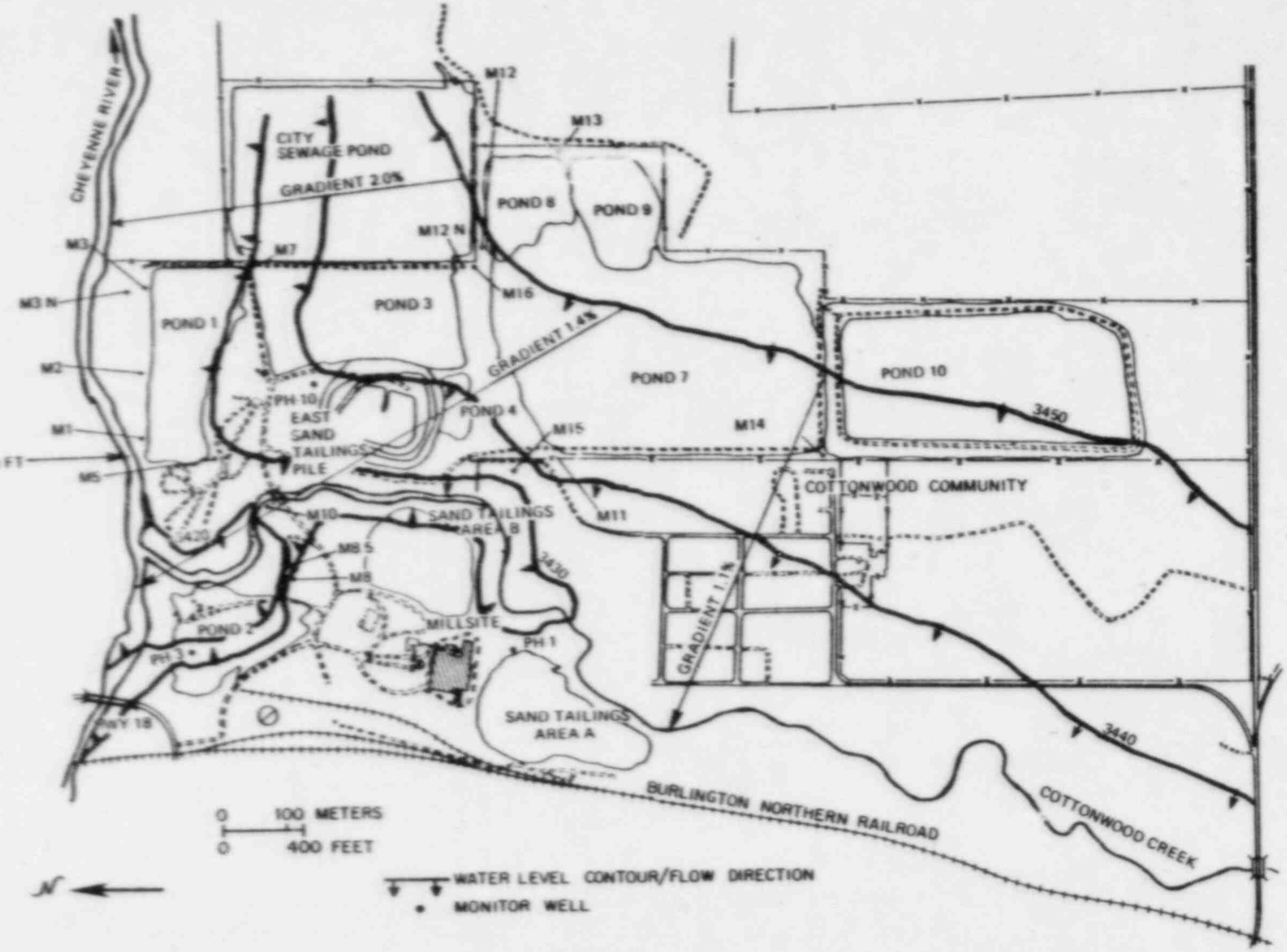

Fig. 3.6. Potentiometric surface and flow gradient of the unconfined groundwater at the existing tailings site. Source: ER, Fig. 4.2-4.

Proposed disposal site

Unconfined groundwater conditions occur in the unconsolidated surficial materials (alluvium) at the proposed disposal site. This perched water generally lies within a few feet of the soil-bedrock contact.[26] Groundwater levels in the vicinity of the stock-watering pond located on the southern side of the site are affected by seepage from the pond. In the absence of the stock pond, the water table in this area would be expected to be lower, probably within a few feet of the bedrock surface.

The surficial materials at the disposal site are underlain by the Lower Greenhorn, Belle Fourche, Mowry, and Skull Creek shales, all of the Cretaceous Age. More than 152 m (500 ft) of these shale units separate the unconfined groundwater in the surficial materials from the underlying Fall River and Lakota aquifers.

3.6.2.3 Regional groundwater quality and use

Evaluation of the water-quality data from quaternary alluvium shows its physical-chemical quality to be very poor. Concentrations of dissolved solids range from 3480 mg/L to 6969 mg/L, and the groundwater is considered to be very hard. The principal cations are sodium and magnesium, and the principal anions are sulfate and bicarbonate. The pH ranges from acidic to slightly alkaline. Concentrations of dissolved solids, iron, sulfate, and chloride are greater than those concentrations specified by the EPA "Proposed Secondary Drinking Water Standards"[28] for finished drinking water. Using the U.S. Department of Agriculture (USDA) diagram for evaluating groundwater for irrigation purposes, the groundwater is unsuitable for irrigation purposes because of its high salinity hazard.[32]

Alluvium is used locally as a water source for domestic and stock water supplies. Many wells are located in the alluvial deposits along the larger streams. The alluvium deposits represent an existing and future water supply zone primarily because of accessibility, adequate amount, and lowest cost outlay resulting from the shallower drilling depths.

An evaluation of the water-quality data from the Fall River Formation shows its physical-chemical quality to be fair to very poor. Concentrations of dissolved solids range from 1010 to 3189 mg/L, and the groundwater is considered to range from soft to very hard. The principal cations are sodium and calcium, and the principal anions are sulfate and bicarbonate. The pH is alkaline, ranging from 7.7 to 8.9. Concentrations of dissolved solids, iron, sulfate, and chloride are greater than the proposed EPA secondary standards. The groundwater is unsuitable for irrigation purposes because of its high salinity and sodium hazards.

Both the Fall River and Lakota formations, which together form the Inyan Kara group, are the principal sources of water for domestic, irrigation, and livestock uses.

3.6.2.4 Site groundwater quality and use

Existing site

Approximately 2.1 x 10^6 MT (2.3 x 10^6 tons) of solid uranium mill tailings, about 80% of which were sand tailings and the balance were slime tailings, were deposited in 11 ponds or piles [the approximate surface area is 50 ha (123 acres)] at the existing site. Except for Pond 10, the storage areas were probably not designed to prohibit or to minimize the mitigation of leachates beneath the areas. At present, Ponds 3, 4, 7, 8, and 10 contain V_2O_5-bearing liquors of varying assay.

Evaluation of the chemical data from the ponds shows the standing water to be acidic and to contain extremely high concentrations of dissolved solids, sulfate, cadmium, chromium, iron, nickel, titanium, and vanadium. Sediment samples from the ponds were heavily concentrated with aluminum, barium, chromium, iron, nickel, titanium, and vanadium. Lower concentrations of other metals were measured in both the water and sediment samples. Leachates migrating from the ponds and tailings piles are a potential source of contamination of the alluvial aquifer, Cottonwood Creek, and the Cheyenne River near the mill site.

The water quality found in the alluvial aquifer beneath the mill site has been determined by the sampling of 14 observation wells (potentiometers) (Fig. 3.6). Evaluation of groundwater-quality data clearly shows that the groundwater directly beneath the site is contaminated with leachates from the tailings and slimes storage areas.

Groundwater that entered the site from the southeast was found to contain concentrations of dissolved solids on the order of 6500 mg/L. As the water passed under the site, it mixed with contaminated leachates resulting in concentrations of dissolved solids ranging from 14,545 to 32,000 mg/L.

This pattern also was observed west of Cottonwood Creek, but the maximum observed concentration was much lower (15,575 mg/L). This pattern was also found to exist generally for nitrate, sulfate, and most metals analyzed. Extremely high concentrations of dissolved solids, nitrate, sulfate, lead, manganese, and nickel were measured in those wells east of Cottonwood Creek adjacent to the Cheyenne River. As shown in Fig. 3.6, leachate from a large percentage of the tailings and slime storage areas would migrate in the direction of these observation wells. Data from the onsite observation wells east of and adjacent to Cottonwood Creek also indicate contamination by leachates from the storage areas. Samples from those observation wells west of Cottonwood Creek indicate some contaminat.on, but not contamination as significant as that found to the east of Cottonwood Creek.

Proposed disposal site

No data are currently available to assess the existing groundwater quality at the disposal site; as previously mentioned, however, the quality of water in the alluvial material is generally very poor in the region.

3.7 GEOLOGY, MINERAL RESOURCES, AND SEISMICITY

3.7.1 Geology

3.7.1.1 Regional geology

The mill site and proposed disposal site lie within the Missouri River Plateau and the south-western edge of the Black Hills uplift (Fig. 3.7). Figure 3.8 contains a complete stratigraphic column for the project area, which includes rocks that range in age from Precambrian to Quaternary. Because sedimentary strata of Cretaceous Age are of primary concern at the existing mill site, the following brief description is restricted to these units.

The Inyan Kara group, of early Cretaceous Age, lies unconformably over the Morrison Formation of Jurassic Age. This group includes the Fall River and Lakota formations, which comprise a complex interbedded sequence of fluviatile channel sandstones, fine-grained floodplain deposits, and lacustrine or marsh deposits of mudstone, shale, and limestone.[33] The Inyan Kara group represents a change in depositional environments from continental to marginal marine.[33,34]

Overlying the Inyan Kara group is the Skull Creek shale of early Cretaceous Age. This unit is composed of a sequence of dark-gray to black marine shales. The Newcastle sandstone, which overlies the Skull Creek shale and is of early Cretaceous Age, is a fine-grained sandstone interbedded with siltstone and, in places, mudstone.[33] Overlying the Newcastle sandstone is the Mowry shale of early Cretaceous Age. This shale consists primarily of gray marine shales.

The Belle Fourche shale, which overlies the Mowry shale and is of late Cretaceous Age, is a dark-gray marine shale and contains a few bentonite seams.[33] The Greenhorn Formation, which overlies the Belle Fourche shale and is of late Cretaceous Age, is a marine shale that contains a few thin beds of limestone and bentonite.[33]

Quaternary terrace gravels, alluvium, colluvium, and eolian deposits unconformably overlie the Cretaceous units throughout this region.

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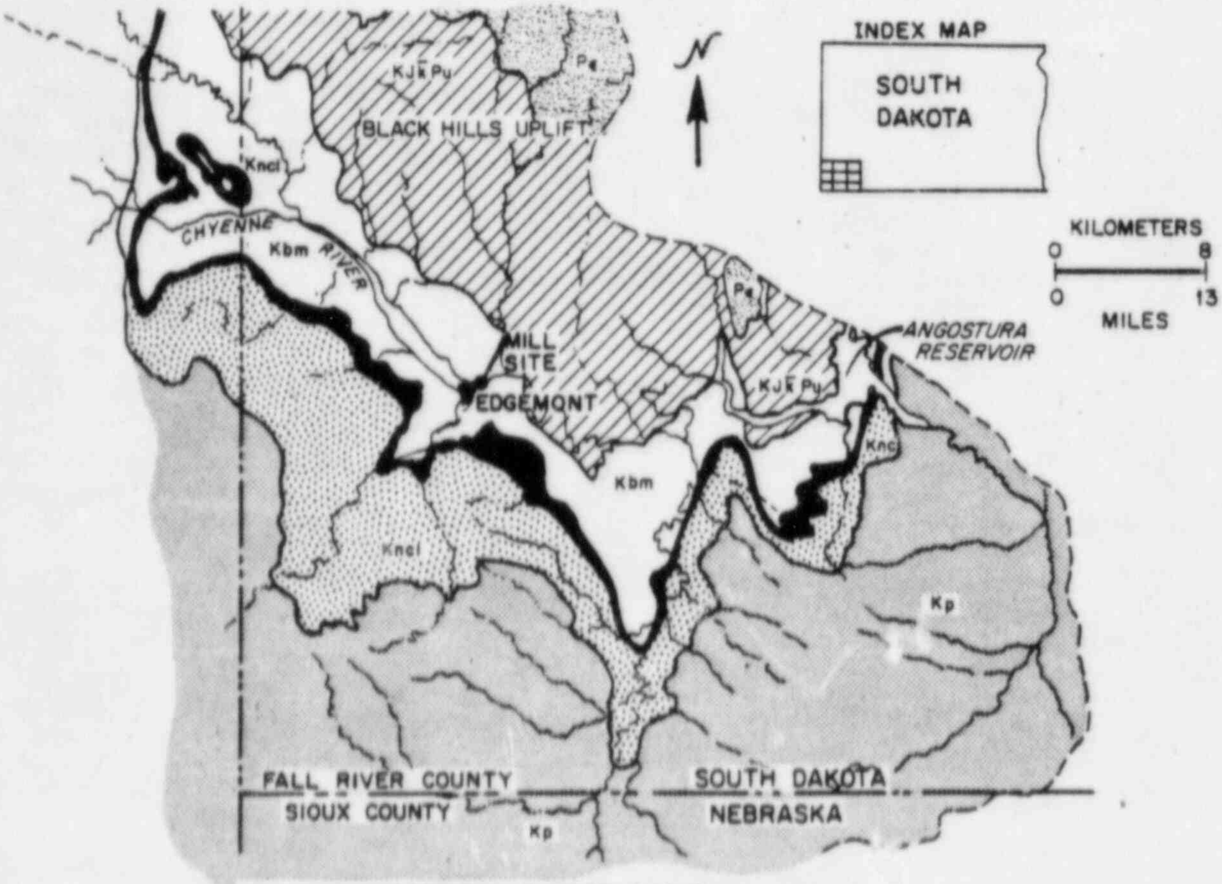

Kp – PIERRE SHALE, CRETACEOUS
Kncl – NIOBRARA FORMATION AND CARLILE SHALE CRETACEOUS
Kg – GREENHORN LIMESTONE, CRETACEOUS
Kbm – BELLE FOURCHE AND MOWRY SHALES, CRETACEOUS
KJŦPu – SKULL CREEK SHALE, INYAN KARA GROUP, CRETACEOUS; MORRISON FORMATION, JURASSIC; AND TRIASSIC AND PERMIAN FORMATIONS
Pє PRECAMBIAN (CRYSTALLINE ROCKS)

Fig. 3.7. Geologic map of Edgemont and surrounding area. Source: R. C. Culler, "Hydrology of the Upper Cheyenne River," *U.S. Geol. Surv. Water-Supply Pap.* 1531 (1961).

3.7.1.2 Site geology

Existing site

The existing tailings site is underlain by alluvial deposits of Quaternary Age. These deposits, which are up to 9 m (30 ft) thick, consist primarily of interbedded lenses and layers of fine-grained sands, silts, and clays, with minor amounts of gravel and are underlain by approximately 66 m (200 ft) of the Skull Creek shale, which acts as an aquiclude between the Quaternary alluvium and the underlying Fall River and Lakota aquifers of the Inyan Kara group (Sect. 3.6.2.1).

PERIOD	FORMATION NAME	SYMBOL	COLUMN	LITHOLOGIC DESCRIPTION	THKNS IN FEET	HYDROLOGIC CHARACTERISTICS
Quaternary	Alluvium	Qal		Gravel, sand, and silt floodplain deposits. Alluvial terraces and windblown material	1-30	Good to excellent aquifer along floodplains, terraces generally non-productive except for scattered springs
Cretaceous	Pierre Fm	Kp		Dark gray shale, weathering brown or buff and containing many fossiliferous concretions Scattered concretions which form "teepee buttes" Black fissile shale, cone-in-cone concretions	1000+	Relatively no value as an aquifer, locally large diameter wells in stream valleys may yield small amounts of highly mineralized water during wet seasons
	Niobrara Fm	Kn		Gray calcareous shale, weathering yellow and impure chalk with Ostrea Congesta	100-225	No known wells
	Turner sand Carlile Fm Wall Creek sand	Kcr		Light gray shale with large concretions Gray shale with thin sandstone layers Bed of impure limestone Thin sandstone	520-540	Relatively impermeable, possible small yields from Turner and Wall Creek sands
	Greenhorn Lms	Kg		Thin bedded hard limestone, weathering creamy white, contains Inoceramus Labiatus	50	Too thin and dense to be an aquifer
	Belle Fourche Fm Mowry Shale Graneros Group Newcastle sand Skull Creek Shale	Kgs		Light gray shale, bentonite, large concretions Light gray siliceous shale Thin brown-to-yellow sandstone Black shale	870	Newcastle sand may yield water, permeability is variable
	Fall River Fm	Kfr		Interbedded red-brown massive sandstone and Carbonaceous shales	30-165	Largest producer in the area. Yields up to 60 gpm of highly mineralized water (flow). Water quality generally poor, sometimes yields hydrogen sulfide
	Fuson Shale Minnewasta Lms Lakota Fm	Klk		Gray-to-purple shale, thin shales Light gray massive limestone Coarse, hard, cross-bedded sandstone, buff-to-gray, coal beds locally near base	0-180 0-25 130-230	Relatively good aquifer from the lower Chilson member, up to 30 gpm artesian flow
	Morrison Fm	Km		Green-to-maroon shale, thin sandstone	0-125	No known wells, possible aquifer
Jurassic	Unkpapa Fm	Ju		Fine grained, massive, vari-colored sandstone	0-240	No known wells, possible aquifer
	Sundance Fm	Jsd		Alternating beds of red sandstone and red-to-green marine shales	250-450	Produces small amounts of water from the sands suitable for domestic use
Triassic ?	Spearfish Fm	₨s		Red silty shale, limestone, and anhydrite near the top Redbeds Gypsum locally near the base	400	Poor producer, small yields of sulfate water
Permian	Minnekahta Lms	Cmk		Pale brown, to gray dense, crystalline limestone	50	Locally secondary fracture porosity
	Opeche Fm	Co		Red thinly bedded sandstones and shales, purple shale near top	100	No known wells
? Pennsylvanian	Minnelusa Fm	Cml		Converse sand, red-to-yellow cross bedded sand Red marker, thin red shale near middle Leo sands, series of thin limestones Dolomite at bottom with basal laterite zone	755-1040	Permeability variable, tremendous flows of warm mineralized water recorded near the perifery of the Black Hills. Excellent potential
Mississippian	Pahasapa Fm	Cps		Massive, light colored dolomite and limestone, cavernous in upper 100 feet	165-465	Most promising aquifer in the area. The 2 wells in this aquifer produce large amounts of water suitable for domestic use
Precambrian	Metamorphic and igneous rocks	P€		Granite, schists, quartzite, and slates	---	No potential

Fig. 3.8. Stratigraphic column for Edgemont and surrounding area. Source: J. R. Keene, *Groundwater Resource of the Western Half of Fall River County, S.D.*, Sciences Center, University of South Dakota, Report of Investigations, No. 109, 1973.

Proposed disposal site

The proposed disposal site is located at the head of an ephemeral drainage, a tributary to the Cheyenne River. Local relief is less than 18 m (60 ft), and the site has low erosion potential. Sedimentary rocks of early to late Cretaceous Age are of major importance at the disposal site (Fig. 3.9).

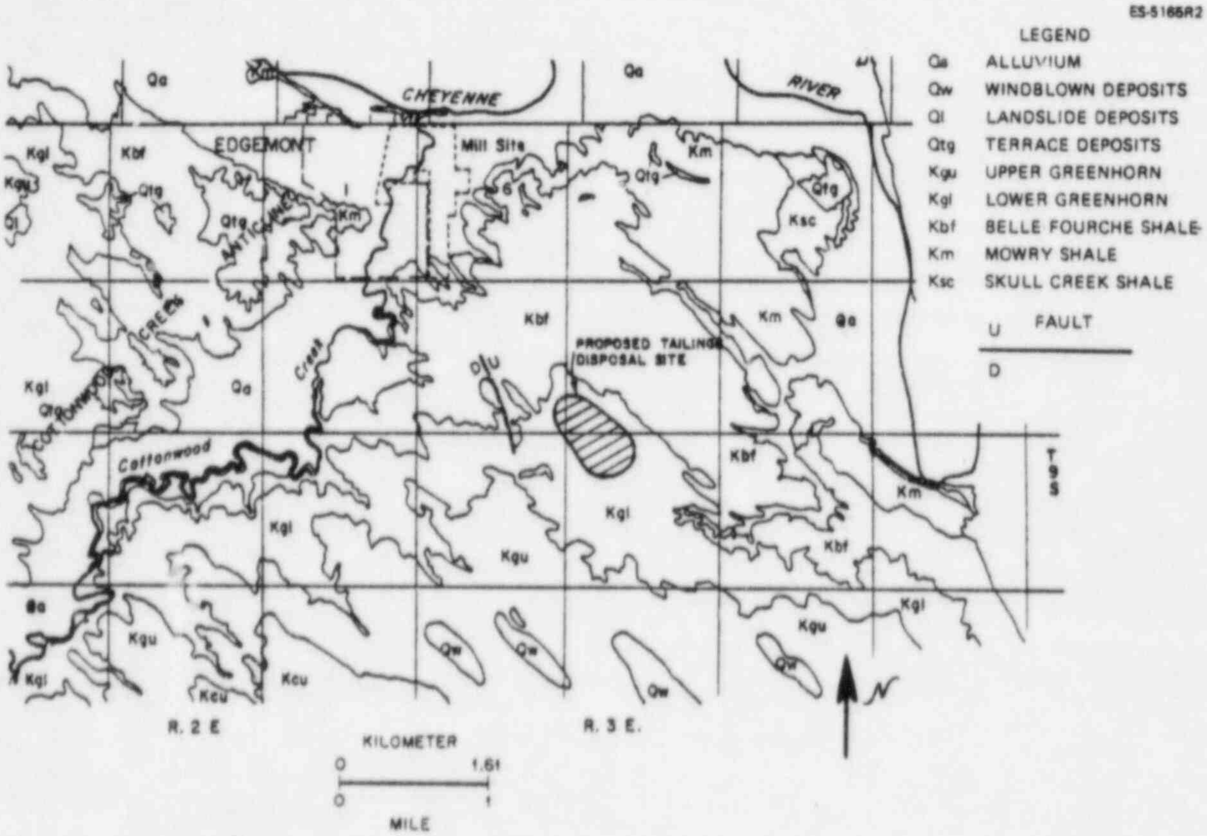

Fig. 3.9. Geologic map of proposed disposal site. Source: ER, rev. 2, Fig. 4.4-2.

A preliminary geotechnical investigation conducted at the proposed disposal site has provided the following subsurface geologic information:

As indicated in Fig. 3.10, four test borings along the proposed impoundment dike (embankment) axis and four test borings in the proposed disposal area were drilled to depths ranging from 7 to 15 m (21.5 to 50 ft). Cross sections of the subsurface materials encountered during drilling are displayed in Fig. 3.11. Data from these test borings indicate three distinct units.

The upper layer consists of residual soils that are probably relatively recent eolian and alluvial/colluvial materials. These materials are typically fine-grained silts and sands with varying amounts of clays, generally ranging from 15 to 30% by weight. The residual soils have a gradational contact with the underlying weathered silty clays (weathered shales) of the Lower Greenhorn Shale Unit.

The weathered silty clays of this formation comprise the second unit and are typically much thicker where the overburden of residual soils is thin and thinner with a corresponding thicker layer of the residual soils. The silty clays are characterized by numerous horizontal partings (very fissile) that are often filled with calcium deposits or stained with iron and sulfur (limonitic staining). Vertical fractures are also common in this zone and impart a blocky

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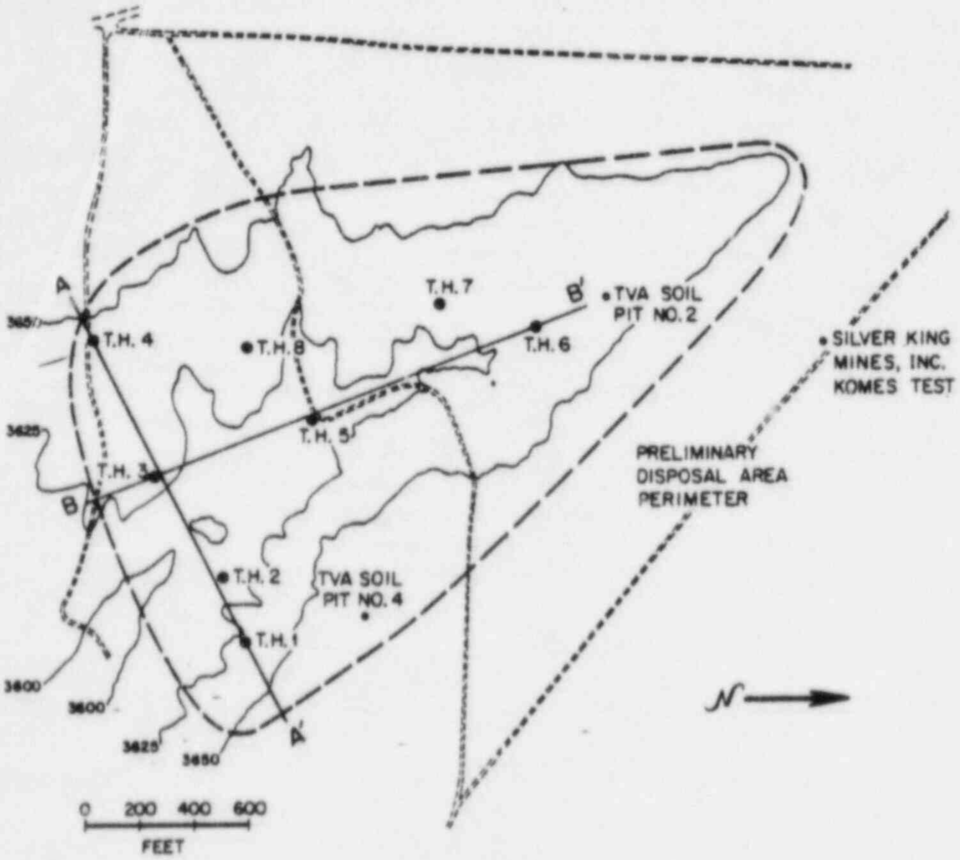

Fig. 3.10. Location of test borings at the proposed disposal site. Source: Francis-Meador-Gellhaus, Inc., *Subsurface Soil Exploration for Proposed Edgemont Uranium Waste Disposal Site*, prepared for Silver King Mines, Inc., Edgemont, S.D., June 1980.

structure to the formation. These silty clay soils are defined as CL and CH soils by the Unified Soils Classification System. Soils of this group are typically very fine grained with medium to high plasticity. Packer tests performed in the silty clay materials indicate that they are relatively impermeable and also have a tendency to self-seal with time.

The materials that comprise the third unit occur below the weathered silty clays and are very dense, slightly fissile, relatively unaltered clays of the Lower Greenhorn Shale Unit. These materials are very hard and can be considered highly impermeable (10^{-8} cm/s or less) to the depths explored.

A stratigraphic column derived from data obtained from the Komes Test 1 test hole (Fig. 3.10) drilled by Silver King Mines, Inc., is presented in Fig. 3.12. The following stratigraphic units are briefly described in descending order.

Surface materials at the disposal site consist of fine-grained alluvial sediments, weathered rock residuum, and eolian deposits. The thickness of the surficial and weathered material ranges from 0 to 15 m (0 to 50 ft).

Underlying the surficial materials is the lower unit of the lower Greenhorn Formation of Late Cretaceous Age. Only 8.5 m (28 ft) of this formation is exposed at the site. The unweathered part of this formation consists of black shale containing thin bentonite seams.

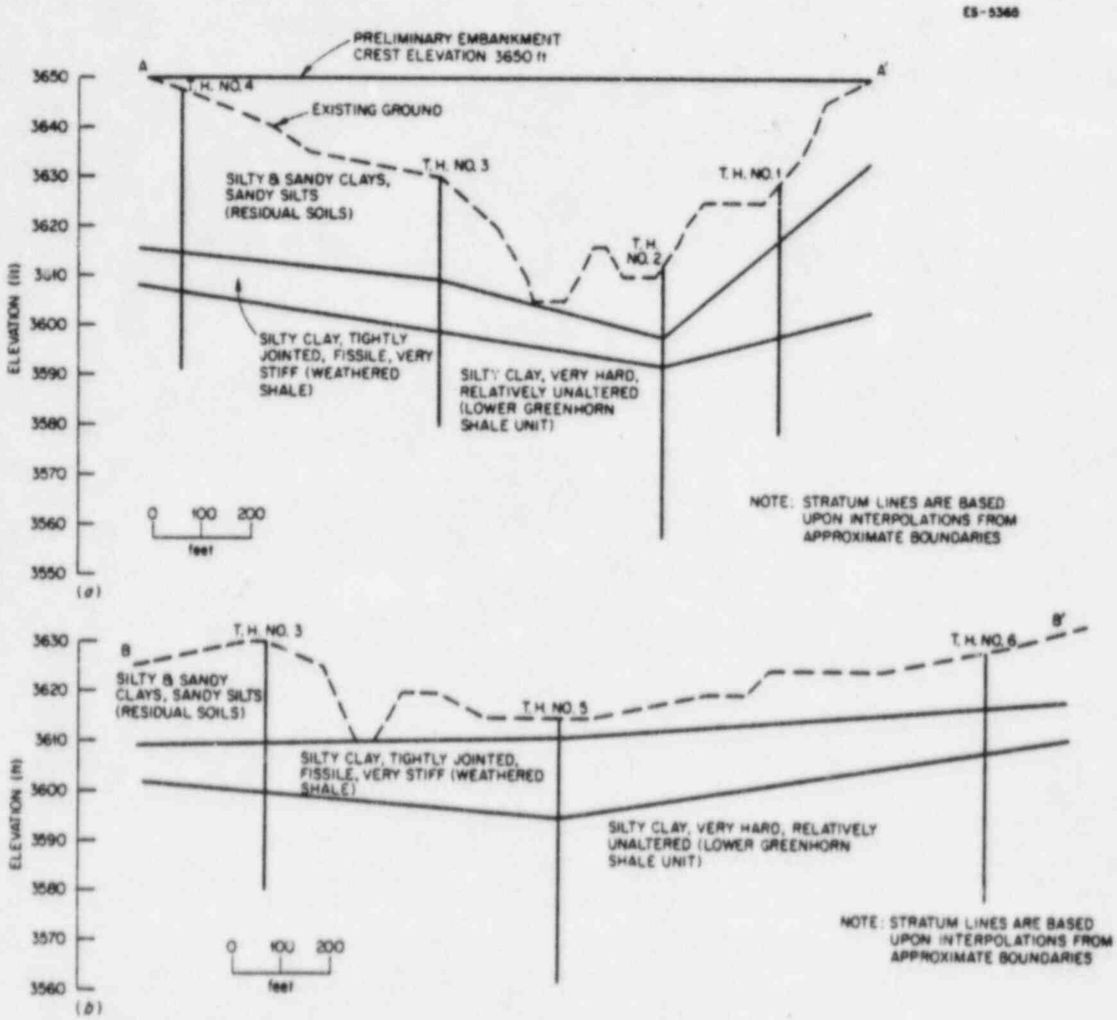

Fig. 3.11. Cross sections of subsurface materials encountered during geotechnical investigation (see Fig. 3.11). Source: Francis-Meador-Gellhaus, Inc., *Subsurface Soil Exploration for Proposed Edgemont Uranium Waste Disposal Site*, prepared for Silver King Mines, Inc., Edgemont, S.D., June 1980.

The base of the proposed disposal site will lie in the Belle Fourche shale, which is of late Cretaceous Age and has a thickness of 56 m (185 ft) adjacent to the site. The Belle Fourche shale is black and contains brown limestone beds and thin bentonite seams.

Underlying the Belle Fourche shale is the Mowry shale of early Cretaceous Age. The Mowry shale is light gray and is comprised of minor amounts of siltstone, sandstone, and thinly laminated beds of bentonite. The thickness of this formation adjacent to the site is 44 m (145 ft).

Below the Mowry shale lies the Newcastle sandstone (early Cretaceous Age), a lenticular, light- to medium-gray siltstone and very fine-grained sandstone. This formation is relatively permeable but is not considered an aquifer in this area because of its lenticular nature and limited areal extent. The thickness of this formation adjacent to the site is 3 m (7 ft).

The Skull Creek shale, which underlies the Newcastle sandstone (early Cretaceous Age), is black fissile shale containing limestone concretions. The thickness of this shale unit adjacent to the site is 66 m (215 ft).

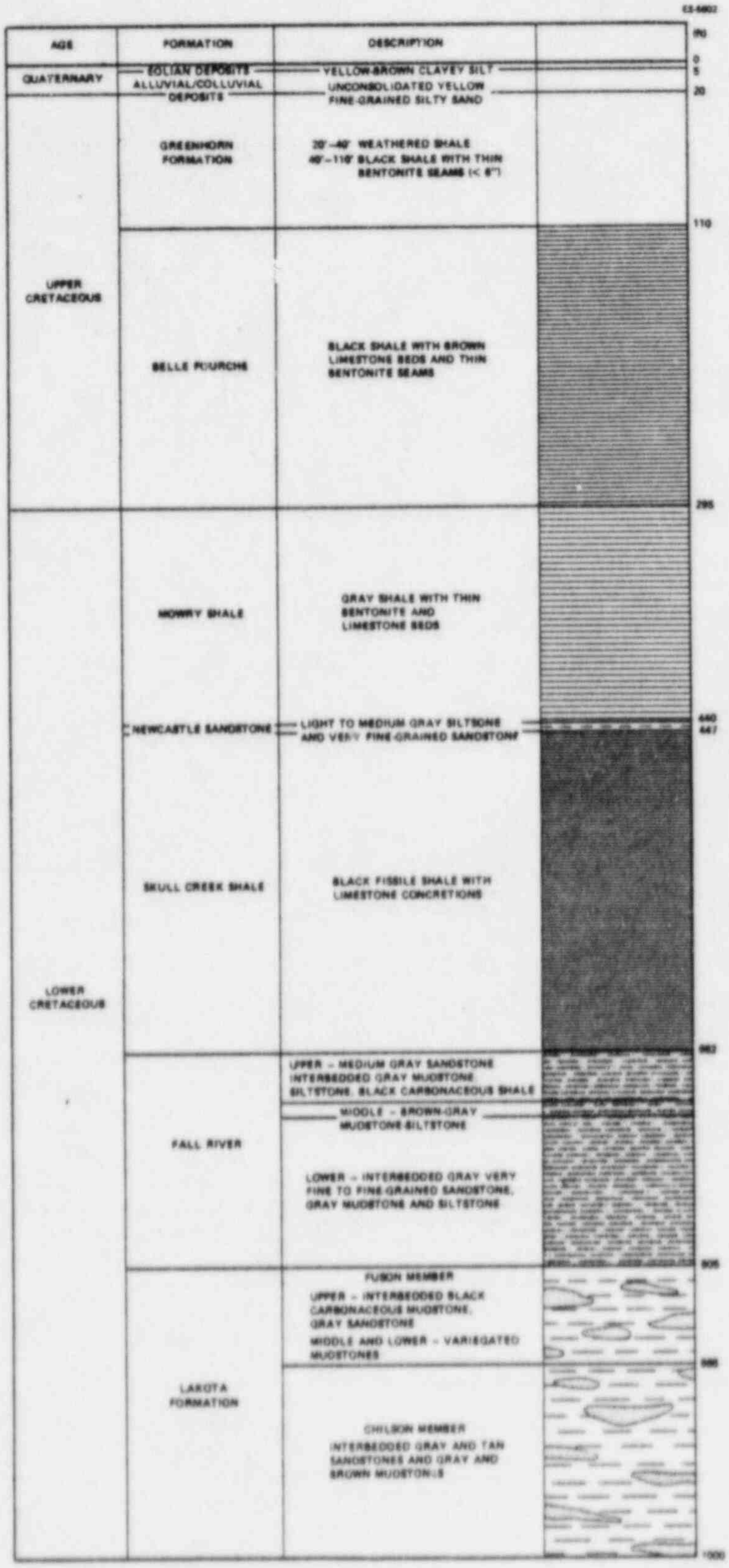

Fig. 3.12. Stratigraphic column based on data from Komes Test I test hole [elevation 1124 m (3687 ft)] (see Fig. 3.11). Source: Francis-Meador-Gellhaus, Inc., *Subsurface Soil Exploration for Proposed Edgemont Uranium Waste Disposal Site*, prepared for Silver King Mines, Inc., Edgemont, S.D., June 1980.

The Inyan Kara group (early Cretaceous Age) lies beneath the Skull Creek shale and includes the Fall River and Lakota formations. These two formations, both discussed in Sect. 3.6.2.1, are not expected to be affected by the proposed disposal plan because of the confining nature of the overlying Belle Fourche, Mowry, and Skull Creek shales.

The structural orientation of the formations at the proposed disposal site generally follows the regional dip of 2 to 4° to the southwest, striking approximately north 25° west. No major disturbance of the underlying geologic structure was encountered over the entire site.

3.7.1.3 Regional structure

The existing mill site and proposed disposal site are located along the southwest flank of the Black Hills uplift, an elongate northwest-trending dome of Laramide Age, approximately 200 km (125 miles) long and 97 km (60 miles) wide. Superimposed on the Black Hills uplift are numerous folds plunging radially outward. Local structures of this type are the Chilson anticline and Sheep Canyon monocline east of the community of Edgemont and the Cottonwood Creek anticline trending southwest from the community of Edgemont (Fig. 3.13). The regional dip of the sedimentary rocks in the project area is 2 to 4° southwest.

Two major structural zones, Dewey Mountain and Long Mountain, are located north and northwest of the project area (Fig. 3.13). The Dewey structural zone consists of sinuous, en echelon, steeply dipping to vertical normal faults. The Long Mountain structural zone consists of small northeast-trending normal faults. Many of the individual faults within this zone have been traced less than 1.6 km (1 mile).

There are two major sets of joints in the southern Black Hills area. These two joint sets strike northeast in the northern and central parts of the area, whereas, in the eastern part of the area, the dominant orientation is to the northwest.[35]

3.7.1.4 Seismicity

The area of southwestern South Dakota, where the Edgemont mill site is located, lies in a relatively quiet seismic region of the United States (Fig. 3.14). Earthquakes in this region have been few and low to moderate in magnitude. Few damage-producing earthquakes have originated in this region. According to the National Geophysical and Solar-Terrestrial Data Center, only seven earthquakes of significance have occurred within a 200-km (124-mile) radius of the proposed disposal site from the first documented earthquake in 1895 through 1976.[36]

The strongest observed earthquake, with an intensity of VII based on the modified Mercalli intensity scale, occurred in 1964 and was centered approximately 178 km (110 miles) east-southeast of the proposed disposal site. Some damage was reported in Alliance and Rushville, Nebraska.[37] Acceleration attenuation curves were used to estimate the maximum acceleration of rock that could be expected at the proposed disposal site from such an earthquake as less than 0.04 gravities.[38]

The epicenter of the nearest tremor to the site, which occurred in 1895, was located approximately 80 km (50 miles) northeast of the site. The tremor was reported to have had an intensity of V, but no damage was associated with that tremor. The maximum acceleration of rock at the site for a seismic event of such intensity would be much less than 0.01 gravities.

A recent probabilistic acceleration map of the contiguous United States indicates that the horizontal acceleration of rock at the project site is about 0.04 gravities, with 90% probability of not being exceeded in 50 years.[38] On the basis of the historic seismicity record and the tectonic framework of the region, it is highly unlikely that an earthquake of large magnitude will affect the disposal area in the foreseeable future.

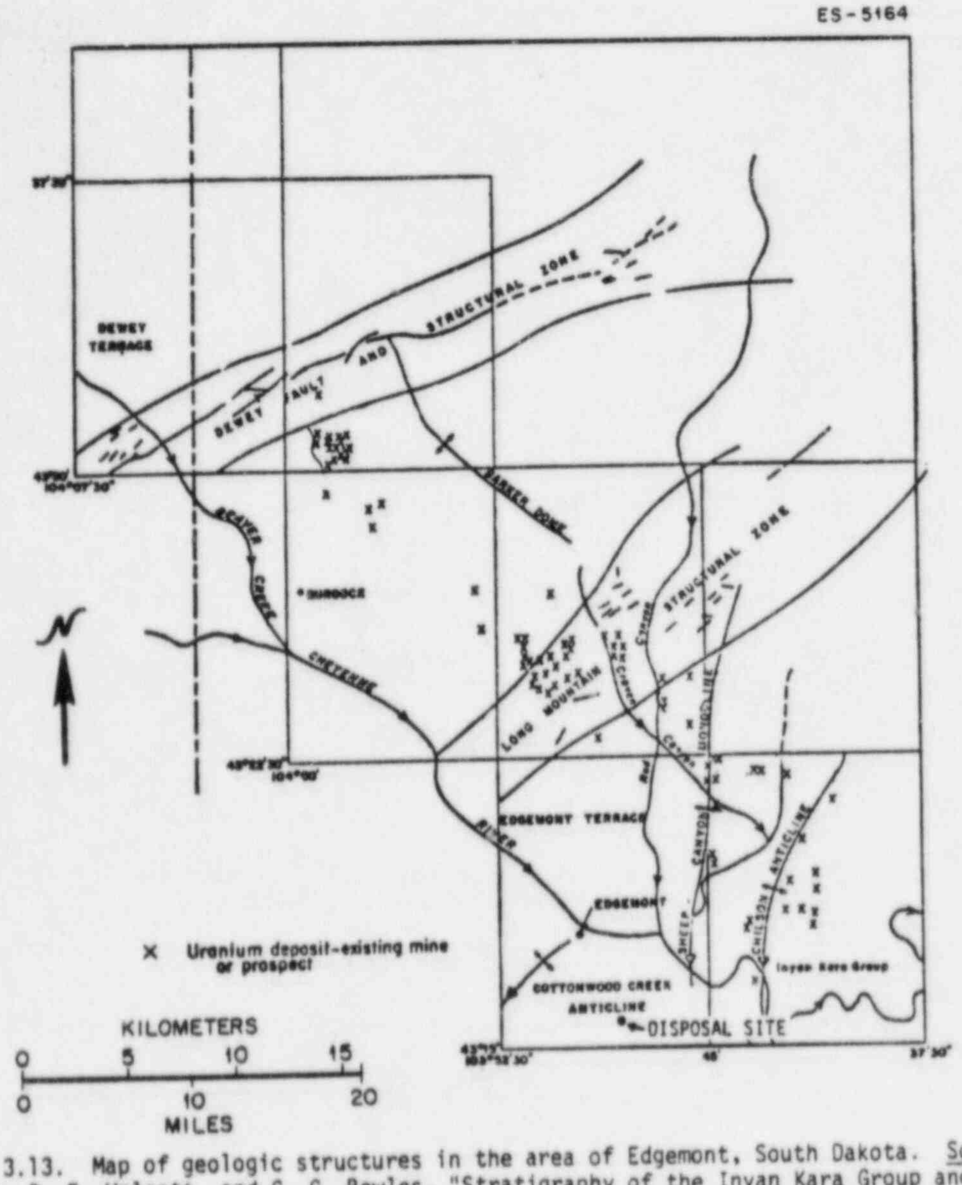

Fig. 3.13. Map of geologic structures in the area of Edgemont, South Dakota. Source: G. B. Gott, D. E. Wolcott and C. G. Bowles, "Stratigraphy of the Inyan Kara Group and Localization of Uranium Deposits, Southern Black Hills, South Dakota, and Wyoming," *U.S. Geol. Surv. Prof. Pap.* 763: 27-33 (1974).

3.7.2 Mineral resources

3.7.2.1 Uranium

Uranium is currently the most economically important mineral resource known in Fall River County. Numerous uranium deposits and occurrences have been delineated in rocks of the Inyan Kara group of Cretaceous Age. This area has been referred to as the Edgemont mining district. Production of uranium ore started in this area as early as 1952. Most of the early deposits contained the yellow uranium minerals carnotite and tyuyamunite and were mined from shallow open pits on short adits.

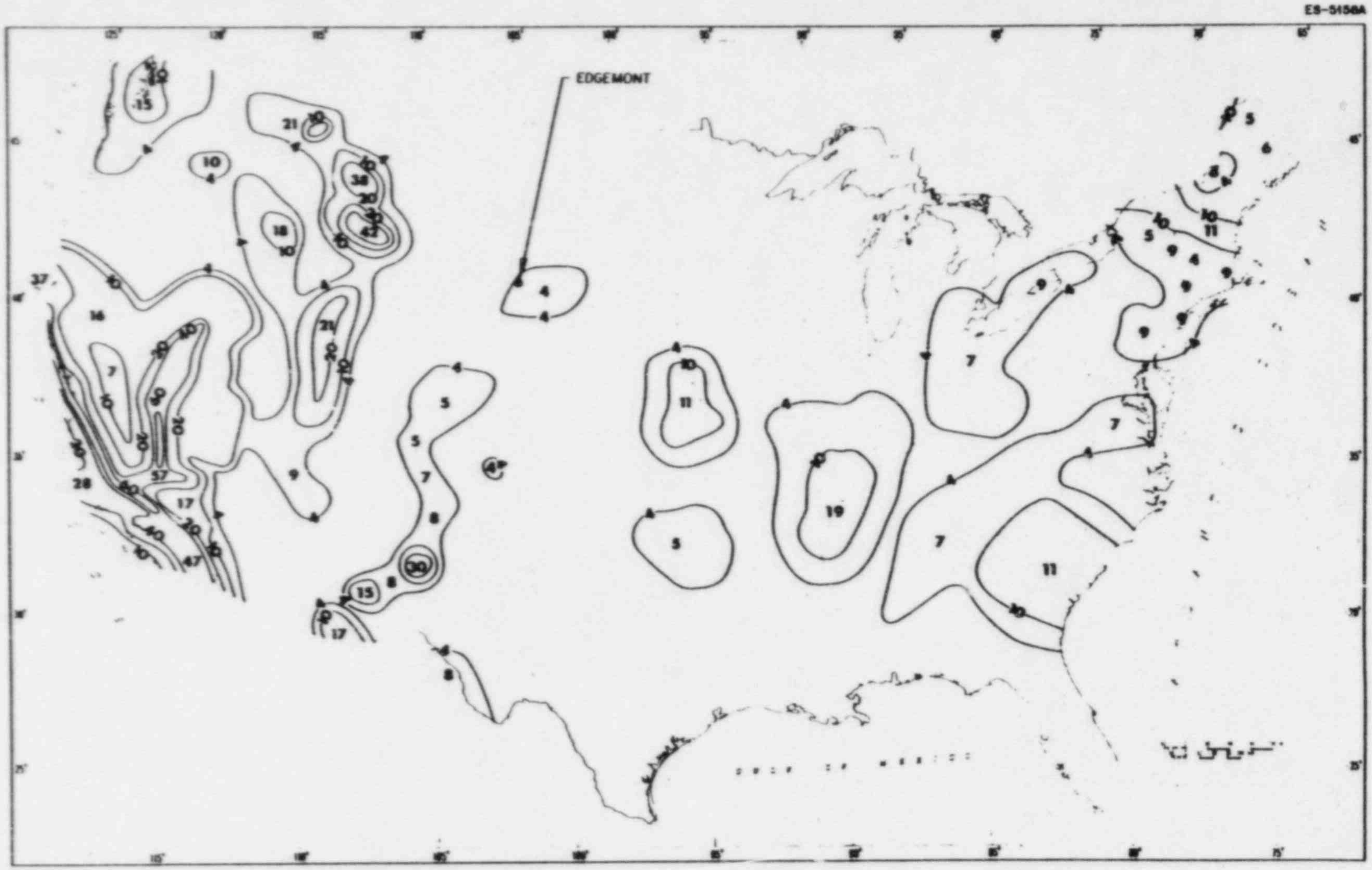

Fig. 3.14. Preliminary map of horizontal acceleration (expressed as percent of gravity) in rock with 90% probability of not being exceeded in 50 years. Source: U.S. Geological Survey Open-File Report 76-416, 1976.

3.7.2.2 Oil and gas

Several exploratory wells have been drilled in Fall River County. Because most wells have proved to be unsuccessful, only a small amount of oil has been produced from this area.

3.7.2.3 Coal

Although limited quantities of low-grade coal have been mined from the Chilsom member of the Lakota Formation in Fall River County, the prospect for commercial development seems unlikely.

3.7.2.4 Sand and gravel

Sand and gravel previously used for road building in the area are abundant in the alluvium of the Cheyenne River and the higher level terrace deposits in the county.

3.8 SOILS

A soil association map for the mill site, the preferred tailings disposal site, and the surrounding area is presented in Fig. 3.15. Characteristics of those soils expected to be disturbed directly and indirectly by decommissioning activities at the mill site, haul road, disposal site, and soil-stockpiling and borrow areas are presented in Table 3.19.

Soils in the area generally vary from a loose, friable silt-clay loam to a sticky or plastic clay. Although most of the soils on the disposal site have formed from weathering of the Lower Greenhorn Formation, a few soils have formed from eolian deposits (ER, Sect. 4.5.1). It is planned that Norka silt loam and Nunn clay loam from the disposal site and immediate vicinity will be used for reclamation.

Norka silt loam is a deep, well-drained, gently sloping soil that is formed from eolian deposits on uplands. According to the applicant's consultation with the Soil Conservation Service (Sect. 4.5.1), Norka soil is medium in fertility and moderate in organic matter and has a good tilth and deep root zone. The available water capacity is high, and permeability is moderate to moderately slow. The shrink-swell potential is moderate, and runoff is slow to medium. Norka soil has good potential for use as cropland, range, windbreaks, and most types of recreation; it also has a fair-to-good potential for most engineering uses.

The Nunn clay loam is a deep, well-drained, very gently sloping soil found on terraces, alluvial fans, and uplands. The Nunn soil is medium in fertility and moderate in organic matter content. The good tilth and deep root zone of this soil make it well suited for use as cropland. The available water capacity is moderate to high, permeability is moderately slow, and runoff is characterized as slow to medium (ER, Sect. 4.5.1).

In June 1980, Norka silt loam and Nunn clay loam associations within the proposed disposal site and along its immediate boundaries were sampled to determine the volume and suitability of material for use as plant growth media. Approximately 751,000 m^3 (982,800 yd^3) of soils suitable for plant growth exist in this area. The soils are predominately sandy loams ranging in depth from 165 cm (70 in.) to 300 cm (120 in.) (ER, Sect. 4.5.1.2). The following chemical and physical characteristics of the soils were all considered "good" based on a Wyoming Department of Environmental Quality publication regarding suitability ratings of soils for use as topsoil (ER, Table 4.5-2): pH; electrical conductivity; saturation percentage; texture class; and copper, molybdenum, and soluble calcium and magnesium. Levels of major nutrients such as nitrogen and phosphorus were not presented in the Environmental Report (ER). The ER recognized, however, that such nutrients are generally lacking in the regional soils and concluded that application of commercial fertilizer will be necessary to improve the suitability of the soil for use in reclamation (ER, Sects. 4.5.1.2 and 4.6.3.3).

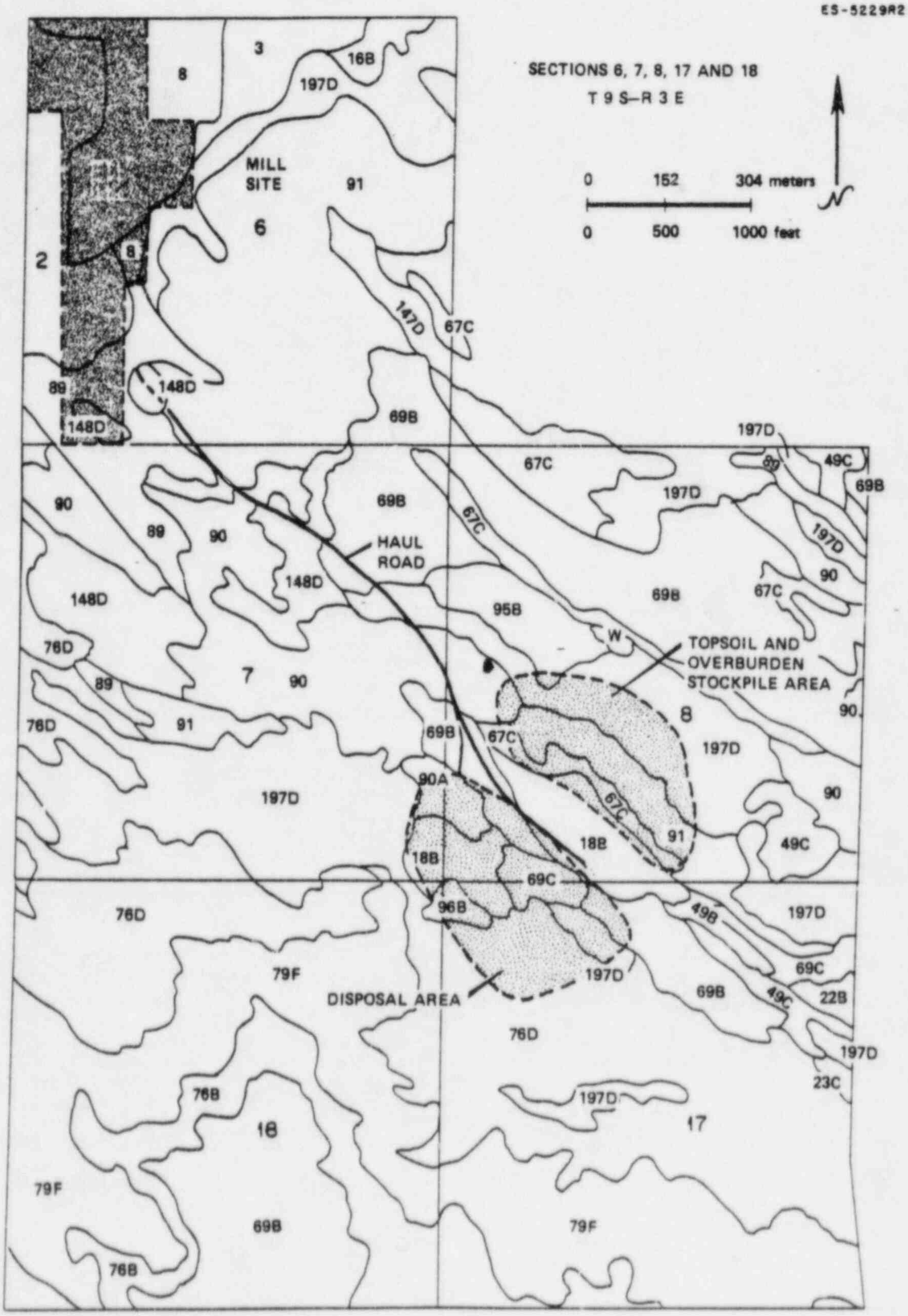

Fig. 3.15. Soil association map. Soil mapping unit, name, and characteristics are given in Table 3.19. Source: Modified from ER, Fig. 3.3-4 and L. M. Mills, TVA, personal communication, March 20, 1980.

Table 3.19. Characteristics of soils expected to be disturbed by project-related activities

Map symbol[a]	Soil mapping unit name	Cropland capability unit[b]	Pasture and hay land groups[c]	Slope (%)	Thickness of "A" horizon (cm)	Suitability as topsoil[d]	Depth to bedrock (cm)	Suitability of soil material for plant growth[e]
2	Lohmiller silty clay loam	IIIc2	F	0–2	20	Fair	>152	Fair
3	Haverson loam	IIIc2	F	0–2	15	Good	>152	Good
8	Glenbuerg fine sandy loam	IVe6	H	0–2	15	Good	>152	Good
18B	Nunn clay loam	IIIe1	F	2–6	20	Fair	>152	Fair
67C	Colby-Norka silt loams, Colby part	VIe3	GN	6–15	18	Fair	>152	Fair
69B	Norka silt loam	IIIe1	F	2–6	15	Good	>152	Good
69C	Norka silt loam	IVe1	F	6–9	15	Good	>152	Good
76D	Minnequa-Midway silty complex, Minnequa part	VIe3	GN	6–25	33	Poor	51–102	Poor
89	Bradhurst clay	VIs6	NS	2–9	10	Poor	>152	Poor
90	Grummit-Snomo clays, Grummit part	VIe12	NS	3–15	15	Poor	<51	Poor
91	Grummit-rock outcrop complex, Grummit part	VIIe5	NS	3–40	15	Poor	<51	Poor
95A	Kyle clay	IVs3	I	0–2	10	Poor	>152	Poor
95B	Kyle clay	IVe3	I	2–6	10	Poor	>152	Poor
148D	Dwyer loamy fine sand	VIIe3	NS	2–6	15	Poor	>152	Fair
1C7D	Pierre-Grummit clay Pierre part	VIe4	IN	6–25	10	Poor	51–102	Poor

[a] See Fig. 3.16.

[b] The capability of each of the following mapping units for agricultural uses reflects on its suitability for use in reclamation:

IIIc2 Deep, loamy soils on nearly level (0 to 2%) bottom lands and foot slopes that sometimes receive beneficial overflow. The main limitation is inadequate moisture, and the main hazard is wind erosion.

IIIe1 Deep and moderately deep, loamy soils on gently sloping (2 to 6%) uplands. The main limitation is moisture shortage, and the main hazards are wind and water erosion.

IVe1 Moderately deep and deep, loamy soils on undulating and sloping (6 to 9%) uplands. They have severe water and moderate wind erosion hazards. The main limitation is inadequate moisture.

IVe3 Deep and moderately deep, clayey soils on gently sloping (2 to 6%) uplands. The main limitations are inadequate moisture and an unfavorable rooting zone, and the main hazards are water and wind erosion.

IVe6 Deep and moderately deep, moderately sandy soils on nearly level (0 to 2%) bottom lands, terraces, and uplands. They have severe wind erosion hazards. The main limitations are inadequate moisture and low water-holding capacity.

IVs3 Moderately deep, clayey soils on nearly level (0 to 2%) uplands. The main limitations are inadequate moisture and unfavorable rooting zone, and the main hazard is wind erosion.

IVe3 Deep and moderately deep, clayey soils on gently sloping (2 to 6%) uplands. The main limitations are inadequate moisture and an unfavorable rooting zone, and the main hazards are water and wind erosion.

VIe4 Deep and moderately deep, clayey soils on sloping to steep (6 to 25%) uplands. These soils have severe water and wind erosion hazards. The main limitations are inadequate rainfall and unfavorable rooting zones.

VIe12 Shallow, clayey soils on nearly level to moderately steep (0 to 25%) uplands. These soils have a severe water erosion hazard, limited rooting depth, and are not suited for cultivation.

VIs6 Dense clay soils on nearly level to sloping (0 to 9%) uplands and toe slopes. The main limitations are unfavorable rooting zone and salts, and the main hazard is water erosion.

VIIe3 Shallow to deep, sandy soils on steep (25 to 40%) uplands. They have severe wind and water erosion hazards. The main limitations are low or very low available water capacity and steep slopes.

VIIe5 Shallow, clayey soils on steep and very steep (25 to 50%) uplands. They have a severe water erosion hazard.

[c] The following grouping of soils for use as pastureland and hay land reflects on their suitability for use in reclamation:

Group F Loamy or silty soils well suited for all climatically adapted plants.

Group H Sandy soils with choice of species and yields limited by limited available water capacity and wind erosion hazard.

Group GN Steeper slope phases (9 to 40%) of limy soils with thin surface layers not recommended for pasture plantings because of erosion hazard.

Group NS Soils not suited for pasture plantings because of severe limitations in depth of rooting zone, water intake rate, available water capacity, or low fertility.

Group I Clayey soils with choice of species and yields limited by very slow water intake rate and slow permeability.

Group IN Steeper slope phases (6 to 40%) of clayey soils not recommended for pasture plantings because of erosion hazard.

[d] Suitability for use as topsoils refers generally to the A horizon.

[e] This column refers to suitability of materials to 152 cm or to bedrock that will support vegetation or is a medium of plant growth, based upon general texture, structure, erodibility, available water capacity, soluble salt content, depth, and accessibility or availability.

3.9 BIOTA

3.9.1 Terrestrial

Natural plant communities in the vicinity of Edgemont are classified as potential shortgrass prairie, Black Hills ponderosa pine, and sagebrush steppe (ER, Sect. 4.6.1.1). The grasslands are dominated typically by western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and buffalo grass (*Buchloë dactyloides*). Major species within the ponderosa pine communities include ponderosa pine (*Pinus ponderosa*), Rocky Mountain juniper (*Juniperus scopulorum*), and sedge (*Carex* spp.). The sagebrush steppe association is reflected in the occurrence of big sagebrush (*Artemesia tridentata*) and black greasewood (*Sarcobatus vermiculatus*) communities. In addition to the three major vegetation assemblages, the riparian habitat found along Cottonwood Creek and the Cheyenne River provides a wide diversity of habitat conditions.

3.9.1.1 Flora

Because nearly all of the mill site (including Cottonwood Creek) has been disturbed by the milling activities, very little natural vegetation remains. About 50 ha (123 acres) of the 86-ha (213-acre) site are covered by tailings in 11 distinct areas (Fig. 3.5). Approximately 30 ha (74 acres) have received varying degrees of reclamation in the past with varying degrees of success.[17] Generally, revegetation attempts were unsuccessful. Some areas established sparse stands of yellow sweet clover (*Melilotus officinalis*) and crested wheatgrass (*Agropyron desertorum*). Other areas are covered by sparse stands of native weeds.

A ponderosa pine community is located immediately east of the mill site. An undetermined amount of windblown sand tailings have contaminated an estimated 32 ha (80 acres) of this habitat.[17]

The composition and average ground cover of plant communities located between the mill and proposed tailings disposal area and at the disposal site itself are listed in Table 3.20. The plant communities consist of both short and medium-tall grasses and sagebrush typical of the region in general. Staff inspection of the area in October 1979 confirmed that no unique natural communities occur in areas to be disturbed.

Table 3.20. Natural perennial ground cover in the vicinity of the Edgemont mill and proposed tailings disposal site

Community	Average ground cover (%)	Representative dominant species
Big sagebrush, medium stand	40	Big sagebrush, buffalo grass, blue grama, western wheatgrass, prairie sandreed
Big sagebrush, heavy stand	58	Big sagebrush, blue grama, buffalo grass, western wheatgrass threadleaf sedge
Rough breaks	14	Big sagebrush, wild buckwheat, blue grama, buffalo grass, side oats grama
Grassland	29	Buffalo grass, blue grama, prairie sandreed, little bluestem, western wheatgrass

Source: ER, Table 4.6-1.

According to South Dakota Statutes 41-2-32, 41-2-18, and 34A-8-3, the State has not classified any plant species as threatened or endangered.[39] In addition, no Federally listed endangered or threatened plant species occur in the vicinity of the project.[40]

3.9.1.2 Fauna

Numerous species of wildlife are known to occur in the Black Hills and outlying areas.[41-43] Although principal species in the project area are those that depend upon grassland/sagebrush habitat, the diversity is great because of the riparian habitat along Cottonwood Creek and the Cheyenne River, the ponderosa pine adjacent to the east boundary of the mill site, and the rimrocks and canyons in the Edgemont area (ER, Sect. 4.6.1.2).

Because of the diverse structure, species composition, and increased density of trees, shrubs, sedges, forbs, and grasses, riparian habitat provides food, shelter, and breeding areas for numerous animals including turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*). Turkey, raptors (hawks and owls), and mule deer (*Odocoileus hemionus*) utilize the pine stands extensively, and the rimrocks and canyons in the Edgemont area provide habitat for several species of raptors as well as their prey.

As described in the previous sections, nearly all of the mill site has been disturbed by the uranium milling activities. Perching birds found along Cottonwood Creek are the dominant species of wildlife using this area. For the last few years, a white-tailed deer (*Odocoileus virginianus*) with a single fawn has been observed at the mill site each year.

Communities in the vicinity of the project are important directly to several wildlife species and indirectly by modifying the environment. Shrubs tend to collect snow, and their shade results in a slow release of moisture in the spring, creating microhabitats favorable for mixed grasses and forbs. Shrublands are especially important as browse for antelope (*Antilocapra americana*) and mule deer. Further, sagebrush shrublands are used by sage grouse (*Centrocercus urophasianus*) for feeding and strutting grounds.

Limited onsite surveys of the sagebrush/grass and grass associations of the disposal site were conducted in the spring and summer of 1980 (ER, 4.6.1.2). Five species of mammals and 11 species of birds were observed (ER, Tables 4.6-3 and 4.6-4); all are considered common to the area.

Estimations of the densities of selected game species that could be supported on the lands within a 19-km (12-mile) radius of Edgemont are given in Table 3.21. In addition, habitat within the region is available for ring-necked pheasant (*Phasianus colchicus*), sage grouse (*Centrocerus urophasianus*), and mourning dove (*Zenaidura macroura*), although no sage grouse presently occurs in Fall River County. Hunting of sage grouse may occur if populations return. A referendum was passed in November 1980 that will allow hunting of mourning dove. Hunting predators, such as red fox (*Vulpes fulva*) and bobcat (*Lynx rufus*), are common in the region.

Table 3.21. Estimations based on sport hunting of density capability for selected game species in the vicinity of Edgemont

Species	Crude density capability	
	No./km^2	No./sq mile
Deer (*Odocoileus* spp.)	1.5–2.7	4.0–6.9
Antelope (*Antilocapra americana*)	0.2–0.6	0.6–1.5
Sharptail grouse (*Pedioecetes phasianellus*)	0.3–20.9	0.8–54.2
Turkey (*Meleagris gallopavo*)	0.6–0.7	1.5–1.7
Cottontail rabbit (*Sylvilagus* spp.)	0.0–3.9	0.0–10.0
Ducks	4.1–20.2	10.5–52.3
Muskrat (*Ondatra zibethica*)	4.2–5.7	10.9–14.8
Coyote (*Canis latrans*)	1.1–1.5	2.9–4.0
Prairie dog (*Cynomys ludovicianus*)	20.4–28.0	52.9–72.6

Source: C. Keeler, South Dakota Department of Wildlife, Parks, and Forestry, personal communication, Jan. 3, 1980.

The staff contacted the U.S. Fish and Wildlife Service regarding the presence of threatened and endangered species. Endangered species that may occur at the site and vicinity are the bald eagle (*Haliaeetus leucocephalus*), American peregrine falcon (*Falco peregrinus anatum*), and black-footed ferret (*Mustela nigripes*).[40] Field surveys conducted by the applicant in 1976, 1979, and 1980 did not reveal the presence of any of these species in the vicinity of the project (ER, Sect. 4.6.1.2). Staff inspection of the area in October 1979 confirmed that no habitat suitable for these species occurs in areas to be disturbed. The peregrin falcon, however, is known to inhabit the Black Hills region, and the bald eagle could be found in the area during winter as a transient. The ferret is not known to inhabit the area but potentially exists because of the presence of prairie dogs, a primary food source. However, no prairie dog towns are located in the immediate vicinity of the project.[44] The Northern swift fox (*Vulpes velox hebes*), classified as threatened by the State of South Dakota,[44] is known to occur in Fall River County. Jon Sharps, Endangered Species Coordinator for Region 1, South Dakota Department of Game, Fish, and Parks, doubts if any are present in the Edgemont area because of lack of suitable habitat (J. Sharps, South Dakota Department of Game, Fish, and Parks, Rapid City, personal communication, Nov. 20. 1979).

3.9.2 Aquatic

The extent of habitats available in the Edgemont area depends in part on surface water flow. The gradient of the Cheyenne River from the Wyoming line to the Edgemont area is low and creates an aquatic habitat characterized by long reaches of moderate depth [generally less than 15 cm (5.9 in.)] interspersed by occasional deep pools [>75 cm (29.5 in.)] and shallow riffles [<5 cm (1.9 in.)]. Irregularities in substrate elevations combined with low flows produce small sloughs and backwater areas with little flow.[45] The topography of Cottonwood Creek is similar to that of the Cheyenne River. Variances in stream flow are such that the substrate may be scoured by flood flow, covered with deposited silt, or exposed and subjected to drying, which causes changes in habitat availability.

The aquatic flora and fauna of Cottonwood Creek and the Cheyenne River are characteristic of western semiarid regions. Expected wide fluctuations in diversity and number of species occur as a result of frequent changes in habitat availability. Cottonwood Creek exhibits rich aquatic communities[46] (phytoplankton, zooplankton, macrobenthos, and fish), probably results of relatively stable flow regime and of varied habitat provided by submerged and emergent aquatic vegetation (ER, Sect. 4.6.2). Thirty-four fish species (20 native and 14 introduced) representing nine families have been reported for the Cheyenne River.[47] Samples taken by consultants for TVA at ten sites in the Cheyenne River showed that seven species representing four families occur on or near the Edgemont site. Of these seven species, only bluegill and black bullhead are considered sport species; the remainder are forage species.

No significant fishery exists for either of the two sport species in the vicinity of Edgemont[45] (ER, Sect. 4.6). The Angostura Reservoir [54 km (33.5 miles) downstream of Edgemont] was characterized by the South Dakota Department of Game, Fish and Parks in a 1971 unpublished report as providing good fishing in the spring and fall. A 1975 survey described summer fishing as good with moderate pressure and winter fishing as good with light pressure and revealed that walleye (*Stizostedion vitreum vitreum*) and smallmouth bass (*Micropterus dolomieui*) were the predominant species.[48] Species caught during the 1975 survey are shown in Table 3.22.

Rare and endangered species

No rare, threatened, or unique phytoplankton, zooplankton, or marcrobenthos species nor unique habitats were identified from either Cottonwood Creek or the Cheyenne River. In 1976, the plains topminnow (*Fundulus sciadicus*), a South Dakota threatened species, was taken from the Cheyenne River. The consultants found submerged and emergent aquatic vegetation, which is the preferred habitat for this species. The applicant took further samples (Fig. 3.16) in 1979 but did not find individuals of this species (Table 3.23) or their preferred habitat.[45] Natural fluctuations between wet/dry years and high/low flows within a year may cause habitat variation that could influence the presence or absence of this species in the Edgemont area. For example, although Bailey and Allum[47] did not record the plains topminnow in the Cheyenne River drainage in South Dakota, the presence of *F. sciadicus* in headwater streams of the Cheyenne River in Wyoming[49] could serve as a source of individuals in the Cheyenne River near Edgemont.

Table 3.22. Fish species collected in gill and trap nets from Angostura Reservoir, South Dakota, June 1975

Carp	*Cyprinus carpio* Linnaeus
Golden shiner	*Notemigonus crysoleucas* (Mitchill)
River carpsucker	*Carpiodes carpio* (Rafinesque)
White sucker	*Catostomus commersoni* (Lacépède)
Redhorse	*Moxostoma* sp.
Black bullhead	*Ictalurus melas* (Rafinesque)
Channel catfish	*Ictalurus punctatus* (Rafinesque)
Bluegill	*Lepomis macrochirus* Rafinesque
Smallmouth bass	*Micropterus dolomieui* Lacépède
Crappie	*Pomoxis* sp.
Yellow perch	*Perca flavescens* (Mitchill)
Walleye	*Stizostedion vitreum vitreum* (Mitchill)

Source: South Dakota Department of Game, Fish and Parks (unpublished data).

A joint survey of the Cheyenne River in the Edgemont area was conducted by TVA and the South Dakota Department of Game, Fish, and Parks in July of 1980 for the plains top minnow (Jon Sharps, South Dakota Department of Game, Fish, and Parks, personal communication, Apr. 3, 1980). Additional sampling did not find the species or its preferred habitat.

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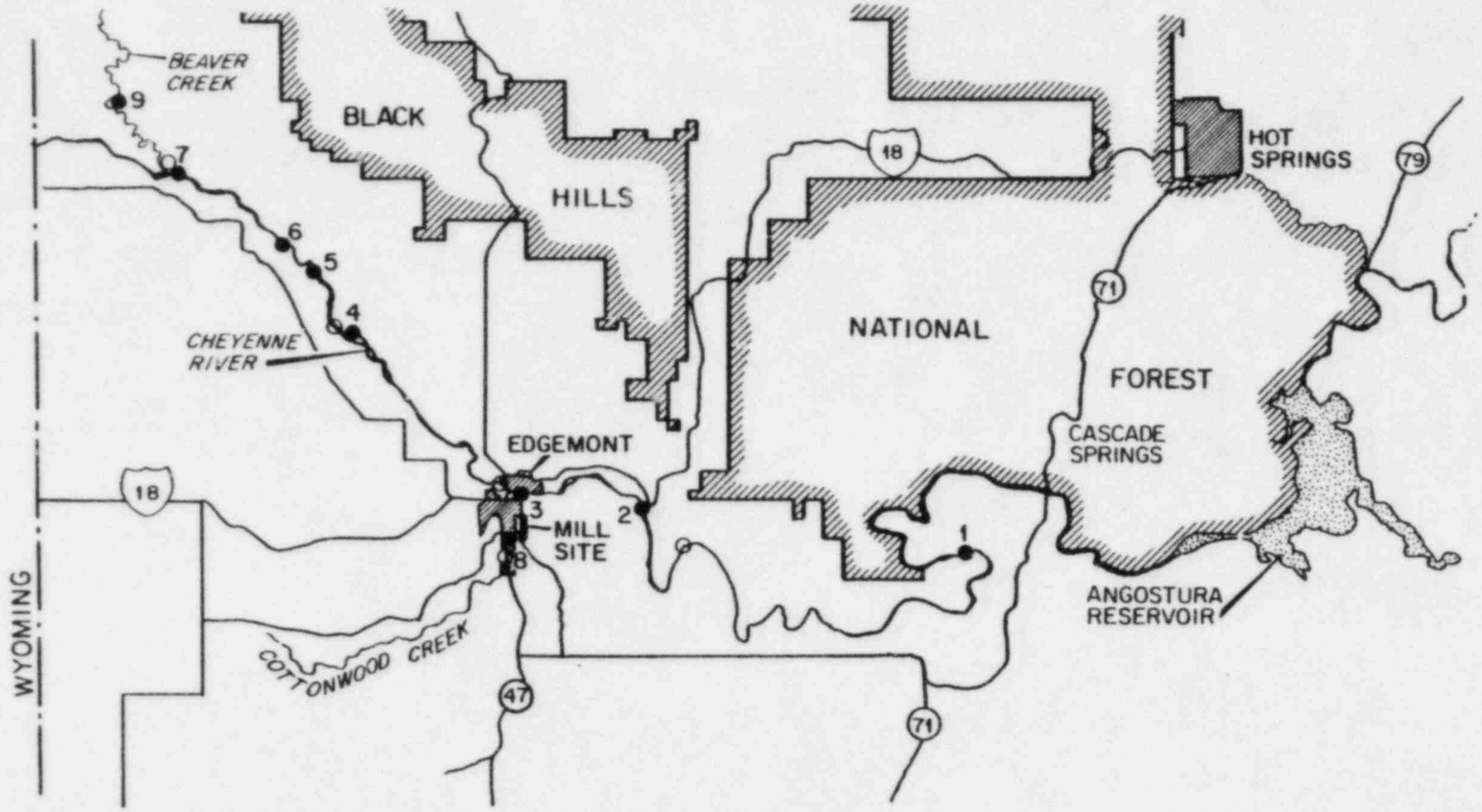

Fig. 3.16. Fish sample stations, Cheyenne River Basin, May 18 through May 22, 1979. Source: Modified from R. B. Fitz, *Fisheries Resources of the Cheyenne River Basin, Fall River County, South Dakota, May 18-22, 1979*, Tennessee Valley Authority, Fisheries and Aquatic Branch, Division of Water Resources, Norris, Tenn., July 1979, Fig. 1.

Table 3.23. Fish species distribution and relative abundance in the Cheyenne River Basin, May 1979

Species	Relative abundance (%) at station:								
	1	2	3	4	5	6	7	8	9
Plains minnow *(Hybog athus placitus)* Girard		2	[illegible]	29	27	45	74		7
Sand shiner *(Notropis stramineus)* Cope	92	83	62	22	28	22	*a*	55	50
Plains killifish *(Fundulus kansae)* Garman	4	*a*	4	22	7	6	19	36	1
Fathead minnow *(Pimephales promelas)* Rafinesque	4	4	*a*	14	2	15	1		10
Flathead chub *(Hyhopsis gracilis)* Richardson		*a*	9	9	28	4	2		15
Longnose dace *(Rhinichthys cataractae)* Valenciennes			3	1	3	5	1	9	11
River carpsucker *(Carpiodes carpio)* Rafinesque		*a*		1	2		1		1
Channel catfish *(Ictalurus punctatus)* Rafinesque		5		*a*		1			2
Green sunfish *(Lepomis cyanellus)* Rafinesque			*a*	*a*	1	*a*	*a*		2
White sucker *(Catostomus commersoni)* Lacepede		6					*a*		
Carp *(Cyprinus carpio)* Linnacus			*a*		*a*		*a*		
Black bullhead *(Ictalurus melas)* Rafinesque					*a*				*a*

[a] <1 %.

Source: Modified from R. B. Fitz, *Fisheries Resources of the Cheyenne River Basin, Fall River County, South Dakota, May 18–22, 1979,* Tennessee Valley Authority, Fisheries and Aquatic Branch, Division of Water Resources, Norris, Tenn., July 1979, Table 2.

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4. ENVIRONMENTAL CONSEQUENCES, MONITORING TO DETECT IMPACTS, AND MITIGATION OF IMPACTS

4.1 IMPACTS ASSOCIATED WITH PROPOSED ACTIONS

4.1.1 Air quality

The major nonradiological atmospheric pollutants from the decommissioning activities will be gaseous emissions from internal combustion engines and total suspended particulates (TSP) from scraping and loading the tailings and borrow material, from transporting this material, and from wind erosion of exposed surfaces (e.g., disturbed lands and stockpiled soils). In general, these emissions will not produce significant long-term (annual-average) impacts on the air quality of the region. The utilization of a slurry pipeline and nearby disposal site will significantly reduce emissions generated in transporting the tailings and contaminated material. The proposed plan would therefore result in relatively minor short-term impacts to air quality compared with other alternatives that involve the exclusive hauling of materials by truck to a more distant location.

The projected annual-average ambient concentrations of pollutants from internal combustion engines (SO_2, NO_X, CO, and hydrocarbons), calculated by the applicant using EPA's Climatological Dispersion Model, are well below Federal and State standards (ER, Sect. 4.1.2.2.4). Consequently, impacts from these emissions are expected to be insignificant.

The amount of TSP generated during the decommissioning operation will be related primarily to the amount of material (tailings and soils) transported. It is anticipated that the entire mill site [86 ha (213 acres)] and disposal site [104 ha (258 acres)] will be disturbed. Construction of the haul road and diversion ditch will disturb an additional 12 ha (30 acres) and 5.3 ha (13 acres), respectively. Additional lands will be disturbed for cleanup of contaminated areas east of the mill site and for obtaining borrow material in excess of that available from the disposal area. The applicant used the amount of material to be moved (ER, Table 4.1-10) in conjunction with soil-particulate-size distributions, moisture contents, wind speeds and turbulence characteristics, vegetative cover, vehicle speeds, and proposed techniques to reduce fugitive dust to estimate the total fugitive dust emissions during decommissioning activities (ER, Sect. 4.1.2.2.3). This information was then used by the applicant to derive worst-case estimates of the short-term (24-h) and long-term (annual-average) emission rates for TSP based on onsite meteorological data (ER, Sect. 4.1.2.2.4).

Short-term impacts from TSP were studied by selecting three 24-h periods of onsite wind data that will result in the highest predicted concentrations and inputting these data with the estimated emission rates into the U.S. Environmental Protection Agency's (EPA's) PAL (Gaussian-Plume Algorithm for Point Area and Line Sources) model (ER, Sect. 4.1.2.2.4). The maximum ambient concentrations of TSP for these three periods are expected to be 335 $\mu g/m^3$, 237 $\mu g/m^3$, and 63 $\mu g/m^3$, respectively. Two of the worst-case 24-h periods occurred during a time when decommissioning operations are likely to have ceased due to winter conditions (mid-February and early March). The third worst-case 24-h period occurred in late July. If meteorological conditions similar to those in mid-February/early March occur during the operational period, the 24-h Federal secondary and State of South Dakota ambient air quality standards for TSP (150 $\mu g/m^3$) are expected to be exceeded, although infrequently. The nonradiological air quality monitoring program (Sects. 4.2.2.1 and 4.2.3.1) will provide an operational check on the frequency of the concentrations in excess of Federal and State standards and will indicate the need to apply appropriate mitigative actions as committed to by the applicant.

As with the short-term estimates, the annual-average ambient concentrations of TSP were estimated based on the expected worst year of operation with regard to emissions. Using EPA's Climatological Dispersion Model, the applicant predicted the highest annual-average concentrations of TSP to occur east of the haul road and in Cottonwood Community (ER, Sect. 4.1.2.2.4).

The maximum annual-average TSP concentration expected to result from the decommissioning operation (23 $\mu g/m^3$), when added to background levels in the vicinity (27 $\mu g/m^3$; see Sect. 3.2), will not exceed the Federal secondary and State annual-average ambient air quality standard for TSP (60 $\mu g/m^3$).

The staff agrees with the applicant's predictions on air quality. However, this is based on the applicant's assumptions regarding fugitive dust control including: (1) average vehicle speed at the mill site will not exceed 16 km/h (10 mph); (2) average vehicle speed along the haul road will not exceed 32 km/h (20 mph); (3) some type of road carpet will be used in addition to watering to achieve a 60% reduction in fugitive dust emissions; (4) the main transfer routes on the mill site and between the disposal site and overburden stockpile will be watered; (5) the extent of the disturbed area at any one time will be limited as much as possible; and (6) disturbed areas (mill site, disposal site, and stockpiled soils) will be revegetated as soon as practicable.

The applicant believes that stopping work because of high wind speeds will not effectively diminish fugitive dust generation (ER, Sect. 4.1.2.3.2). The rationale for this belief is that the increase in dust during periods of high winds will be offset by the enhanced dispersion associated with the increased wind speed. The staff believes that this view should be adopted only for periods of intermittent high wind speeds (gusting). For periods of sustained high winds, the staff notes that although the resultant ambient concentration of the pollutant may not increase, the area affected by a given concentration will be greatly expanded. This is of particular importance because the dust will carry radionuclides. Therefore, the staff recommends that decommissioning operations be temporarily stopped when sustained wind speed exceeds 40 km/h (25 mph).

Air quality of the area will be monitored during the project to determine if the mitigative methods are adequate or if additional or modified procedures are necessary (Sects. 4.2.2.1 and 4.2.3.1). If inadequate, effective measures will be implemented.

4.1.2 Radiological environment

Normally, background radiological environment is discussed in Sect. 3, "The Affected Environment." This discussion is to establish baseline values for comparison with potentially adverse impacts to be discussed in this section.

Because the Edgemont site environment presents an already radiologically contaminated situation with a chronic low-level release of radioactive materials to unrestricted areas, the background radiological environment is briefly presented here to emphasize that the objective of the project is to remove an existing problem. The staff's assessment of the incremental radiological impacts of the project is presented in Sect. 4.1.9.

The Edgemont mill produced about 2.1 x 10^6 MT (2.3 x 10^6 tons) of uranium tailings. These tailings were disposed of as sands and slimes in piles and ponds on the mill site (Fig. 2.9).

Although most of the tailings have been temporarily stabilized by earthen cover, radon flux measurements taken on the site have ranged up to 970 $pCi/m^2 \cdot s$. Radon gas concentrations above background levels have been detected up to 1.1 km (0.7 mile) from the site.

Direct gamma radiation levels as high as 3780 $\mu R/h$ (on ponds) have been measured on site, with measured values of over 1000 $\mu R/h$ on ponds 1, 2, 3, and 7. In general, gamma levels from 70 to 260 $\mu R/h$ were measured on the tailings sand piles. These may be compared with a normal background level of about 13 $\mu R/h$.

Site conditions require remedial action, the subject of this Draft Environmental Statement (DES).

4.1.3 Soils

Lands to be affected by the proposed project are listed in Table 4.1; the soils are depicted in Fig. 3.15. In addition to the millsite, 5.3 ha (13 acres) of soils will be distrubed along the eastern edge of the mill for construction of a diversion ditch, and an unknown amount of land east of the mill will be distrubed by removing tailings that have blown into this area (ER, Sect. 3.5).

Table 4.1. Land area affected by the proposed project[a]

Location	Area	
	ha	acres
Mill site	86	213
Diversion ditch at mill site	5.3	13
Disposal area	68	168
Soil stockpiles	36	90
Haul road	12	30
Total	207.3	514

[a]Additional areas may be disturbed for (1) topsoil required at the mill site and (2) removal of tailings blown east of the mill site.

Source: ER, Sect. 3.0.

Removal of topsoil and natural vegetation will accelerate wind and water erosion. Generally, these impacts are expected to occur primarily during the summer months when project activity will be the greatest. To minimize soil erosion, all soils stored for later use will be contoured and seeded (ER, Sects. 3.3 and 3.4). Areas not immediately available for reclamation because of decommissioning scheduling will be seedeo with a temporary crop of barley, rye, or oats (ER, Sect. 4.6.3), and heavily travelled areas will be sprinkled with water from the onsite well (ER, Sect. 3.5). Up to 80% of the sand tailings at the site will be moved by a slurry pipeline, thereby minimizing dust generation (ER, Sect. 3.2). Contaminated material moved by trucks will be sprayed, as necessary, with a stabilizing agent to minimize fugitive dust during transport. Erosion by rainfall will be minimized by constructing (1) water diversion ditches at the mill site (ER, Sect. 3.5) and disposal area (ER, Sect. 3.3), (2) trench drains along the outside of the haul roads and a median drain between the haul roads that empty into Pond 10 on the mill site (ER, Sect. 3.4), and (3) a sediment pond below the impoundment dike to control sediments resulting from construction of the disposal pit (ER, Sect. 3.3).

Soils at the disposal site which are suitable for plant growth will be stored north of the disposal area (Fig. 3.15). Topsoil from the haul road will be stored along the route for use in reclamation. The applicant has recently determined that it appears unlikely that sufficient suitable topsoil exists at the disposal site for reclaiming all disturbed areas. Thus, the applicant will be required to obtain topsoil from other areas. Use of topsoil from the disposal site is environmentally preferable to disturbing additional lands and should receive first priority. However, since opening up new borrow areas will be required for fill and topsoil material, these will have to be clearly justified by the applicant.

Although topsoil and subsoil will be segregated prior to storage, a reduction in the quality of the soils is unavoidable. Moving the soils will disrupt existing physical, chemical, and biotic soil processes, and the heavy machinery required to move the material will cause soil compaction, which is not conducive to plant growth. Ripping the soil and applying the recommended fertilizer rates (ER, Sect. 4.6.3) will enhance the likelihood of successful revegetation, but a temporary decrease in natural soil productivity is probable.[1] If reclamation efforts are successful, long-term impacts to the soil are not expected to be significant.

4.1.4 Mineral resources

The project as proposed or with any of the identified alternatives will not affect future recovery of any known mineral resources. There are no known commercially valuable mineral resources underlying the proposed disposal site (site C1).

4.1.5 Land use

The proposed action should have no significant direct adverse impacts on land use. The mill site currently has a nonuse status, and the mill has not operated since 1974. Decontamination and reclamation of the site [86 ha (213 acres)] would allow productive use of this area.

Although Fall River County does not have a comprehensive land use plan or zoning ordinance, Edgemont's temporary zoning ordinance designates that portion of the mill site within the city limits as industrial. Because the railroad borders one side of the site and the city sewage lagoon the other, it can be expected that the permanent zoning of this area will also be industrial. Therefore, the remainder of the site would be most suitable for industrial use as well. If no industry were to locate on the mill site or until industries do locate, the area could be used as pastureland because the reclamation plan is designed primarily to provide livestock forage (Sect. 2.2.2.7).

Preparation of the proposed disposal site for long-term isolation of tailings and contaminated materials will temporarily remove about 122 ha (301 acres) of grazing land [68 ha (168 acres) for disposal area, 36 ha (90 acres) for stockpiled soils, 12 ha (30 acres) for haul roads, and 5 ha (13 acres) for a diversion ditch along the mill site]. At least 17 ha (41 acres) of ponderosa pine may be lost as a result of cleanup of windblown tailings east of the mill site (ER, Table 4.6-2), although techniques are currently under evaluation which would allow cleanup of this area without disturbing the trees. Additional areas in the vicinity of the mill probably will be disturbed for borrow material (ER, Sect. 3.2), although the staff encourages minimization of such action (Sect. 4.1.1.3). All disturbed areas, with the exception of the tailings impoundment, will be revegetated with species primarily suitable for livestock grazing (Sect. 2.2.2.9). The impoundment will be revegetated with species which will not specifically promote livestock grazing but will allow wildlife utilization of the area. This measure will help to ensure that vegetative cover over the tailings impoundment will be sustained over time, providing erosion protection. The staff recommends that the seed mixture include species that accomodate wildlife as well as permit forage production for livestock (Sect. 2.2.3.8).

The effect of decommissioning on land use would be a net increase of about 51 ha (127 acres) available for productive land use. Given time, it is possible that even the reclaimed disposal site could be released to grazing. Land use control (as required by Sect. 202 of the Uranium Mill Tailings Radiation Control Act of 1978) will ensure that no disruption by either natural erosion or by human or animal activities will take place.

Because no significant direct adverse impacts on land use are anticipated, no mitigation measures were proposed by the applicant (ER, Sect. 4.3.1.3). The staff concurs with this decision. Mitigation measures for potential adverse impacts from such causes as dust and erosion, which could affect land use, are discussed in their respective sections.

4.1.6 Water

4.1.6.1 Surface water physical effects

Mill site

The major impacts of the decommissioning plan on the existing surface water features at the mill site are: (1) permanent reduction of surface water contamination resulting from runoff and flood erosion of existing tailings, (2) elimination of contamination from standing water in the tailings ponds following removal of the tailings and associated liquids, (3) alteration of existing local drainage patterns during decommissioning by construction of a ditch to divert uncontaminated surface runoff from the area east of the mill site to the Cheyenne River floodplain, and (4) removal of all contaminated materials from the margins and streambed of Cottonwood Creek, (5) restoration of the channel as close to its original course as feasible, and (6) revegetation of the stream margins. After removal of the windblown tailings (Sect. 2.2.2.3), construction of a diversion ditch along the eastern margin of the mill site will disturb about 5.3 ha (13 acres) (Sect. 2.2.2.3). The applicant proposes to reroute the reach of Cottonwood Creek flowing through the mill site through a temporary diversion channel constructed in uncontaminated native material (Sect. 2.2.2.5). During the two years of staged construction and stream decontamination, which would occur during low flow to minimize transport of contaminated sediment, the stream would be diverted through a pipe (Sect. 2.2.2.5). Following decontamination of the site, a new permanent route close to the original course would be constructed for the creek (Sect. 2.2.2.5). The stream margins would be stabilized along meandering bends by using riprap where needed and then revegetated, according to the plan presented in Sect. 2.2.3.8. Riprapping and revegetation would reduce erosion and subsequent sedimentation. Erosion and sediment transport from the temporary diversion channel will occur as the result of construction and transport of unconsolidated material. Measures taken to stabilize the bed and margins of this channel will minimize erosion (Sect. 2.2.2.5). Following the routing

of the creek, erosion of the new stream channel will occur until the streambanks are shaped by erosion and unconsolidated materials are carried from the streambed.

The full extent of contamination of streambed sediments in Cottonwood Creek is not known at this time. Lack of information exists on the quantity of streambed materials that will have to be removed from the creek to remove sediment contaminated with radionuclides or heavy metals. If only isolated pockets of contamination occur within the stream, these areas could be isolated and removed with minimal impacts to surface hydrology. In anticipation that contaminants are spread throughout the streambed sediments, it has been proposed, as discussed, to reroute the stream while removing these materials. The extent of material to be removed depends in part on the extent of transfer of contaminant materials from groundwater into stream alluvium and surface waters (Sect. 4.1.6.4). A data base defining types and quantities of contaminated material must be determined by the Tennessee Valley Authority (TVA) in coordination with the U.S. Nuclear Regulatory Commission (NRC), EPA, and the State of South Dakota, and the extent of contaminated material in both Cottonwood Creek and the Cheyenne River must be determined by the applicant before the effects of removal of the streambed material on hydrology and water quality can be fully determined. The extent of contaminated groundwater beneath the mill site and the time necessary for the groundwater to cleanse itself are not known (Sect. 4.6.1.4).

Disposal site

The major impact of the decommissioning plan on the surface water features at this site will be the complete and permanent alteration of surface water features of the 68-ha (168-acre) site (Sect. 2.2.2.1).

Alteration of drainage to the ephemeral stream will reduce the volume of annual runoff received by the stock ponds downslope and could cause a reduction in the peak flood flows in the drainage courses downstream of the disposal site. Permanent loss of the small stock pond [0.04 ha (0.1 acre)] at the toe of the containment area (Fig. 3.4, Pond 1) will occur because of construction of the disposal area. Given the close proximity of Pond 2 (Fig. 3.4) to this site, the availability of another pond downstream (Fig. 3.4, Pond 3), and the numerous small ponds in the Edgemont area, the staff considers this loss to be minor.

Construction of a sediment pond downslope of the impoundment dike could result in increased erosion and sedimentation in the existing ephemeral drainage channels until construction is completed and the disposal area revegetated. The sediment pond, however, should prevent downstream transport of sediment and resultant streambed alteration. Any sediment not contained by the sediment pond could reach the two stock ponds downstream and ultimately the Cheyenne River (Fig. 3.4). In the opinion of the staff, use of the best available technology for impoundment construction, diversion ditches to intercept runoff, and sediment ponds to retain sediment from runoff will minimize the impacts to surface water hydrology associated with the disposal site.

Temporary increases in erosion and subsequent sedimentation in the small intermittent drainage courses along the haul road/slurry pipeline route (Sect. 2.2.2.2) will be minimized by culverts and ditches. A trench-drain system along the haul road/slurry pipeline route (Sect. 2.2.2.2) will be designed to contain any spilled or contaminated materials. The potential for contamination of surface water from the drainage system will be minimized by drainage of the system to and containment within Pond 10.

4.1.6.2 Potential surface water quality effects

Potential adverse surface water quality impacts associated with the decommissioning of the Edgemont mill could result from area runoff, point-source discharges, dredging, seepage, or accidental spills of toxic or hazardous materials. Surface water quality impacts may also occur as the result of groundwater recharge of Cottonwood Creek following decommissioning (Sect. 4.1.6.1).

The primary adverse impacts associated with the decommissioning are surface runoff and resultant erosion and sedimentation. Erosion during the decommissioning can occur from the mill site, haul road and slurry pipeline route, disposal site, and borrow areas. The applicant's proposed

specific constructional techniques designed to reduce erosion and sedimentation are discussed in Sect. 2.2.2 of this document and in Sect. 4.2 of the ER. These techniques should ensure that, over the short term, the quantity of suspended material is within an order of magnitude of the mean values for suspended solids in the vicinity of the site (Sect. 3.6.1, Table 3.18). This will minimize any long-term impacts of sediment on water quality and should minimize further water contamination by heavy metals contained in the tailings and potential runoff from the site.

Although the contaminated tailings will be removed from the mill site, some water quality degradation of Cottonwood Creek is expected to continue as the result of groundwater inflow from beneath the mill site. The extent of present and projected groundwater contribution to surface water quality degradation cannot be determined because the extent of groundwater contamination beneath the site and the time necessary for the groundwater to be cleansed are not known (Sect. 4.6.1.4).

Mill site

Increased levels of suspended contaminants are associated with surface runoff from the exposed tailings.[2] These mill tailings are of particular concern at the Edgemont site because of potential radioactive and trace metal contamination (i.e., aluminum, barium, chromium, titanium, nickel, iron, vanadium) of the tailings (ER, Sect. 4.2.2.2.1.2). The Cheyenne River does not currently meet recommended standards for drinking water[3,4] or for agricultural use[5] because of high concentrations of barium, arsenic, iron, manganese, and dissolved solids (see Sect. 3.6). However, during decommissioning, the levels of iron, manganese, and dissolved solids may be further accentuated by runoff from the site. In addition, during decommissioning, levels of aluminum, sulfate, chromium, barium, and vanadium may be increased. The proposed diversion ditches around the mill site and sumps or sediment basins within the mill site are designed to intercept or contain runoff before it reaches Cottonwood Creek so that water quality impacts can be minimized (Sect. 2.2.2.3).

The applicant has not determined the extent of heavy metal contamination of streambed sediments in Cottonwood Creek or the Cheyenne River as a result of tailings erosion nor the method of isolation and removal of the contaminated materials from the Cheyenne River. The applicant proposes to remove any contaminated material occurring in the Cheyenne River during low flow (ER, Sect. 4.2.2.2) and should do so only after consultation with the EPA in coordination with the State of South Dakota to locate contaminated areas and to establish acceptable concentrations that may remain in the river. Determination of impacts to water quality from migration of the trace element contaminants in the Cheyenne River depend upon the concentration, sediment particle size, and location of the contaminated material within the river relative to stream flow, all of which are unknown at this time. However, based on EPA findings[2] that although Cottonwood Creek was contaminated by the Edgemont mill operation, contamination did not extend into the Cheyenne River, contamination in the river should be minimal. The extent of contamination in the river, however, may be greater than the 1973 EPA study indicates because it has been shown that leakage has occurred from ponds adjacent to the river (ER, Sect. 4.2).

Additional impacts to water quality from the decommissioning activity include potential accidental leakage or breaks in the outfall line from the Edgemont city sewage lagoon as it crosses the mill site. If breakage of the line occurs, sumps and pumps will be used to isolate the leakage and return it to the lagoon while the system undergoes repair (ER, Sect. 4.2).

Also included as accidental or potentially unavoidable discharges to adjacent water bodies are potential spills of fuels or oils. These materials, which will be stored in diked areas designed to retain 110% of the total volume contained within the area (ER, Sect. 4.2), are the only hazardous materials to be stored onsite.

Disposal site

Any point-source discharge associated with surface runoff at the disposal site will be contained by the sediment pond. Because this pond will be designed to remove all particles larger than 0.005 mm in diameter during a 10-year, 24-h precipitation event, only clay particles would

reach the Cheyenne River. Some of these clay particles could eventually be carried as far downstream as the Angostura Reservoir, where they would be deposited. The limited erosion from the disposal or mill sites should not result in significant adverse impacts to either the Cheyenne River or the Angostura Reservoir because both carry naturally heavy silt loads during runoff events (J. Hatch, personal communication, March 1980).

4.1.6.3 Reclamation

As the result of decommissioning the mill site and subsequent stabilization and reclamation (Sect. 2.2.3.8), water quality and hydrologic and water use characteristics of Cottonwood Creek at the mill site should be similar to upstream areas of the creek. Reclamation of the mi`l site should also significantly reduce windborne erosion and resultant erosional input into adjacent water bodies (see Sect. 4.1.5).

The haul road and slurry pipeline route will subsequently be returned to approximate predecommissioning conditions (Sect. 2.2.3.8). This reclamation and revegetation will reduce erosion into nearby Cottonwood Creek.

Following completion of tailings disposal and installation of the clay cap and top soil, the disposal site will be revegetated according to the plan outlined in Sect. 2.2.3.8. Stabilization at the disposal site and reclamation/revegetation of the surrounding area should reduce erosion and sedimentation carried into the ephemeral drainage channels and subsequently the Cheyenne River to levels typical of surrounding undisturbed drainage courses.

4.1.6.4 Groundwater

The groundwater under the mill site is presently chemically contaminated by past and present seepage from and through the tailings piles and ponds on the site. Removal of the tailings and other contaminated materials from the mill site will allow natural processes, primarily subsurface flows, eventually to restore this groundwater to its previous condition by transporting excess soluble ionic species into Cottonwood Creek and the Cheyenne River.

Such transport is presently occurring and does not result in measurable degradation of either stream. The staff is of the opinion that continuation of this natural process is the only practical solution for restoration of groundwater quality under the mill site. The staff recommends that shallow wells not be permitted on the mill site after reclamation until chemical concentrations (mostly sulfate) decrease. No radiological contamination of groundwater in excess of standards is presently observed or expected after reclamation.

The disposal site will be designed and constructed to preclude groundwater contamination. Preliminary tests indicate that a very thick sequence of shale material underlies the site and will isolate the tailings and contaminated materials from contact with groundwater. Dewatering of the slurried tailings will result in the presence of a negligible amount of solutions available for transport of contaminants. If a clay liner is used, it will add an extra margin of safety regarding seepage control. The staff concludes that the project, over time, will result in an overall improvement from present conditions, and adverse impacts to groundwater resources would be the same or greater if an alternative other than the staff's preferred alternative for tailings disposal were implemented.

4.1.7 Biota

4.1.7.1 Terrestrial

Decommissioning and stabilization

The primary impact to terrestrial biota from decommissioning the mill will result from temporary loss of habitat. This impact, however, will be minor because the mill site is already highly disturbed (Sect. 3.9.1) and because the land proposed for the disposal site is not considered to be unique wildlife habitat (Sect. 3.9.1.1). Lands to be affected by the proposed project are listed in Table 4.1. Very little natural vegetation exists at the mill site, even along Cottonwood Creek, because of past milling activities. Most revegetation attempts on portions of the site in the past have been unsuccessful.[6] Therefore, decommissioning and restoration of this site is expected to improve its ecological characteristics. A big game utilization transect

established on the disposal site in December 1979 has shown no use by either mule deer or antelope during winter, spring, or summer seasons; a similar utilization study revealed no use by big game of the disposal site over the entire year.[6] Nongame bird and small mammal surveys in 1980 indicate that population levels are lower on the disposal site than on other nearby areas sampled in 1975 and 1976 (ER, Sect. 4.6.1.2.2). Furthermore, vegetation to be disturbed is not considered to be unique habitat for any wildlife species in the area. Because similar habitats are common throughout the region (Sect. 3.9), it is expected that the temporary inaccessibility of this relatively small amount of land to wildlife will not significantly reduce the amount of habitat for any wildlife populations.

Land clearing, operation of heavy equipment, and other construction activities will destroy small animals that move too slowly to escape or that retreat to burrows for protection. Other animals will be displaced, possibly reducing their populations because of predation or increased competition for food, territory, and other habitat requirements. Although many of these species are important members of the terrestrial food web, their population densities are believed to be low (Sect. 3.9), and their loss would represent an insignificant regional impact.

Suspended particulate matter emitted into the air by construction activities (Sect. 4.1.1) will eventually be deposited in part on the surrounding vegetation, possibly reducing plant vigor or causing the plants to be less palatable. Gaseous emissions from internal combustion engines may also interfere with the physiological processes of the vegetation. Although the magnitude of these potential impacts is not known, it is expected to be negligible. No significant deleterious effects have been demonstrated at other construction projects of similar or greater magnitude. Moreover, if any impacts do occur from fugitive dust and/or gaseous emissions, they will be minor and short term.

Noise from project activities is not expected to affect seriously the area wildlife. Few data are available to demonstrate the effects of noise on wildlife, and much of what is available lacks specific information concerning noise intensity, frequency, and duration of exposure.[7] Some typical ranges of sound levels from common construction activities are listed in Table 4.2. Noise associated with the project may initially cause migration by some wildlife away from the immediate vicinity, but those that remain or return will generally become habituated to construction noises and activities.[7] Also, because this project does not involve the continued operation of any facility in the future, ambient noise levels are expected to return to normal once the area has been reclaimed.

Table 4.2. Sound levels from construction equipment

Source	Sound level, dB(A), at indicated distances from source				
	15 m	30 m	61 m	152 m	305 m
Trucks, cranes, bulldozers, etc., with diesel-type internal combustion engines	70–95	64–89	58–83[a]	50–75	40–69
Air compressors and other stationary sources, typically diesel powered	76–86	70–80	64–74	56–66	50–60
Pile driver	105	99	93	85	79
Front-end loaders	73–86	67–80	61–74	53–66	47–60

[a]Source levels above 80 dB(A) are usually produced by a combination of several pieces of equipment operating at the same time.

Source: U.S. Senate, *Report to the President and Congress on Noise*, Senate Document 96–63, U.S. Government Printing Office, Washington, D.C., 1972.

Increases in personnel associated with the decommissioning project will adversely affect most wildlife in the area. Although some species may be benefited, most of the larger mammals will abandon habitats in close proximity to intense human activity. Additional stress will be placed on the terrestrial biota as a result of greater legal and illegal hunting pressure and destruction of habitat by off-road recreational vehicles. An insignificant increase in wildlife losses is expected to occur as a result of greater vehicular traffic on highways.

Federally listed endangered species that may occur at the site and vicinity are the bald eagle (*Haliaeetus leucocephalus*), American peregrine falcon (*Falco peregrinus anatum*), and black-footed ferret (*Mustela nigripes*) (Sect. 3.9.1.2). Field surveys of the project vicinity in 1976, 1979, and 1980 did not reveal the presence of any of these species. Further, habitat suitable for these species does not exist in areas to be disturbed by the project (Sect. 3.9.1.2). The peregrine falcon is known to inhabit the Black Hills region and the bald eagle can be found as a transient in the area during winter. However, because habitat in the project vicinity is not considered to be unique for these raptors, the staff believes that the proposed action will not affect these species. Jon Sharps, Endangered Species Coordinator for Region 1, South Dakota Department of Game, Fish, and Parks, concurs with the staff's conclusion. Although the black-footed ferret is not known to inhabit the area, the potential exists for this species to occur in the region because of the presence of prairie dogs, a primary food source for the ferret.[8] However, no prairie dog towns are known to be located within 3.2 km (2 miles) of the mill or proposed disposal site.[9] Dr. Raymond Linder, Leader for the U.S. Fish and Wildlife Service's black-footed ferret recovery team, knows of no sightings of ferrets in Fall River County; the most recent sighting of a ferret was in the spring of 1979 in Todd County, South Dakota, more than 250 km (150 miles) east of the project site (personal communication, February 2, 1981). The U.S. Fish and Wildlife Service concurs with the staff's conclusion that the proposed action will not affect any federally listed endangered species that may occur in the vicinity of the site.[10] Although the northern swift fox (*Vulpes velox herbes*), classified as threatened by the State of South Dakota,[9] is known to occur in Fall River County, it is unlikely that any are present in the Edgemont area because of lack of suitable habitat (Jon Sharps, personal communication, Nov. 20, 1979).

Reclamation

The primary objective of the applicant's reclamation plan for the mill site, disposal site, haul roads, and borrow areas is to stabilize the soil and tailings and to provide livestock forage (Sects. 2.2.2.7 and 2.2.2.9). Plans for reclamation of the mill site may change, depending on future use of the area for industrial or other purposes. As recommended by the U.S. Fish and Wildlife Service (K. D. Keenlyne, letter to R. A. Scarano, Chief, Uranium Recovery Licensing Branch, Division of Waste Management, NRC, Oct. 27, 1980), the applicant should consider a seed mixture that includes little bluestem (*Andropogon scoparius*), silver sagebrush (*Artemisia cana*), rice grass (*Oryzopsis hymenoides*), and fourwing saltbush (*Atriplex canescens*). These seeds are commercially available, can be planted with other mixtures, and would improve the area's diversity.

Revegetation of the riparian community along Cottonwood Creek, which runs through the mill site, (Sect. 2.2.3.8) has been designed not only to stabilize this area but also to further enhance the wildlife values of the area. The staff recommends that any portion of the ponderosa pine community disturbed as a result of cleanup of windblown tailings should be replanted with species typical of the area (Sect. 2.2.3.8).

4.1.7.2 Aquatic

Decommissioning and stabilization

One of the major consequences associated with the proposed decommissioning which could adversely affect aquatic biota is rerouting Cottonwood Creek to a decontaminated reach and removal of contaminated material from the floodplain and streambed of the creek (Sect. 4.1.6.1). The applicant's proposed plan for decommissioning of Cottonwood Creek (Sect. 2.2.2.5) would involve diverting the stream for two nonsequential six-month periods, with the resultant destruction of the associated biological communities in the affected reach during both periods. The staff believes that if this is done such that erosion and sedimentation are minimized and the streambank stabilized and revegetated, long-term adverse impacts to the stream community through the mill site should be minimal, though these communities would be lost in the short term prior to restoration.

If, in meeting requirements for decontamination, extensive areas of the creekbed through the mill site are identified as contaminated, the biota through this section, as discussed previously, would be destroyed. However, from a study by Wade and Wright, [Tennessee Valley

Authority (TVA)],[11] it appears that Cottonwood Creek upstream of the mill site has a diverse aquatic community from which repopulation of the stream reach through the mill site would occur. This should minimize long-term effects on the aquatic biota.

Following decontamination, reconstruction of the stream channel will be necessary. The applicant should consult with qualified fisheries biologists in reconstructing the channel. The U.S. Fish and Wildlife Service recommends that the stream should have meandering bends and that, instead of uniformly regrading the stream banks to a 10°-slope, the stream banks should be permitted to develop naturally or have structures built that produce undercut banks and other instream flow structures (J. W. Sayler, U.S. Fish and Wildlife Service, personal communication, Dec. 22, 1980). The applicant plans to place natural or man-made obstructions (i.e., such as concrete boulders and diversions) within the stream in order to provide diverse habitats (i.e., pools and riffles) and stable, diverse substrate for reestablishment of aquatic communities. These substrate materials or obstructions should be sufficiently numerous so as to be characteristic of undisturbed streams in the area. Decontamination and stabilization of the streambed and stream margins of Cottonwood Creek (Sect. 2.2.3.8) and provision of more diverse habitats within the stream should mitigate short-term impacts associated with decommissioning by permitting recolonization of a diverse aquatic community. Revegetation of the stream margins should reduce erosion and sedimentation and, over time, provide overhanging vegetation of aquatic habitat enhancement.

During decommissioning, biological communities in the Cheyenne River and Cottonwood Creek should be protected from increased erosion and sedimentation from tailings removal and transport from the mill site or accidental spills of hazardous or toxic materials. Diversion ditches east of the mill site and along the haul road will restrict drainage at the site (Sect. 2.2.3). Removal of windblown tailings will reduce wind erosion and transport of contaminated material into the adjacent water courses. The containment and diversion measures proposed by the applicant should reduce the impacts associated with the mill decommissioning on the aquatic biota of Cottonwood Creek and the Cheyenne River. Until the groundwater beneath the site has been purged of contaminants, impacts to the biota from trace metals resulting from groundwater discharge to surface waters at the mill site may continue. The impacts associated with this groundwater discharge should be minimal because of the normally large dilution capacity of the streams in relation to the seepage inflow and capacity of the alluvium to neutralize, absorb, and retain a large portion of the seepage contaminants (ER, Sect. 4.2).

Specific impacts to aquatic communities at the disposal site are anticipated only as a result of destruction of the stock-watering pond at the toe of the containment area (see Fig. 3.4). This impact is considered of minimal significance because of the very small size of the pond and the assumption that the resident aquatic community is similar to that of other ponds in the area. Effects on other pond communities downstream of the disposal area are not expected because of their distance from the site, limited erosional input because of runoff diversion around the disposal site, and sediment retention by the sediment pond to be located immediately downslope of the containment dike. No significant impacts to the biota of the streams draining the disposal site are expected because of the ephemeral nature of these streams. Effects on Cottonwood Creek and the Cheyenne River are not expected because of their location and distance from the disposal site. In the event that runoff from the disposal area reaches the Cheyenne River, the aquatic biota could be affected during decommissioning by the increased sediment and trace elements carried by the runoff. However, any effect should be minimal because aquatic organisms in the Cheyenne River are already subjected to heavy sediment loads associated with increased flows in the river (Sect. 3.6.1.2) and because flow in the river should dilute any contaminants (ER, Sect. 4.2).

Reclamation

Reclamation of the stream margins of Cottonwood Creek through the mill site by stabilizing revegetation or riprap, where necessary (Sect. 2.2.2.5), should prevent most erosion from the mill site, particularly during periods of increased runoff. This stabilization should minimize impacts to the biota from runoff and erosion (Sect. 4.1.7.2). Habitat stability and diversity within the decontaminated stream channel will be provided by natural or man-made obstructions placed in the reclaimed stream. These obstructions should increase streambed stability and provide spawning and refuge areas for aquatic biota within the stream. Overhanging riparian vegetation following streamside revegetation will provide additional aquatic habitats. Habitat stability and diversity will enable recolonization of the stream by numerous aquatic species moving upstream from the Cheyenne River or migrating and drifting downstream from above the mill site.

4.1.8 Socioeconomic effects

4.1.8.1 Introduction

Quantitatively predicting the socioeconomic impacts of the proposed mill decommissioning project is extremely difficult. Because the socioeconomic environment in the area surrounding the project has seldom been stable, historical trends are not very useful for forecasting. In addition, an already dynamic situation has been made even more so because of potential energy-related industrial development on a relatively large scale. Nevertheless, impact assessments have been formalized by local planners and the applicant. The staff has reviewed these forecasts, the assumptions upon which these forecasts were based, and additional impact assessment sources. The staff has included in this review discussions with the applicant and with various authorities in the Edgemont–Hot Springs region and has independently developed a set of assumptions upon which to base the analyses (see Appendix B). The following impact assessments, when quantified, because of the uncertainties involved, should be read with caution. The staff feels, however, that the analysis possesses the basic validity necessary to gauge the impacts of the decommissioning project.

Some of the more important project-related impacts are summarized in Tables 4.3 and 4.4. Overall, when compared with the composite impacts of proposed new industries, the impacts of the proposed project are small. The staff believes that, in a socioeconomic sense, the long-term beneficial effects of the safe removal and ultimate disposal of aesthetically displeasing, property-value-reducing radioactive materials to a remote location will far outweigh any short-term socioeconomic costs to the local communities.

Table 4.3. Estimated incremental impacts on employment, population, and housing caused by Edgemont mill decommissioning construction activities[a]

	Total regional impacts		Edgemont		Hot Springs	
	Low range	High range	Low range	High range	Low range	High range
Employment Opportunities	128–144[b]					
Population influx	165–183	216–236	102–117	174–195	30–32	82–88
Families	25–27	39–42	16–16	32–34	6–7	16–17
School-age children	22–24	35–37	13–14	28–30	5–6	15–16
Housing demands	102–115	118–131	67–74	101–110	15–17	41–45

[a] Based on peak construction employment (~80); for other assumptions, see Appendix B.

[b] Only one range was developed for employment opportunities.

Table 4.4. Estimated incremental impacts on employment, population, and housing caused by Edgemont mill decommissioning operation activities[a]

	Total regional impacts		Edgemont		Hot Springs	
	Low range	High range	Low range	High range	Low range	High range
Employment opportunities	198–225[b]					
Population influx	426–474	486–534	213–237	365–401	107–119	243–267
Families	107–119	122–134	54–60	92–101	27–30	61–67
School-age children	94–105	107–118	47–52	80–89	24–26	54–59
Housing demands	158–176	180–198	79–88	135–149	40–44	90–99

[a] Based on peak operation employment (~90); for other assumptions, see Appendix B.

[b] Only one range was developed for employment opportunities.

4.1.8.2 Employment

According to the applicant, the project will have two distinct phases: construction and operation. Construction is planned to occur for about six months during the first project calendar year (CY). Employment for this phase will be steady and will peak at about 80 during the initial four months. The operation phase is planned to start at a very low level in the first CY and will last approximately 5.5 years. Table 4.5 illustrates this employment timetable referenced to an assumed May 1981 construction phase start date. It should be noted that employment due to construction will phase down as employment due to operations increases. Because of inclement weather, most work will be conducted during the warmer months (~May through October). Operations employment will steadily increase until a maximum (~90 employees) is reached in the third year. Thereafter, operations employment needs will steadily decline to minimum levels during the last year of decommissioning.

Table 4.5. Peak employment levels, over time, for construction and operation, Edgemont mill decommissioning

	Time period	Peak employment levels[a]
Construction phase	May–October 1981	65–80
Operation phase[b]	1982	55–70
	1983	80–90
	1984	70–75
	1985	40–50
	1986	5–20

[a] Approximations, that is, levels rounded off in increments of five.

[b] The peak employment ranges occur from May to October each year.

Source: G. R. Deveny, Supervisor, Socioeconomic Analyses Section, Division of Community Services, personal communication, April 7, 1980.

Construction activities will add, as an upper limit, 48 to 64 secondary jobs. Operation activities should cause, at most, 108 to 135 new secondary jobs (see Appendix B for an explanation of the assumptions utilized to develop these estimates). The predicted total maximum number of incremental job opportunities caused by construction is between about 130 and 145 (Table 4.3). As many as 200 to 225 total new jobs could result from project operations (Table 4.4).

4.1.8.3 Population

Because the unemployment rates in the affected region are low (Sect. 3.4.3) and considerable economic development is impending, the staff anticipates that the labor markets in the Edgemont-Hot Springs area may be very restricted during most of the 1980s. Therefore, a high percentage of the job opportunities created by the proposed project will have to be filled by nonlocal or in-migrating workers (Appendix B). Consequently, project-induced population increases and, hence, population-related impacts could be relatively large.

Assuming a worst-case scenario — that is, assuming that (1) peak employment levels are ~80 during construction and ~90 for operation; (2) none of the basic and secondary workers are from the same family; (3) most of the basic and secondary workers are in-migrants; and (4) all local hirees were previously unemployed — the total population influx generated by construction activities could range from about 165 to 235 persons (Table 4.3). About 425 to 535 new residents could conceivably in-migrate because of operation activities (Table 4.4). Edgemont's population could increase by about 100 to 195 during construction and by approximately 210 to 400 during operation. The Hot Springs increases would range, respectively for construction and operation, from about 30 to 90 and from about 105 to 270 (Tables 4.3 and 4.4 and Appendix B). When compared with the respective Edgemont and Hot Springs 1980 population estimates (~1500 and 4700), population increases of these sizes are relatively significant. However, when compared to the projected long-term populations for these communities, the contributory effects are considerably less. The Edgemont and Hot Springs 1982 populations could possibly range from 3400 to 5700 and from 7400 to 7500, respectively (Table 3.4). The mill decommissioning project may thus combine with other developments to significantly affect Edgemont, Hot Springs, and, consequently, Fall River County, but the project, by itself, would cause only a small portion of the overall impacts. All anticipated industrial developments would have to occur, however, for this to be the case.

4.1.8.4 Housing

Assuming a worst-case scenario, that is, the assumptions outlined in Sect. 4.1.8.3 and further assumptions that (1) nonmarried in-migrants will each require a separate residence and (2) a zero vacancy rate will prevail, about 100 to 130 new housing units may be needed during construction. About 160 to 200 new units may be needed to house operation-induced employees (Tables 4.3 and 4.4 and Appendix B). Because of typical housing preferences[12,13] and the rapidly escalating purchase costs of single-family homes, the staff anticipates that most demand will be for rental properties and privately owned mobile and modular homes. These incremental housing needs, though possibly high, are only a small fraction of total anticipated requirements. Approximately 2235 housing units existed in Hot Springs and Edgemont in 1980 (Table 3.5). However, local planners estimate that as many as 1475 additional units may be needed by 1982 (ref. 14). Edgemont, which is expected to receive the brunt of the housing demand, is less capable of absorbing the impact than is Hot Springs because of fewer available vacant lots.[14] Consequently, Edgemont may have to annex large areas of land or allow scattered development around its fringe.[13]

4.1.8.5 School enrollment

The short-term construction activities, to be conducted during summer months, will minimally impact school enrollments. Only about 20 to 40 new students will be enrolled (Table 4.3 and Appendix B). However, operation activities, which will be long-term and involve more employees, could significantly impact school enrollments. The staff estimates that as many as 95 to 120 new students (Table 4.4) may enter the local school systems. Of these students, from about 50 to 90 could enroll in the Edgemont School District and 25 to 60 in the Hot Springs School District. Some additional classrooms and teachers may be needed to accommodate these increased enrollments. The staff did not, however, quantitatively estimate the number of additional teachers and classrooms that could be required because the communities have several options and combinations of options that could be utilized to handle enhanced enrollments. In addition, it is difficult to estimate the age distribution of incoming students and, consequently, enrollment in elementary schools, high schools, and special education classes.

4.1.8.6 Personal income

The staff estimates that the project, including construction and operation, will generate approximately $7.8 million (1979 dollars) in personal incomes within the local economies (for comparative purposes, the total personal income in Fall River County was about $49.2 million in 1977). This income estimate does not include the additional incomes from incremental markups induced by increased commodity demands, local expenditures for project-related supplies, or interest charges for credit purchases. These beneficial impacts will, over time, be unevenly distributed (Table 4.6).

Table 4.6. Estimated project-induced personal incomes and tax revenues in the affected local economies (1981–1986), 1979 dollars[a]

Year	Personal incomes ($)	Tax Revenues ($)
1981	1,441,000	82,538
1982	1,626,000	75,354
1983	1,846,000	102,880
1984	1,535,000	82,886
1985	982,000	52,030
1986	385,000	16,513
Totals	7,815,000	412,201

[a] Assumes that construction and operation activities commence in 1981.

4.1.8.7 Public sector finances

The staff estimates that the project will generate for both construction and operation activities approximately $400,000 (1979 dollars) in tax revenues (Table 4.6). Because the affected communities will have to spend additional funds for potable and wastewater treatment facilities, school and medical facilities, and street and road improvements, the staff doubts that the project will generate sufficient public funds to compensate for required additional expenditures. Local planners anticipate that a very serious shortfall in public funds will occur over the next few years because of the expected influx of industries.[14] Accordingly, Federal monetary assistance has been requested to aid in mitigating impending impacts.[14]

4.1.8.8 Public services and facilities

Public facilities and services will be differentially impacted by project-related population increases.

Water and sewage

Assuming peak per capita daily usage of approximately 1022 liters (270 gal),[14] total maximum usage for each year of the project was estimated by the staff (Table 4.7). During the operation period, about 50 to 75% of this usage could occur in Edgemont. However, up to 90% of the usage could occur in Edgemont during the construction period. Both the Hot Springs and the Edgemont water systems should be able to handle these additional loads since both systems have been upgraded. Neither of the cities' sewage systems are currently capable of processing additional wastes; however, both systems, under EPA mandate, will be expanded and improved in the middle 1980s.

Table 4.7. Estimated project-induced increments in peak water usage (1981–1986)[a]

Year	Peak water usage	
	liters/d	gpd
1981	168,600–241,200	44,500–63,600
1982	339,600–425,600	89,600–112,300
1983	435,400–545,700	114,900–144,900
1984	353,082–452,900	95,400–119,500
1985	243,824–305,600	64,344–80,600
1986	96,800–121,300	25,500–32,000

[a]Assumes that construction and operation activities commence in 1981.

Health services

The Hot Springs health services and facilities can adequately supply incremental health needs. Edgemont's health services and facilities are limited, but, given no extensive population increases, are reasonably adequate. If Edgemont's population does increase significantly (e.g., up to 2500 or more residents) because of energy-related developments, then — if no additional services are provided — a more serious shortfall would result.

Roads

Although it is doubtful that the decommissioning project, by itself, will significantly impact local traffic, local planners estimate that a considerable amount of public funds will have to be spent to improve local roads in order to handle anticipated total community development-related traffic increases in the 1980s.[14]

Recreation

Local public recreation facilities will be only marginally impacted by the project.

Fire protection

Additional fire and police protection requirements will be negligible.

4.1.8.9 Aesthetics and noise

The proposed disposal site will be minimally visible to the public. Because construction activities will cause some increases in truck traffic, noise will be generated. However, these adverse impacts will be short term. A slurry pipeline will transport most of the tailings, and thus, noise and traffic impacts should be insignificant during the operation phase.

4.1.9 Radiological assessment

4.1.9.1 Introduction

This section represents the staff's assessment of the incremental radiological impacts resulting from the operation of the proposed project and the methodology used to perform the evaluation. The evaluation includes estimates of resulting concentrations at the restricted area boundaries of the mill site and resulting dose commitments to nearby individuals and the general population within 1.6 km (1 mile) (town of Edgemont, including Cottonwood Community) of the mill site.

All potential pathways that are likely to contribute a significant fraction of the dose commitment have been included in the analysis. One pathway which is usually included in a radiological assessment but is omitted here is the milk pathway. Because of the existence and enforcement of a city ordinance which restricts free grazing of livestock within the city limits, it is reasonable to assume that any penned livestock present would be fed primarily stored feed, and would not be significantly affected by the decommissioning. There is presently no dairy industry in the Edgemont area.

4.1.9.2 Estimated releases

A summary of the information and data assumptions used to calculate the annual releases of radioactive materials from the mill site and disposal area is presented in Table 4.8. The estimated annual releases of radioactive material are outlined in Table 4.9. A more detailed description of the release estimates is provided in Appendix C. Furthermore, releases in the postdecommissioning period are assumed to be within cleanup standards of 5 pCi/g or less for particulates (U-238, U-234, Th-230, Ra-226, Pb-210, and Po 2 pCi/m^2·s radon flux.

A schedule of operation based on 2.5 years of disturbance, transport, and disposal of tailings and contaminated materials was used in estimating the parameters and releases for the decommissioning project as proposed.

4.1.9.3 Exposure pathways

Potential exposure pathways by which people would be exposed to radioactive materials resulting from the project are presented in Fig. 4.1. Pathways of concern for the airborne effluents include inhalation of radioactive materials in the air, external exposure to radioactive materials in the air or deposited on ground surfaces, and ingestion of contaminated food products (i.e., vegetables and meat).

There will be no planned releases of radioactive materials directly into surface waters. While there is a possibility of some small amount of seepage of radioactive liquids from the tailings impoundment into the groundwater system, this amount will be minimal if the seepage control measures recommended in this Statement are employed. Therefore, seepage is not considered to be a significant pathway of human exposure in this radiological assessment.

Table 4.8. Principal parameter values used in radiological assessment of decommissioning for Edgemont facility

Parameter	Value
Average activities in tailings solids, pCi/g[a]	
U-238	63.5
Th-230	702.4
Ra-226	705.2
Pb-210	705.2
Activities for tailings slimes, pCi/g	
U-238	269.9
Th-230	2985.2
Ra-226	2997.1
Pb-210	2997.1
Activities for tailings sands, pCi/g	
U-238	11.9
Th-230	131.7
Ra-226	132.2
Pb-210	132.2
Decommissioning and disposal time period, years	2.5
Estimated amount of tailings to be moved, metric tons	2.09×10^6
Estimated total amount of material to be moved to disposal site, metric tons	3.72×10^6
Release rate from machinery and activities at the Edgemont site, %	2.4×10^{-3}
Release rate from machinery and activities at the disposal site, %	1.2×10^{-3}
Dust-to-tailings activity ratio, dimensionless	2.5
Assumed reduction factor for tailings dusting mitigation measures, %	0.0
Specific radon flux from exposed beach, $\frac{(pCi/m^2 \cdot s\ Rn\text{-}222)}{(pCi/g\ Ra\text{-}226)}$	1.0
Tailings impoundment areas, hectares (acres)	
Pond 1	4.5 (11.1)
Pond 2	3 (7.4)
Pond 3	6 (14.8)
Pond 4	2 (4.9)
Pond 7	7 (17.2)
Pond 8	3.5 (8.6)
Pond 9	3.5 (8.6)
Pond 10	2 (5.0)
East pile	12 (29.5)
Area A	4 (9.8)
Area B	2.5 (6.2)
Disposal site	29 (71.1)
Dispersed area of tailings	32 (80)

[a]Activities are based on an ore grade of 0.25% U_3O_8 and the following loss to tailings. U-238 9%; Th-230 99.5%; Ra-226 99.9%; Pb-210 99.9%. Slimes are considered to be 4.25 times as radioactive as the average tailings. Sands are considered to be 0.19 times as radioactive as the average tailings.

Table 4.9. Estimated annual releases of radioactivity resulting from cleanup operations at Edgemont mill and disposal site

Source of release	Annual radioactive releases (Ci/year)[a]				
	U-238	Th-230	Ra-226	Pb-210	Rn-222
			Edgemont		
Machinery and handling	3.18E–03[b]	3.51E–02	3.53E–02	3.53E–02	0.0
Pond 1	1.95E–03	2.16E–02	2.16E–02	2.16E–02	1.00E+03
Pond 2	2.74E–04	3.03E–03	3.04E–03	3.04E–03	6.67E+02
Pond 3	1.24E–02	1.37E–01	1.38E–01	1.38E–01	1.33E+03
Pond 4	9.74E–04	1.08E–02	1.08E–02	1.08E–02	4.41E+02
Pond 7	2.92E–03	3.24E–02	3.24E–02	3.24E–02	1.55E+03
Pond 8	1.46E–03	1.62E–02	1.62E–02	1.62E–02	7.75E+02
Pond 9	1.46E–03	1.62E–02	1.62E–02	1.62E–02	7.75E+02
Pond 10	1.83E–04	2.02E–03	2.02E–03	2.02E–03	4.50E+02
East pile	1.10E–03	1.21E–02	1.22E–02	1.22E–02	2.66E+03
Area A	3.65E–04	4.04E–03	4.06E–03	4.06E–03	8.83E+02
Area B	2.74E–04	3.03E–03	3.04E–03	3.04E–03	5.58E+02
			Disposal site		
Machinery and handling	1.59E–03	1.76E–02	1.77E–02	1.77E–02	0.0
Disposal pit windblown	1.46E–02	1.62E–01	1.62E–01	1.62E–01	6.39E+03
			Dispersed tailings		
	1.58E–02	1.75E–01	1.75E–01	1.75E–01	7.21E+03

[a] Releases of all other isotopes in the U-238 decay series are also included in the radiological impact analysis. These releases are assumed to be identical to those presented here for parent isotopes. For example, the release rate of U-234 is assumed identical to that for U-238. Release rates of Pb-210 and Po-210 are assumed equal to that for Ra-226.

[b] Read as 3.18×10^{-3}, or 0.00318.

4.1.9.4 Radiation impacts to individuals

Four locations near the mill site were chosen to assess the impacts to individuals: one 0.40 km north-northwest of the mill site, one in the Cottonwood Community 0.43 km south-southeast of the site (in the prevailing wind direction), one 0.23 km west of the mill site, and one 0.68 km north of the mill site in the Dudley area.

Table 4.10 presents a summary of the individual dose commitments calculated for these locations. For each of the nearest residences, it was assumed that individuals ingest meat from cattle that graze on land 1.5 km from the center of the mill site. It is also assumed that locally grown vegetables are consumed at each of the nearest residences. As previously mentioned, the milk pathway is not considered to be significant in this situation.

Table 4.11 presents a comparison of individual dose commitments to NRC radiation protection standards and with background radiation estimates. Under 10 CFR Part 20, air concentrations of radioactive materials in unrestricted areas are limited to maximum permissible concentrations (MPCs). It should be pointed out that in none of the locations near to restricted areas are the MPCs expected to be exceeded. As to be expected, after decommissioning operations cease, air concentrations will be well below the MPCs. Table 4.12 summarizes these observations.

4.1.9.5 Radiation dose commitments to populations

The annual environmental population dose commitments predicted within 1.6 km (1 mile) of the mill site are presented in Table 4.13, along with estimated annual environmental population dose commitments to the same population from natural background radiation sources. The population distribution data for this area is presented in Table 4.14.

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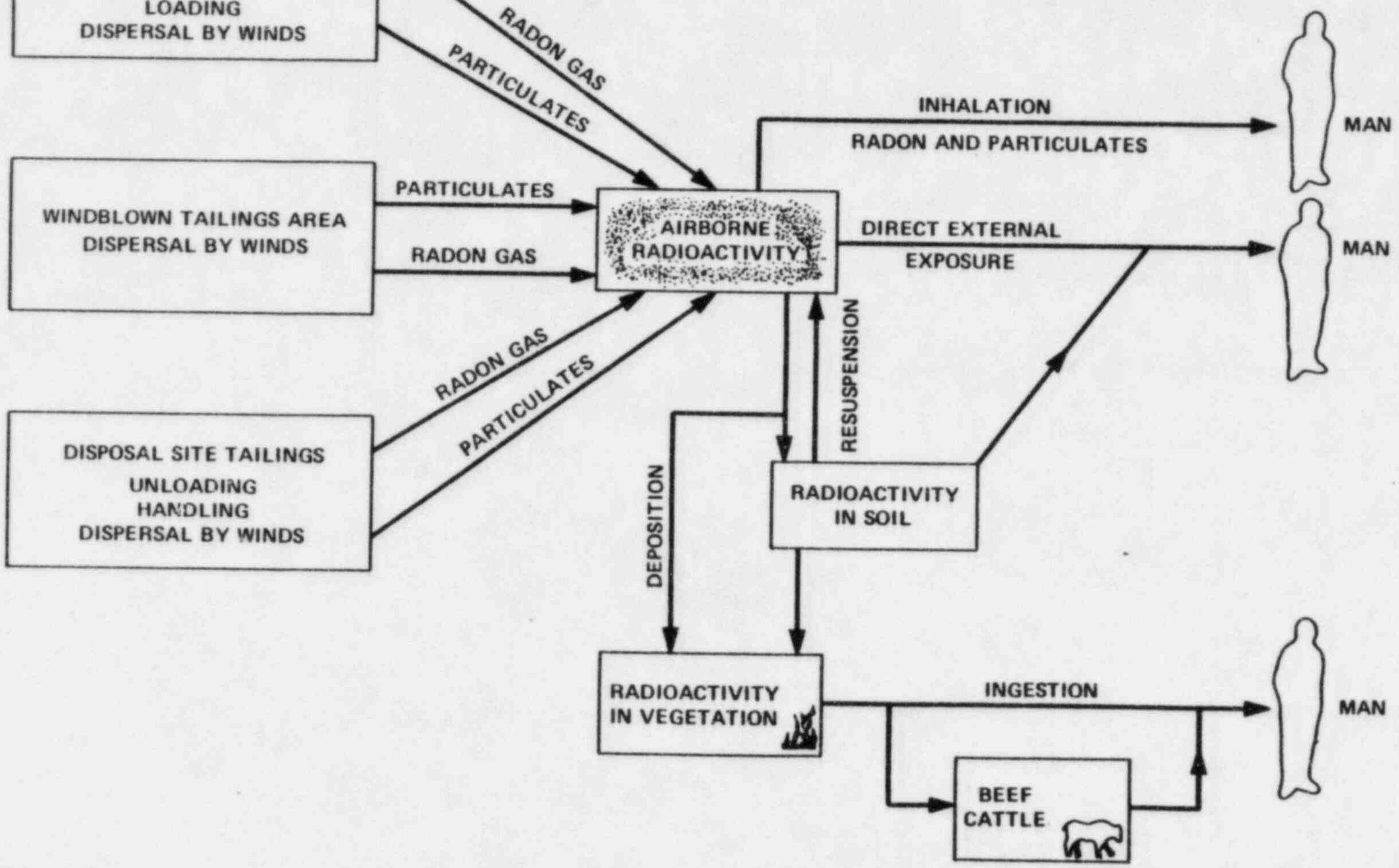

Fig. 4.1. Radioactive emissions from decommissioning and exposure pathways to man.

Table 4.10. Predicted annual dose commitments to individuals in vicinity of Edgemont site (millirems per year of exposure)[a,b]

Exposure pathway	Whole body		Bone		Lung		Bronchial epithelium	
	Decommissioning	Postdecommissioning[c]	Decommissioning	Postdecommissioning	Decommissioning	Postdecommissioning	Decommissioning	Postdecommissioning
North-northwest residence, 0.40 km from mill								
Inhalation	1.67E+00	1.04E−02	4.52E+01	2.78E−01	4.19E+01	2.27E−01	8.68E+02	2.47E+00
External ground	6.02E+00	5.76E+00	6.02E+00	5.76E+00	6.02E+00	5.76E+00		
External cloud	5.44E−01[d]	1.55E−03	5.44E−01	1.55E−03	5.44E−01	1.55E−03		
Vegetable ingestion	1.41E+01	3.78E−01	1.69E+02	4.32E+00	1.41E+01	3.78E−01		
Meat ingestion[e]	6.31E+00	2.77E−01	7.86E+01	3.27E+00	6.31E+00	2.77E−01		
Total	2.86E+01	6.43E+00	2.99E+02	1.36E+01	6.89E+01	6.64E+00	8.68E+02	2.47E+00
Cottonwood residence, 0.43 km southeast of mill (nearest residence in prevailing wind direction)								
Inhalation	1.94E+00	1.79E−02	5.27E+01	4.79E−01	5.00E+01	4.00E−01	1.25E+03	3.55E+00
External ground	6.61E+00	6.29E+00	6.61E+00	6.29E+00	6.61E+00	6.29E+00		
External cloud	6.39E−01	1.82E−03	6.39E−01	1.82E−03	6.39E−01	1.82E−03		
Vegetable ingestion	1.53E+01	4.76E−01	1.84E+02	5.48E+00	1.53E+01	4.76E−01		
Meat ingestion[e]	6.31E+00	2.77E−01	7.86E+01	3.27E+00	6.31E+00	2.77E−01		
Total	3.08E+01	7.06E+00	3.23E+02	1.55E+01	7.89E+01	7.44E+00	1.25E+03	3.55E+00
Edgemont residence, 0.23 km west of mill (Nearest residence)								
Inhalation	2.13E+00	1.39E−02	5.78E+01	3.70E−01	5.36E+01	3.02E−01	7.96E+02	2.26E+00
External ground	7.66E+00	7.36E+00	7.66E+00	7.36E+00	7.66E+00	7.36E+00		
External cloud	5.40E−01	1.53E−03	5.40E−01	1.53E−03	5.40E−01	1.53E−03		
Vegetable ingestion	1.80E+01	4.90E−01	2.16E+02	5.60E+00	1.80E+01	4.90E−01		
Meat ingestion[e]	6.31E+00	2.77E−01	7.86E+01	3.27E+00	6.31E+00	2.77E−01		
Total	3.46E+01	8.41E+00	3.61E+02	1.66E+01	8.61E+01	8.43E+00	7.96E+02	2.26E+00
Town of Dudley, 0.68 km north of mill								
Inhalation	8.64E−01	5.58E−03	2.35E+01	1.49E−01	2.24E+01	1.27E−01	5.59E+02	1.59E+00
External ground	2.92E+00	2.76E+00	2.92E+00	2.76E+00	2.92E+00	2.76E+00		
External cloud	6.18E−01	1.76E−03	6.18E−01	1.76E−03	6.18E−01	1.76E−03		
Vegetable ingestion	6.73E+00	1.83E−01	8.10E+01	2.09E+00	6.73E+00	1.83E−01		
Meat ingestion[e]	6.31E+00	2.77E−01	7.86E+01	3.27E+00	6.31E+00	2.77E−01		
Total	1.74E+01	3.23E+00	1.87E+02	8.27E+00	3.90E+01	3.35E+00	5.59E+02	1.59E+00

[a] Doses are integrated over a 50-year period from one year of inhalation or ingestion.

[b] Doses to the whole body, lungs, and bone are those resulting from the inhalation of U-238, U-234, Th-230, Ra-226, Pb-210, and Po-210 particulates. Doses to the bronchial epithelium are those resulting from the inhalation of radon daughters.

[c] Doses in these columns reflect cleanup standards of 5 pCi/g or less soil concentration for particulates (U-238, U-234, Th-230, Ra-226, Pb-210, and Po-210) and of 2 $pCi/m^2 \cdot s$ radon flux.

[d] 5.44E−01 should be read as 5.44×10^{-1}, or 0.544.

[e] Ingestion doses result from the consumption of the meat of cattle grazing 1.5 km southeast of the mill.

Table 4.11. Comparison of annual dose commitments to individuals with NRC radiation protection standards and with background radiation estimates (mrem/year)

	Whole body		Bone		Lung		Bronchial epithelium	
	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning
NRC limit (10 CFR 20)	500		3000		1500		3.3×10^{-2} WL[a]	
Estimated background radiation dose[b]	153		188		154		4.48×10^{-3} WL[c]	
Location								
NNW residence (0.40 km from mill)	28.6	6.43	299.0	13.6	68.9	6.64	1.64×10^{-3}	4.65×10^{-6}
Fraction of NRC limit	0.057	0.013	0.100	0.005	0.046	0.004	0.049	0.0001
Fraction of background	0.187	0.042	1.59	0.072	0.447	0.043	0.366	0.001
Cottonwood (0.43 km SE of mill)	30.8	7.06	323.0	15.5	78.9	7.44	2.42×10^{-3}	6.86×10^{-6}
Fraction of NRC limit	0.062	0.014	0.108	0.005	0.053	0.005	0.073	0.0002
Fraction of background	0.201	0.046	1.72	0.082	0.512	0.048	0.540	0.0015
Edgemont (0.23 km W of mill)	34.6	8.41	361.0	16.6	86.1	8.43	1.67×10^{-3}	4.73×10^{-6}
Fraction of NRC limit	0.069	0.017	0.120	0.006	0.057	0.006	0.050	0.0001
Fraction of background	0.226	0.055	1.92	0.088	0.559	0.055	0.373	0.001
Town of Dudley (0.68 km N of mill)	17.4	3.23	187.0	8.27	39.0	3.35	1.57×10^{-3}	4.45×10^{-6}
Fraction of NRC limit	0.035	0.006	0.062	0.003	0.026	0.002	0.047	0.0001
Fraction of background	0.114	0.021	0.995	0.044	0.253	0.022	0.350	0.001

[a] Radiation standards for exposures to Rn-222 and daughter products are expressed in Working Level (WL). WL means the amount of any combination of short-lived radioactive decay products of Rn-222 in 1L of air that will release 1.3×10^5 mega electron volts of alpha particle energy during their radioactive decay to Pb-210.

[b] Source: G. L. Montet et al., *Descriptions of United States Uranium Resource Areas, a Supplement to the Generic Environmental Impact Statement on Uranium Milling*, Report NUREG/CR-0597, ANL/ES-75, prepared by Argonne National Laboratory for the U.S. Nuclear Regulatory Commission, June 1979. The staff assumes the population dose due to background is equivalent to the general background dose for the Western Great Plains.

[c] The WL corresponds to the suggested bronchial epithelium background dose of 560 mrem in reference *b*.

Table 4.12. Comparison of predicted air concentrations during Edgemont decommissioning with 10 CFR Part 20 limits for unrestricted areas

Radionuclides	10 CFR 20 limits[a] (pCi/m³)	Restricted area boundary locations											
		0.9 km east[b]				0.9 km east-southeast[b]				Water tower			
		Decommissioning		Postdecommissioning[c]		Decommissioning		Postdecommissioning[c]		Decommissioning		Postdecommissioning[c]	
		Predicted value (pCi/m³)	Fraction of limit	Predicted value (pCi/m³)	Fraction of limit	Predicted value (pCi/m³)	Fraction of limit	Predicted value (pCi/m³)	Fraction of limit	Predicted value (pCi/m³)	Fraction of limit	Predicted value (pCi/m³)	Fraction of limit
U-238	5.0	3.71E−3[d]	7.42E−4	2.50E−5	5.01E−6	4.16E−3	8.31E−4	3.64E−5	7.28E−6	5.21E−3	1.04E−3	2.27E−5	4.53E−6
U-234	4.0	3.71E−3	9.28E−4	2.50E−5	6.26E−6	4.16E−3	1.04E−3	3.64E−5	9.10E−6	5.21E−3	1.30E−3	2.27E−5	5.66E−6
Th-230	0.3	4.10E−2	1.37E−1	2.77E−4	9.24E−4	4.60E−2	1.53E−1	4.03E−4	1.34E−3	5.76E−2	1.92E−1	2.50E−4	8.35E−4
Ra-226	2.0	4.12E−2	2.06E−2	2.78E−4	1.39E−4	4.61E−2	2.31E−2	4.04E−4	2.02E−4	5.78E−2	2.89E−2	2.51E−4	1.26E−4
Pb-210	4.0	4.11E−2	1.03E−2	2.78E−4	6.94E−5	4.61E−2	1.15E−2	4.03E−4	1.01E−4	5.77E−2	1.44E−2	2.51E−4	6.28E−5
Bi-210	200.0	4.11E−2	2.05E−4	2.77E−4	1.39E−6	4.60E−2	2.30E−4	4.03E−4	2.02E−6	5.77E−2	2.88E−4	2.51E−4	1.26E−6
Po-210	7.0	4.11E−2	5.87E−3	2.77E−4	3.96E−5	4.60E−2	6.57E−3	4.03E−4	5.76E−5	5.77E−2	8.24E−3	2.51E−4	3.59E−5
WL[e] concentrations	0.0333	3.33E−3	1.00E−1	9.46E−6	2.84E−4	3.82E−3	1.15E−1	1.08E−5	3.26E−4	1.97E−3	5.90E−2	5.58E−6	1.68E−4
Sum of fractions[f]			2.75E−1		1.47E−3		3.11E−1		2.05E−3		3.05E−1		1.24E−3

[a] Values from 10 CFR Part 20, Appendix B, Table II, column 1.

[b] Distances and directions are from water tower (see Fig. 2.8).

[c] These columns indicate the predicted concentrations at these locations after the Edgemont cleanup operations have been completed.

[d] Read as 3.71×10^{-3}, or 0.00371.

[e] WL denotes working level. A one-WL concentration is defined to be any combination of air concentrations of the short-lived Rn-222 daughters Po-218, Pb-214, Bi-214, and Po-214 that, in 1 L of air, will yield a total of 1.3×10^5 MeV of alpha particle energy in their complete decay to Pb-210. Predicted values given for outdoor air are those calculated on the basis of actual ingrowth from released Rn-222.

[f] Compliance with 10 CFR Part 20 is not achieved if the sum of the fractions is greater than 1. That is, if radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C and if the applicable maximum permissible concentrations (MPCs) are MPC_A, MPC_B and MPC_C, respectively, then the concentrations shall be limited so that the following relationship exists: $(C_A/MPC_A) + (C_B/MPC_B) + (C_C/MPC_C) < 1$.

Table 4.13. Predicted annual environmental dose commitments (EDCs) to local population within 1.6-km (1-mile) radius resulting from cleanup operations at Edgemont and disposal sites

Exposure pathway	100-year EDCs (person-rem/year)[a]							
	Whole body		Bone		Lung		Bronchial epithelium[b]	
	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning	Decom-missioning	Postdecom-missioning
Inhalation	1.717	0.009	46.72	0.255	44.36	0.236	814.7	2.314
External ground	122.0	0.712	122.0	0.712	122.0	0.712		
External cloud	1.115	0.003	1.115	0.003	1.115	0.003		
Vegetable ingestion[c]	7.550	0.035	87.79	0.407	7.550	0.035		
Meat ingestion[c]	2.588	0.012	29.22	0.135	2.588	0.012		
Total	135.0	0.771	286.8	1.512	177.6	0.998	814.7	2.314
Estimated population dose from natural background	306.0	306.0	376.0	376.0	308.0	308.0	1120	1120
Ratio of total annual regional population dose to that from natural background[d]	0.441	0.003	0.763	0.004	0.577	0.003	0.727	0.002

[a]Doses to the whole body, lung, and bone are those resulting from the releases of U-238, U-234, Th-230, Ra-226, and Pb-210 particulates.
[b]Inhalation doses to the bronchial epithelium are those resulting from the inhalation of radon daughters.
[c]Ingestion dose commitments do not reflect potential food export and thus may exceed dose commitments actually received by the local population.
[d]Background doses are based on the local population size of 2000.

Table 4.14. Population distribution within 1.6 km (1 mile) of Edgemont site

Distance from site [km (miles)]	Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.0–0.40 (0.0–0.25)	0	0	0	0	0	0	2	12	7	0	0	0	25	44	61	27
0.40–0.80 (0.25–0.50)	22	17	0	0	0	0	0	42	12	0	108	184	223	218	44	37
0.80–1.6 (0.50–1.0)	81	76	0	0	0	0	0	0	3	54	79	80	343	162	27	10
Total[a]	103	93	0	0	0	0	2	54	22	54	187	264	591	424	132	74

[a]Total 0–1.6 km (0–1 mile) population is 2000 persons.

As can be seen from Table 4.13, predicted population dose commitments are significantly below natural background radiation. Following completion of the project and reclamation of the mill and disposal sites, radiation doses will be at essentially background levels. Although this project necessitates increased exposure to radioactive materials in the short term, it provides for the elimination of the present health hazard over the long term.

4.1.9.6 Occupational dose

Comprehensive radiation protection practices will be utilized during decommissioning activities. These practices will include the use of training programs, contamination control procedures, personnel monitoring methodologies, and, as necessary, respiratory protection devices.

The scope of this NRC staff review has not included a review of the site's radiological safety program. The staff will review the radiological safety program, as it is developed by the licensee, and NRC approval of the program must be obtained before any activities having radiological implications are undertaken. The objective of this program should be consistent with the concept of maintaining exposure to employees as low as reasonably achievable (ALARA). Workers will be monitored to ensure that exposure rates are within applicable guidelines, and in the event that abnormally high exposures are detected, mitigative action shall be taken.

4.1.9.7 Radiological impact on biota other than man

Although no guidelines concerning acceptable limits of radiation exposure have been established for the protection of species other than man, it is generally agreed that the limits for humans are also conservative for other species. Doses from particulate effluents to terrestrial biota are quite similar to those calculated for man and arise from the same dispersion pathways and considerations. No adverse radiological impact is expected for resident biota.

4.1.9.8 Summary of radiological impact

While it may be said that the assumptions used as the basis for this assessment may lead to overestimation of the dose commitments, the staff feels that the methodology utilized is justified. The staff realizes that implementation of special design and operational features aimed at reducing particulate and radioactive emissions may result in significantly lower dose commitments to individuals and the population as a whole, but it is impossible to accurately quantify these reductions. The staff feels that in spite of the predicted dose commitments, the long-term benefits of eliminating a chronic health hazard far outweigh the short-term impacts associated with this action.

4.2 MONITORING PROGRAMS

The following sections present preliminary monitoring needs and general programs designed to evaluate the impacts of the proposed action. Details of specific monitoring programs for air quality, surface and groundwater quality, external radiation and soils must be developed by the applicant and submitted to the NRC for review and approval prior to implementation. Finalized programs will be presented in the Final Environmental Statement (FES) on the Edgemont decommissioning.

4.2.1 Nonradiological air quality

4.2.1.1 Predecommissioning

The applicant did not monitor the existing air quality at the site. A TSP monitor, installed about 22 km (14 miles) northwest of the site, has been operating since April 1979. Additional data on TSP in the region were available from State monitoring stations, the nearest being located about 32 km (20 miles) northeast at Hot Springs.

4.2.1.2 During decommissioning and stabilization

Total suspended particulates will be monitored throughout the decommissioning and stabilization phases of the project. In addition to the continued operations of the TSP sampler located 22 km (14 miles) northwest of the site, the applicant plans to establish a monitoring network of four or five standard high-volume TSP samplers (ER, Sect. 5.1.1). Tentative monitor locations are: (1) southeast of the mill area, approximately 500 m (1640 ft) east of the haul road; (2) in Cottonwood Community, approximately 150 m (490 ft) from the site boundary; (3) west of the mill area in the city of Edgemont, approximately 250 m (820 ft) from the site boundary; (4) north-northeast of the mill area, approximately 3000 m (9500 ft) from the site boundary; and (5) east-southeast of the disposal area, approximately 500 m (1640 ft) from the site boundary. These locations are in general agreement with those proposed by the State of South Dakota (ER, Appendix D). The applicant plans to sample every sixth day from midnight to midnight (in accordance with the South Dakota ambient air sampling schedules) prior to decommissioning operations to obtain baseline data and during inactive periods of decommissioning. The sampling frequency may be increased during the active periods of decommissioning, depending upon the type and extent of anticipated activities and the results of the monitoring program (ER, Appendix D). The results will indicate whether mitigation being used is adequate or if additional or modified procedures are necessary (ER, Sect. 4.1.2.3.2).

The proposed monitoring plan also includes continued operation of the meteorological station, although it will be moved because decommissioning activities will disrupt its operation. The new location, yet to be chosen, will be near enough to the project to provide representative data but far enough away to avoid having its operation adversely affected by the project (ER, Appendix D).

Modification of the air quality monitoring plan may be necessary as the final decommissioning design is completed and as the actual decommissioning progresses. Any significant adjustment to the monitoring network during or prior to project operations will be presented to the State before its implementation (ER, Appendix D).

4.2.1.3 During reclamation

Following completion of the decommissioning activities, TSP monitoring (Sect. 4.2.2.1) will be discontinued, except for the site east-southeast of the disposal area and either the Edgemont or the Cottonwood community sites. These two monitors will continue to operate until the reclamation program has been determined to be successful (Sect. 2.2.3.8).

4.2.2 Radiological environment

The applicant will be required to develop and submit for approval a comprehensive environmental monitoring program (EMP) designed to evaluate the radiological impacts of the project. The EMP should include decommissioning and operational monitoring (for generic guidance, see programs specified in NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills"). The EMP should cover activities at the mill site, the disposal area, and the haul roads and should involve soil, groundwater and surface water, air particulate, and vegetation sampling as well as direct gamma exposure, radon, and radon-flux measurements. The details of this EMP will be finalized during the comment period following the issuance of this Statement, and the program will be included in the FES for this project.

4.2.3 Soils

4.2.3.1 Predecommissioning

Soils in the vicinity were studied by the Soil Conservation Service. Soil unit maps were provided as well as descriptions of the characteristics of each soil mapping unit. In June 1980, the applicant sampled the Nunn clay loam and Norka silt loam associations within the proposed disposal site and along its immediate boundaries to determine the volume and suitability of material for use as plant growth media. The soils were analyzed for the following chemical and physical characteristics: pH, electrical conductivity, saturation percentage, texture class, copper, molybdenum, and soluble calcium and magnesium.

4.2.3.2 During decommissioning, stabilization, and reclamation

No monitoring program for soils is required during any decommissioning, stabilization, or reclamation operations except for determination of the radioactivity. Continuing radiological surveys will be required to ensure that cleaned areas are not recontaminated and that areas undergoing decontamination procedures have soil removed until levels are acceptable. It will be required that TVA prepare an operations and monitoring plan for staff approval to ensure that these conditions are met.

The staff will require that removal of overburden from the disposal site be closely monitored to ensure that soils suitable for use in reclamation are segregated from the subsoils.

The applicant did not present any plans to monitor the soils for the reclamation phase of the project. Prior analysis of the soils expected to be used for reclamation indicated that the reclaimed areas should be fertilized with nitrogen and phosphorus after seeding (Sect. 2.2.2.7). The staff believes that the applicant's specific recommendations regarding the application rates of these soil additives are premature at this time. Soils may not be properly segregated prior to storage, and nutrient contents of the soils may change over time. Therefore, the the applicant should analyze the nutrients of the soils after they have been placed on the area to be reclaimed. Soil amendments may be added during seedbed preparation.

4.2.4 Mineral resources

No monitoring efforts are required or needed.

4.2.5 Land use

The applicant acquired land use data from published reports, from correspondence with personnel of various governmental offices, and from onsite visits (ER, Sect. 4.3). No other special methodology was required.

The applicant should ensure that the decommissioning operation does not infringe on the activities (e.g., transportation routes) of the nearby residents to the maximum practicable extent.

The reclamation plan, as proposed by the applicant with recommended changes by the staff (Sect. 2.2.3.8), should allow the land at the disposal site to be used in a manner similar to its use prior to the decommissioning activities, and the land at the present mill site shall be available for future use, possibly with limited land use control measures.

4.2.6 Water

4.2.6.1 Surface water

Predecommissioning

Hydrology. A summary of the flow data for the Cheyenne River is presented in Sect. 3.6. Flow characteristics were determined and a stage-discharge relationship developed for Cottonwood Creek from discharge measurements and culvert flow formulas (Table 3.14, Sect. 3.6; and ER, Sect. 4.2). Flow characteristics of the ephemeral stream draining the proposed disposal area

will be determined by the applicant during 1981. These 1981 samples will provide baseline data for comparison with samples taken during decommissioning (ER, rev. 5).

Water quality. A summary of the results of the surface water quality sample analyses and number of samples taken is presented in Tables 3.15 and 3.17 of Sect. 3.6. The water quality parameters included in these tables as well as ER Tables 4.2-8 and 4.2-9 indicate that elevated chemical and trace metal levels at the mill site should continue to be sampled during predecommissioning, decommissioning, stabilization, and reclamation (Sect. 4.2.6.1) to ensure that contaminants released during decommissioning are determined and that data for all sampling periods are comparable. For example, pH, specific conductance, sulfate, chloride, iron, manganese, magnesium, arsenic, nickel, molybdenum, selenium, titanium, and vanadium should be monitored because levels of these constituents exceed EPA standards in groundwaters beneath the mill site (ER, Table 4.2-9).

Background information on water quality of the ephemeral stream draining the disposal area was not provided by the applicant. There is no flow except during precipitation events. The applicant will conduct a predecommissioning monitoring survey of the ephemeral stream channels at the disposal site during 1981 (ER, Sect. 5.1.2.2.1). The survey will be conducted prior to, during, and after a typical precipitation event to establish predecommissioning baseline water quality at the site.

During decommissioning and stabilization

Hydrology. The applicant will conduct a surface-water-monitoring program at the mill site during decommissioning, with details of the program to be finalized with EPA and NRC in coordination with the South Dakota Division of Water Quality. The applicant will establish a data base, which will include flow, time, and point and non-point-source discharges to predict hydrologic impacts resulting from decommissioning. Sufficient detail will be included to characterize a typical portion of the hydrograph prior to, during, and after precipitation events of sufficient size to produce a substantial, rapid change in stream stage or flow and water quality. Collection of this data base information will begin in 1981 (ER, Sect. 5.1.2.2.1).

Surface water monitoring will include periodic visual inspections during decommissioning to ensure maintenance and functioning of surface water diversion ditches. This monitoring program will also assess erosion at the disposal site and determine corrective action if required (ER, Sect. 5.1.2.1.1).

Water quality.

1. Mill site. A system of diversion structures will isolate runoff and potential hazardous spills within the slurry pipeline and haul road route (Sect. 2.2.2.2) and drain to Pond 10 (ER, Sect. 4.3.3). This diversion system, as well as the diversion ditch to be constructed east of the mill site (Sect. 2.2.2.3), will be inspected by the applicant routinely to ensure integrity, proper maintenance, and erosion control (ER, Sect. 3.5).

Cleanup of Cottonwood Creek will occur as discussed in Sects. 2.2.2.5, 2.2.3.8, and 4.1.6. A water-quality monitoring program, including parameters measured in the baseline monitoring program, will be continued at the mill site during decommissioning and afterwards, if inspections indicate a need to do so. This program will consist of monitoring the various chemical and physical constituents in Cottonwood Creek and the Cheyenne River on a routine basis. The constituents should be those that were determined from the baseline and predecommissioning monitoring programs to provide information for evaluation of the existing environment, tailings, and decommissioning impacts (Sect. 4.2.6.1). The results of the predecommissioning and decommissioning monitoring programs will be compared to determine the effectiveness of erosion control and contaminant removal from Cottonwood Creek and the Cheyenne River and to determine if groundwater contamination from beneath the site is significantly affecting surface water quality (Sect. 4.1.6.4).

2. Disposal site. The impact of the presence of the tailings disposal impoundment and effectiveness of related mitigation measures on water quality of the Cheyenne River will be determined by a monitoring program carried out throughout the emplacement and reclamation phases. This program will include monitoring of the ephemeral stream below the containment area to ensure sediment containment by the sediment pond (see Sect. 4.2.6.1). Monitoring will occur

during periods of stormwater runoff and snowmelt (ER, Sect. 5.1.2.2.1). The results of this monitoring program will be evaluated to determine the effectiveness of erosion control to prevent degradation of the two small downstream ponds and the Cheyenne River.

Suspended solids will be monitored downstream of the mill and disposal sites and will be compared with upstream and predecommissioning levels (Sect. 4.2.6). The suspended-solids monitoring will occur for each precipitation event until the effectiveness of the erosion control measures is determined. The applicant will quantify water quality impacts of the decommissioning to determine conditions that may require additional mitigative measures (ER, Sect. 5.1.2.2.1).

In addition to monitoring for suspended solids at the disposal site, the applicant will conduct a water quality program for the ephemeral streams associated with the disposal site. This program must specifically include contaminants associated with the tailings (Sect. 4.2.6) to ensure detection of any surface water contamination during decommissioning.

During reclamation

Hydrology. The applicant will conduct a surface-water-monitoring program at the mill site during reclamation of the site. This program should be a continuation of the predecommissioning and decommissioning monitoring programs. The monitoring program will include those parameters and sampling regimes established for the predecommissioning and decommissioning programs. The program should include monitoring of the ephemeral stream downstream of the disposal site following rainfall events (ER, rev. 5, Sect. 5.1.2.1.1).

Surface water monitoring will include periodic visual inspections during reclamation to ensure integrity and functioning of the surface water diversion structures. Monitoring during reclamation should continue until the success of revegetation is ensured such that erosion from the sites is typical of the area. Monitoring of Cottonwood Creek should continue until the streambed through the mill site is demonstrated to be similar in composition, stability, and runoff response to the upstream reaches of the stream.

Water quality. Monitoring for water quality during reclamation should follow the program established during predecommissioning and decommissioning (Sect. 4.2.6). This program should include those parameters determined from the earlier monitoring programs to provide information on potential contaminants that may continue to leach from groundwater into the adjacent water bodies or that may enter the streams as the result of runoff from either the mill or disposal sites.

4.2.6.2 Groundwater

Predecommissioning groundwater monitoring

Existing site. In the alluvial aquifer beneath the existing site, the applicant completed 14 monitor wells, from which preoperational groundwater level and quality data have been collected and compiled over the past three years. These data are discussed in Sect. 3.6.2.2.

Proposed disposal site. Prior to construction, the staff will require that monitor wells completed in the shallow alluvial aquifer, which is hydraulically downgradient from the proposed disposal area, have groundwater level and quality data determined to establish preoperational conditions.

During decommissioning, stabilization, and reclamation

Existing site. During the decommissioning and reclamation of the mill site, the staff recommends that groundwater levels and quality be monitored in observation wells in the immediate vicinity of the present tailings disposal site. Water levels should be checked in conjunction with groundwater quality sampling to ensure that groundwater hydraulic gradients that might enhance offsite transport of leachates are not developing. Groundwater samples should be monitored for radiological and nonradiological constituents.

Proposed disposal site. Groundwater levels and quality will be required to be monitored at the proposed disposal site to assess the effects, if any, of the operations on potentially affected groundwater.

Postreclamation groundwater monitoring

Existing site. As the removal of the existing tailings and related material approaches the final stages, the staff will require that the applicant obtain representative samples of both the groundwater and the alluvial material underlying each pond. If the underlying alluvium is contaminated radiologically, the appropriate area should be excavated to remove the contaminated material.

The applicant does not propose to perform any short- or long-term monitoring of the groundwater at the existing site upon completion of the decommissioning. Upon completion of reclamation activities, it will be determined whether additional monitoring is necessary.

Disposal site. The applicant believes that reasonable assurance will be provided by the design of the disposal site to preclude seepage and therefore does not propose any postoperational groundwater monitoring plan for the alluvial aquifer hydraulically downgradient from the disposal site. If operational monitoring indicates that seepage is minimal or nonexistent, the staff agrees that postoperational groundwater monitoring will not be required.

4.2.7 Biota

4.2.7.1 Aquatic biota

Predecommissioning

Samples were taken by the applicant from two tributaries — one site downstream of the mill and disposal site on the main stem of the Cheyenne River, and four sites along Cottonwood Creek, including areas above, through, and below the mill site — in September 1975 and June 1976 to determine the composition and diversity of nonfish aquatic biota (zooplankton, phytoplankton, and microinvertebrates) in the vicinity of TVA Edgemont properties.[9] In addition, TVA biologists sampled ten sites on the Cheyenne River and three of its tributaries to determine the fisheries resources of the area.[15] Additional sampling was conducted by the South Dakota Department of Game, Fish, and Parks and the applicant in the Cheyenne River and Cottonwood Creek during July 1980 to corroborate findings of the TVA biologists in 1979. The plains top minnow (*Fundulus sciadicus*), a South Dakota threatened species reported from the Cheyenne River by Mines Reclamation Consultants in 1976 (ER, Sect. 4.2), was not found by TVA biologists in 1979 nor by the Department of Game, Fish, and Parks. The minnow was not found in either the Cheyenne River or Cottonwood Creek in 1980.[16] All the fish species obtained during the predecommissioning surveys are widespread,[17] and none occur on the South Dakota list of threatened and endangered species.[16]

The fauna and flora of the stock pond in the disposal area, while not determined by the applicant, are probably characteristic of other small stock ponds in the area. The biota of the ephemeral stream through the disposal site, while not investigated by the applicant, is probably typical of other ephemeral streams in the area because of the similarities in topography, ephemeral nature, and potential habitats.

During decommissioning, stabilization, and reclamation

A monitoring program to document changes in population densities and diversities of fish, macrobenthos, and plankton will be conducted by the applicant during decommissioning. Sampling sites will be located on the Cheyenne River and Cottonwood Creek, both above and below the mill site (Fig. 3.16) and will correspond to sites sampled during predecommissioning monitoring (Sect. 4.2.1.7 and ER, Sect. 5.1.4.2). Aquatic communities at these sites will be sampled seasonally (four times a year) during decommissioning under comparable flow and sampling regimes (ER, Sect. 5.1). Samples will be taken from the same habitats and under flow regimes as similar to the baseline studies as possible. The applicant will use the same sampling methods as employed in the baseline study for all groups of aquatic biota.

The applicant will continue the same monitoring program during reclamation as established during predecommissioning and decommissioning. This reclamation program should include the

parameters established during the preceding monitoring programs. Monitoring during the reclamation stage of decommissioning should determine the effectiveness of the reclamation program in minimizing impacts to aquatic biota. The need for postreclamation monitoring should be determined based on the reclamation monitoring results and determination that there will be no long-term effects on biota following reclamation. Monitoring following reclamation should be based on determination of need for further monitoring rather than on an indefinite-term requirement.

Sampling during reclamation will enable the applicant to determine if the aquatic communities are becoming reestablished in the reach of Cottonwood Creek through the mill site and in areas of the Cheyenne River that may have required decontaminating. The sampling program during reclamation will show whether the reestablishment of habitats similar to the upstream reaches of the creek were successful and whether these habitats are capable of supporting aquatic communities of similar density and diversity as the upstream reaches. Sampling should be continued until the composition of aquatic communities in the mill reach is similar to that of communities upstream. After an appropriate period of sampling, in consultation with cognizant Federal and State organizations, the applicant should determine the existence of any impediments to colonization and provide remedial measures to ensure the recolonization of the stream.

4.2.7.2 Terrestrial biota

Predecommissioning

The applicant obtained data for the general vicinity of the project from published literature, discussions with personnel from various governmental agencies, and field surveys of TVA Edgemont leases for uranium production. General field surveys of the site and immediate vicinity were conducted in 1976 and 1979. A transect was established on the disposal site in December 1979 to determine big game utilization of the area by season. The average percent ground cover was estimated for each community in the vicinity of the disposal site in 1980. Limited onsite surveys of small mammals and birds within the sagebrush/grass and grass associations on the disposal site were conducted in the spring and summer of 1980.

During decommissioning, stabilization, and reclamation

Monitoring the terrestrial biota is not specifically planned for the decommissioning and stabilization phases of the project.

The reclamation plan will be consistent with the policy of South Dakota to establish a stand of vegetation that is capable of maintaining and regenerating itself without irrigation or artificial aids (ER, Sect. 5.1.4.1.1). The applicant will monitor all reclaimed areas to ensure that successful reclamation will be achieved. Permanent sampling plots will be used to monitor plant-cover development. At least ten sampling plots will be randomly located throughout the mill site and disposal areas. Each plot will consist of two 25-m (85-ft) transects, along which plant cover and species density will be determined using the line-intercept method. Both ends of each transect will be staked to allow monitoring of the same area each year. Control stations will be established in nearby communities that will not be disturbed by decommissioning activities. Reclamation will be considered successful when the cover and density of perennial species in the reclaimed areas equals the cover of the perennial species at control areas. This condition must be met for two consecutive seasons.

4.3 MITIGATION MEASURES

4.3.1 Air quality

In an effort to control air quality, the applicant should:

1. develop and utilize programs designed to control dusting,
2. limit disturbed areas (where project activities are being conducted) to as small a working area as possible, and
3. revegetate disturbed areas as soon as feasible.

In addition, the staff will require that when there is visible evidence of dust being blown from the site(s) from any source (traffic, dumping, loading, scraping, or wind pickup), that immediate efforts to minimize such transport be initiated. Further, the staff recommends that decommissioning operations be stopped temporarily when sustained wind speeds exceed 40 km/h (25 mph) (Sect. 4.1.1).

The applicant has suggested some type of road carpet on the haul road in addition to watering to minimize dusting. Because this roadway will be removed during reclamation and is carefully designed to capture runoff pollutants, the staff concurs and will require that the road be appropriately treated to prevent dusting during use.

4.3.2 Radiological environment

Mitigation measures for radiological considerations are essentially the same as those required for air quality, except for special emphasis on the disturbed areas containing tailings.

To confirm that the air quality mitigation measures are effective for the tailings area, the staff will require that air monitors be operated continuously during tailings (or slimes) removal operations to detect offsite transport of radionuclides. If unexpectedly high values are observed, the applicant shall determine the cause and provide a plan for mitigation for NRC approval. This control program shall include documented inspections.

4.3.3 Water

4.3.3.1 Surface water

The applicant proposes to mitigate surface water impacts, primarily sediment-containing runoff to the Cheyenne River, by alteration of drainage patterns. The staff approves of the proposal to divert uncontaminated surface runoff from the area east of the mill site to the floodplain of the Cheyenne River by constructing a diversion channel (Fig. 2.7). The staff recognizes that some sediment transport to the river before revegetation will occur but feels this transport will be of minor consequence.

The staff approves the applicant's proposal to control grading on the mill site in a manner to capture and impound rainfall on the site during operations. The applicant will monitor site runoff to document the effectiveness of this erosion control and modify the site operations as required.

The applicant has proposed a temporary diversion of Cottonwood Creek (Fig. 2.13) so that the existing stream channel can essentially be dredged out and eventually a new channel can be constructed. The staff concurs with this plan, contingent upon confirmation that the contamination of the creek bed is widespread, as is currently anticipated.

General staff comments on mitigating measures to control surface water impacts are as follows:

As the creek is decontaminated, the staff concurs that natural and man-made materials (i.e., concrete boulders) be placed in the existing stream as proposed by the applicant for the rerouted stretch of the stream (Sect. 2.2.2.5). These materials should be located in the stream channel along the stream margins and, where possible, in association with vegetation. It is felt that these materials will adequately reduce erosion of the stream margins and prevent the stream from cutting into possibly residually contaminated areas. The stream reach in the vicinity of tailings pile A (Fig. 2.9) may be unstable because a new channel will probably have to be constructed through this area. The addition of natural and man-made material in this area will help stabilize the substrate, provide habitat for colonization by aquatic biota, and prevent new erosion. If the entire stream through the mill site is rerouted as planned, the streambed and margins should be reconstructed of natural and man-made materials to create approximate streambed conditions upstream of the mill site.

Long-term impacts on surface water hydrology, water quality, and aquatic biota resulting from transport of contaminants remaining in the groundwater beneath the mill site will be mitigated in part by removal of the contaminated tailings and further by time and transport from the site (see Sects. 4.2.1.5 and 4.2.2.5).

At the disposal site, construction of a sediment pond downslope from the impoundment dike should prevent downstream sediment transport and streambed alteration. The applicant will be required to utilize diversion ditches and sediment ponds during initial construction to minimize any potential effects of sediment transport to the Cheyenne River.

4.3.3.2 Groundwater

Impoundment design specifically engineered, as currently planned, to minimize seepage in the disposal area is the only available mitigation measure to protect groundwater.

At the mill site, use of already contaminated water from the alluvial zone will enhance, over time, the natural groundwater improvement from infiltration and dilution.

4.3.4 Biota

No effective short-term mitigation measures to protect biota are available. However, long-term impacts to aquatic biota will be minimized by repopulation from upstream.

4.4 STAFF ASSESSMENT OF MONITORING PROGRAMS AND MITIGATION MEASURES

The staff considers the monitoring programs proposed by the applicant and modified by the staff to provide a suitable basis for observing and documenting the impacts of project operations.

The staff is aware that many of the proposed activities remain conceptual in nature. For this reason, the staff will require that before engaging in any activity not evaluated by the NRC staff, the applicant shall prepare an evaluation of the environmental consequences. If such evaluation indicates a potential for significant adverse environmental impacts, the applicant shall provide a written evaluation of the activity, including proposed monitoring and mitigation measures, and submit this evaluation to NRC for approval.

If the monitoring programs disclose unexpected harmful effects or evidence of irreversible damage not identified in this Statement or reducible by improved application of existing mitigation measures, the applicant shall provide to NRC an acceptable analysis of the problem and a mitigation plan to eliminate or significantly reduce the harmful effects or damage. With the above restrictions, the staff considers that the environmental monitoring program and proposed mitigation measures are at the state of the art and will protect the environment and the public to the greatest degree reasonably achievable.

4.5 INDIRECT EFFECTS

4.5.1 Lack of resource development

No valuable resources, as currently defined, that may be developed will be affected by the permanent disposal of the Edgemont tailings and other contaminated materials.

4.5.2 Possible conflicts between proposed action and objectives of Federal, State, regional, and local plans and policies

All of the above authorities are agreed that disposal of the Edgemont tailings and associated materials is desirable.

The specifics of monitoring and mitigation measures for the protection of the environment are subject to approval by many of the above authorities, and any conflicts will be resolved by conformance with legislative mandates of responsibility, when assigned, or negotiated agreement.

4.5.3 Effects on urban quality, historical and cultural resources, and society

The project will not affect any of the above items.

4.5.4 Energy requirement and conservation potential

The project has minimized energy requirements by locating the disposal site at the nearest acceptable location meeting long-term disposal criteria. In addition, much of the tailings will be transported by slurry pipeline, an energy-efficient method. No further conservation appears feasible.

4.5.5 Potential effects of accidents

Because of the nature of the proposed activities, the potential for significant impacts from accidents during the decommissioning of the Edgemont Mill will be small. The impoundment, haul roads, slurry pipelines, and operating procedures will be designed to minimize the possibility and to mitigate the consequences of any accident that may occur. The staff analyses of potential accidents and their effects are presented below.

4.5.5.1 Impoundment failure

During the placement of tailings in the impoundment, there will be some very slight risk of impoundment failure by flooding or by slope failure. The staff believes the probability of such failure and subsequent release of radionuclides to be negligible. The impoundment will be designed to meet Regulatory Guide 3.11 design criteria covering flood-resistant design, retention-dam static and seismic-slope stability, loading factors, settlement, and seepage effect on the dam structure.

The location of the impoundment at the head of a drainage basin, the use of drainage diversion ditches to further reduce drainage area, and the provision of adequate freeboard to accommodate the probable maximum flood (PMF) make the breaching of the impoundment by flooding a highly unlikely event.

The slurry transport phase of the operation will last less than two years, after which time the tailings will evaporate to dryness or otherwise be mixed with dry solids transported to the impoundment by truck. Therefore, the retention-dam structure will not be saturated by seepage as would retention dams for conventional mill tailings disposal which store liquids for 10 to 20 years. The engineered embankments and drainage blanket for seepage removal included in the proposed impoundment design will also provide an additional level of protection. On this basis, spontaneous failure of the dam with release of tailings is judged to be only a remote possibility, with even less likelihood of occurrence than the failure of an impoundment at an operating mill.

4.5.5.2 Slurry pipeline failure

The proposed slurry pipeline system will transport 1.678×10^6 MT (1.85×10^6 tons) of sand tailings to the impoundment within a period of 1 to 1.5 years. A decant return line will parallel the slurry line and will recycle water to the slurry plant on the mill site. The pipeline route from the mill site to impoundment will lie within the median ditch between the proposed haul roads. In the event that one of the pipelines should fail, the spilled slurry or solutions would be confined to the median ditch and haul road surfaces. The spill would be detected by truck drivers using the road or by slurry plant personnel noting a significant drop in pipeline pressure. Upon detection of the leak, the pipeline systems would be shut down and the spilled material would be isolated. Cleanup of the spill could be performed immediately or it could be deferred until the end of operations when the haul roads and pipeline systems are removed, with all contaminated materials being transported to the impoundment for disposal. In either case, contaminated materials would not be released to the environment. Therefore no significant or long-term effects are expected from an accidental failure of the slurry pipeline system.

4.5.5.3 Transportation accidents

To haul 5.37×10^6 MT (5.92×10^6 tons) of tailings and contaminated solids and 2.46×10^6 MT (2.70×10^6 tons) of uncontaminated borrow soils and impoundment cap materials between the mill site and the proposed impoundment, a distance of about 3.2 km (2 miles), 45.5-MT (50-ton) trucks

will be employed. Over the course of the decommissioning activity, material haulage will require approximately 172,500 round trips totaling 1,110,900 km (690,000 miles). All of this mileage will be on the proposed haul road. With the exception of a little used county road crossing the haul road route just within the proposed impoundment site, public roads will not be affected by materials haulage. The applicant is investigating the use of an underpass to isolate the county road and local traffic completely from the haul-road operations. Therefore direct public involvement in any waste transportation accidents is not expected.

The use of parallel one-way roads for outgoing and incoming trucks will reduce the collision hazards to the truck operators. Based on published statistics[18] giving an accident frequency of 1×10^{-6} to 1.6×10^{-6} per km (1.6×10^{-6} to 2.6×10^{-6} per mile), it is likely that one or two accidents may occur during the decommissioning operation. Based on an injury rate of 0.51 per accident,[18] one transportation related injury may be expected. For an accident fatality rate of 0.03 per accident,[18] the probability of a fatality resulting from waste haulage accidents would be no greater than 0.06. These estimates are based on highway accident data and may therefore represent a conservative estimate of the risks involved.

An accident involving the spill of contaminated materials such as tailings slimes may release some small quantities of radioactivity to the environment. Such spills would be cleaned up promptly, and all residual contamination in areas adjacent to the haul roads near the spill would be decontaminated along with the roads at the end of the project.

4.6 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

4.6.1 Air quality

The unavoidable impacts on air quality from the Edgemont decommissioning stem primarily from earth-moving activities. The area's air quality will be monitored during operations (Sect. 4.2.1.2) to determine whether mitigative methods are adequate or if additional or modified procedures should be implemented. The staff anticipates the impact on regional air quality to be minimal. The staff also expects that, at downwind local areas in both Edgemont and Cottonwood, the State and Federal 24-h air quality standard for TSP (150 $\mu g/m^3$) will be exceeded occasionally. The staff believes that no operational controls can prevent this occurrence under severe weather conditions. Decommissioning operations prone to dusting will be suspended during conditions of sustained high wind.

4.6.2 Land use

The mill site presently has a nonuse status. During decommissioning, 207 ha (514 acres) will be disturbed by preparation of the disposal site, construction of the haul road, and cleanup of the mill site. An additional small disturbance of land will occur during cleanup of contaminated areas off site. However, this disturbance will be temporary.

After reclamation, the 86-ha (213-acres) mill site will become available for future use, and 34-ha (86-acres) of the disposal site will be removed from agricultural use but will remain available to small indigenous wildlife.

4.6.3 Water

4.6.3.1 Surface water

The cleanup of Cottonwood Creek on the mill site will cause a short-term increase in sediment transport into the Cheyenne River. Other decommissioning activities will cause increased sediment transport in surface runoff even though mitigative measures are planned to minimize such transport. After reclamation, there will be a complete and permanent alteration of the surface water features at the disposal site. All of these effects are of minor importance on either a local or regional basis.

After reclamation, the water quality in Cottonwood Creek will be somewhat improved. However, since Cottonwood Creek is recharged by unconfined groundwater, water quality and streambed sediments may be temporarily degraded by inflow of contaminated groundwater from beneath the mill site.

4.6.3.2 Groundwater

Up to 1.29 x 10^5 m^3 (105 acre-feet) of water may be removed from the Pahasapa aquifer. This amount is minor in terms of the water available in the aquifer and will be replenished by normal recharge. The staff will require that consideration be given to using the chemically contaminated water in the alluvium under the mill site for slurry transport operations to decrease water use from the Pahasapa aquifer and hasten the restoration of alluvial water conditions under the mill site by natural processing.

Groundwater at the disposal site is not expected to be affected. However, monitoring will confirm this expectation.

4.6.4 Mineral resource

No known or currently commercially valuable mineral resources will be affected by this project.

4.6.5 Soils

Although clean topsoil and subsoil will be segregated prior to stockpiling for later reclamation use, a reduction in the quality of the soils is unavoidable. Moving the soils will disrupt existing physical, chemical, and biotic soil processes; and compaction by heavy machinery will reduce water and air circulation needed for plant growth.

During reclamation, ripping, fertilizing, and using soil amendments should make these impacts insignificant over the long term.

4.6.6 Ecological

4.6.6.1 Terrestrial

Vegetation will be removed from all areas affected by the decommissioning operation. Plant species composition and diversity will be altered because of this disruption of the natural vegetation and subsequent revegetation.

Loss of habitat for most wildlife populations on disturbed areas will occur because of project operations. It is likely that many less mobile forms of wildlife will be destroyed.

Habitat removal will be temporary, but the natural diversity of plant species may not recover.

4.6.6.2 Aquatic

During the cleanup of Cottonwood Creek, all aquatic communities will be destroyed. Assuming that the creek is fully reclaimed, the diverse aquatic community upstream from the mill site will repopulate the reach through the mill site more diversely than at present.

The only aquatic impact at the disposal site results from the destruction of the small existing stock-watering pond. Because many other similar ponds are nearby, this impact is considered minimal.

4.6.7 Radiological

Because most of the existing piles and ponds on the mill site have been covered with soil and vegetated, there is a potential for an increase in windblown tailings and an almost certain short-term increase in radon emanation during decommissioning activities.

The decommissioning activities will be carefully monitored and supervised. In the opinion of the staff, such releases will be less than those occurring during previous mill operation. Those releases will be temporary, and after disposal site closure the present chronic low-level releases will no longer be present, except for release of radon in levels approaching background.

4.6.8 Socioeconomic

The staff estimates that the project will not generate enough tax revenue (about $400,000 in 1979 dollars) to compensate for potential costs for needed potable and wastewater facilities and street and road improvements. The short-term nature of the project and the projected six-month working year will encourage transient labor which may result in housing deficiencies.

The staff, however, believes that the long-term beneficial effects of the disposal of tailings and the cleanup and release of the mill site for unrestricted use (potentially as an industrial site) more than outweighs any short-term economic costs to the local communities.

4.7 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

4.7.1 The environment

4.7.1.1 Surface elements

The short-term increases in suspended particulates and radiological emissions associated with decommissioning activities is more than offset by the removal of a chronic low-level radiological contamination source. The short-term loss of wildlife habitat and aquatic resources will be replaced by long-term conditions more conducive to viable ecological resources.

4.7.2 Society

Any short-term socioeconomic problems encountered by local governmental services will be offset by the long-term disposal of low-level radiological materials in a stable permanent site. Social stresses on employees and families are short term and will not extend into the future.

4.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

4.8.1 Land and mineral resources

After reclamation, a small net gain in land resources will occur. If, over time, the disposal area is made available for grazing, this gain will increase. No known or currently commercially valuable mineral resources are expected to be affected by the project.

4.8.2 Water and air resources

Water used during the project is recycled to the atmosphere for distribution elsewhere. The aquifer(s) used will be recharged by precipitation. The air is self-cleaning of pollutants at the concentrations expected.

4.8.3 Vegetation and wildlife

These resources are renewable; and although some irreversible and irretrievable commitment is required, the commitment is relatively minor.

4.8.4 Material resources

Decommissioning, disposal, and reclamation will require a commitment of human and financial resources. Commitments of machinery, vehicles, and construction materials are required. Fossil fuels are required for operation. None of the resources are in short supply relative to the size of and the necessity for the project.

4.9 THE NRC STAFF COST-BENEFIT SUMMARY

4.9.1 General effects

Uranium produced at the Edgemont site was primarily purchased by the government for defense purposes. Some of the production was used to produce nuclear power reactor fuel. The environmental costs of the onsite tailings and contaminated materials and their long-term disposal are prorated against and affected by the need for fissionable material for defense stockpiles and the benefits of energy generation. However, a review of the specific site-related benefits and costs of long-term disposal at the Edgemont site is appropriate.

4.9.2 Socioeconomic effects

The project will primarily be completed by imported labor because of low local unemployment rates. The imported labor will impact housing availability and, to a lesser extent, schools. Sewage systems may have to be expanded and water systems may need upgrading. It is unlikely that tax revenues from the project would generate sufficient public funds to compensate for needed expenditures. Local business will improve, but this monetary gain may be affected by the competition for personnel.

4.9.3 Environmental effects

Because the tailings disposal operation will be conducted on the mill site and the remote disposal site with material transport by slurry pipeline or trucks over a contained corridor between the two sites, little noise or dust will affect the general public. The radiation exposure of the nearby public may be temporarily increased during project operation, but monitoring and mitigating measures will keep such potential exposure well below permissible guidelines for protection of the health and safety of the public. After project completion, the mill site will be available for unrestricted surface use, and the chronic low-level excess radiological exposure, which presently exists near the site, will no longer be present.

4.9.4 Staff assessment

The staff concludes that the adverse environmental impacts and socioeconomic costs over the short term are more than offset by the removal of the radioactive materials from the Edgemont mill site. The application of the mitigating measures suggested by the applicant and the regulatory agencies involved will reduce the short-term adverse impacts to acceptable levels.

Over the longer term, removal of the uranium tailings from the Edgemont mill site and subsequent subsurface disposal will eliminate a chronic low-level radioactive exposure potential for the forseeable future and will allow future surface use of the mill site.

In considering the short-term land disturbance, the minimal radiological impact and the societal impacts of the project compared with the long-term advantages of elimination of surface radiological contamination near inhabited locations, net reclamation of land for surface use, and disposal of the radioactive materials, the staff opinion is that the benefits outweigh the costs and that the project should proceed with the conditions specified in the summary and conslusions.

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5. PROFESSIONAL QUALIFICATIONS OF THE EDGEMONT DECOMMISSIONING PROJECT DES TASK GROUP

The following individuals were responsible for independent analysis of information provided by the applicant in the ER and in responses to questions subsequently submitted requesting new information or clarification of material in the original ER. This interdisciplinary group obtained information from Federal, State, and local sources to supplement material provided by the applicant and also participated in the scoping process. There are no known relationships between the individuals or the organization that prepared this statement with industries regulated by the NRC and suppliers thereof that might give rise to an apparent or actual conflict of interest regarding the work described in this proposal.

A review of pertinent literature sources was also done to ensure that potential environmental consequences would be fully assessed and that the final recommendations made by the staff would be in conformance with the state of the art and with the interest of the National Environmental Policy Act.

The qualifications of each individual are listed so that primary responsibility for information in particular sections is apparent. Because much of the Environmental Statement represents joint efforts by the staff, it is impractical to provide a separate listing of contributors to many subsections.

Frank S. Anastasi

U.S. Nuclear Regulatory Commission

Washington, D.C.

Frank Anastasi is a project manager for the Uranium Recovery Licensing Branch of the Division of Waste Management. He is involved with the preparation of environmental impact statements and the evaluation of impacts associated with uranium milling. As a project manager, he coordinates technical support activities with licensing actions related to various uranium recovery operations and provides technical assistance to the staff on geology-related matters. Before joining the NRC, Anastasi worked as a field engineer on land development and construction projects.

Education:

- Received a B.S. degree in geology from the University of Maryland in 1980
- Is pursuing graduate studies at the George Washington University.

Jeffrey S. Baldwin

Energy Division

Oak Ridge National Laboratory

Jeffrey Baldwin is a research associate in the Environmental Impacts Section. Since May 1979, his work has involved environmental impact assessments of various nuclear fuel cycle facilities such as fuel fabrication facilities, uranium ore-buying stations, uranium ore-processing mills, and in situ solution mining of uranium. Before coming to Oak Ridge National Laboratory, Baldwin was a research associate with the National Uranium Resource Evaluation at the Oak Ridge Gaseous Diffusion Plant. His training has been in trace element geochemistry, hydrogeology, uranium geology, and coal geology. Baldwin's research has included the development of geochemical exploration models using trace element data from stream sediment, stream water, and groundwater to delineate areas of uranium mineralization; research concerning trace element, pyrite, and sulfur distribution in eastern U.S. coals; and various research topics relating to surface- and groundwater quality.

Education:

- Received an A.B. degree in geology from West Georgia College in 1973
- Received an M.S. degree in geology from the University of South Carolina in 1976
- Is currently working toward an M.B.A. degree at the University of Tennessee

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Giorgio Gnugnoli is primarily responsible for generating the NRC's independent analysis of radiological impacts from the airborne effluents from uranium milling facilities. His technical training is in mathematics, and his experience includes mathematical/computer modeling with applications in engineering and statistics. Since joining the Uranium Recovery Licensing Branch (WMUR) in 1978, he has assisted in the preparation and completion of the Generic Environmental Impact Statement on Uranium Milling, the 40 CFR 190 Compliance Assessment for NRC Licensed Uranium Recovery Facilities, and nearly all environmental assessments involving radiological impacts from uranium milling. His activities include technical monitoring and direction of NRC research contracts with the national laboratories, as well as providing mathematical, statistical, computer, and other technical support to the project managers on the staff.

Prior to joining the NRC, he was a faculty member of Georgetown University and Randolph-Macon College, simultaneously subcontracting with consultants to various U.S. government agencies.

Education:

- Received a B.S. degree in mathematics from Georgetown University in 1972
- Received an M.A. degree in mathematics from Georgetown University in 1974
- Completed all course work at Georgetown University for a Ph.D. degree in mathematics in 1976
- Passed Ph.D. comprehensive examinations at Georgetown University in mathematics in 1976

Affiliations:

- Holds membership in The American Mathematical Society (AMS), The Society of Industrial and Applied Mathematics (SIAM), The Mathematical Association of America (MAA), and The American Association of University Professors (AAUP)

Minton J. Kelly

Energy Division

Oak Ridge National Laboratory

Minton Kelly is the manager of the Nuclear Fuel Cycle Projects in the Environmental Impacts Section. He coordinates the preparation of Environmental Assessments and Statements using interdisciplinary groups of specialists chosen by the requirements of each project. His original experience with environmental studies was in 1947-1948 when he supervised collection of chemical, meteorological, and physical data in estuarine Louisiana as part of a long-range ecological study on oyster mortality. From 1968 through early 1971, he worked with an interdisciplinary team whose responsibilities were to develop methods to assess the radiological impact of proposed Plowshare projects. With the passage of the National Environmental Policy Act, he became a member of the original team at Oak Ridge National Laboratory developing impact statement methodology. He also supervised the preparation of Nuclear Reactor Environmental Statements until mid-1974. Kelly accepted his present job assignment in August 1977. His other experiences include (1) supervision of instrument integration for the bottom stage

of the initial manned moon rocket; (2) electrical and communications design for the Arabian American Oil Company; and (3) development of instrumentation for chemical kinetic studies, radiation resistant insulators, and equipment for studying postulated breeder reactor accidents.

Education:

- Received a B.S. degree in electrical engineering from Texas A&M University in 1947
- Received an M.S. degree in physical chemistry from Texas A&M University in 1951
- Received a Ph.D degree in physical chemistry from Texas A&M University in 1955

Affiliations:

- Elected a Fellow in the American Institute of Chemists
- Holds membership in Sigma Xi

Larry B. Lamonica
Science Applications, Inc.
Oak Ridge, Tennessee

Larry Lamonica is a chemical engineer with additional training and experience in the areas of nuclear engineering, air pollution control, and water-quality management. He has been responsible for assessing proposed milling processes and for aiding in the preparation of project description, accident, and alternative sections of seven uranium milling and mining projects. Lamonica's contribution to a study on comparative risks of electricity generation with uranium and coal involved definition of a model mine/mill complex and the ensuing definition of source terms based on generic effluent data from this type of facility.

Education:

- Received a B.S. degree in chemical engineering from Brigham Young University in 1977
- Is working toward an M.S. degree in chemical engineering at the University of Tennessee

Samuel C. Martin
Science Aplications, Inc.
Oak Ridge, Tennessee

Samuel Martin is an economist specializing in econometrics, environmental impact assessment, program planning, and power system voltage and loading distribution problems. He has been responsible for the preparation of alternative sections for six uranium milling and mining environmental impact statements. In addition, Martin was responsible for updating the socioeconomic sections of the Programmatic Environmental Impact Statement for the Department of Energy's Strategic Petroleum Reserve Program. His duties have also involved the preparation of guidelines to determine unit operations for the High-Temperature Gas-Cooled Reactor Recycle Facility at Oak Ridge National Laboratory.

Education:

- Received a B.S. degree in electrical engineering from Clemson University in 1967
- Received an M.S. degree in industrial management from Clemson University in 1968
- Received an M.A. degree in economics from the University of Tennessee in 1977
- Is working toward a Ph.D degree in economics from the University of Tennessee

Affiliations:

- Holds membership in the Southern Economic Association, Mid-Continent Regional Science Association, South Carolina Academy of Sciences, and Phi Kappa Phi
- Is a registered engineer-in-training in South Carolina

Virginia R. Tolbert
Environmental Sciences Division
Oak Ridge National Laboratory

Virginia Tolbert is in the Aquatic Ecology Section and is actively involved in the Environmental Impacts Program. Before coming to Oak Ridge National Laboratory in 1979, she held an appointment at the University of Tennessee as a postdoctoral fellow. Her research, sponsored by the U.S. Department of Energy, concentrated on the ecological effects of contour surface mining for coal on benthic insect communities. She is also interested in systematics of benthic insects, stream restoration, and environmental impact analysis of energy development on aquatic ecosystems. At Oak Ridge National Laboratory, she has participated in environmental impact assessments of geothermal energy, development; uranium mining and milling; and oil shale development. She has also participated in preparation of environmental report guidelines and environmental guidance for preparing major acquisition projects for the U.S. Department of Energy Division of NEPA Affairs. The research/assessment activities have dealt with aquatic habitats in deserts, grasslands, and deciduous forest ecosystems.

Education:

- Received a B.S. degree in biology from East Tennessee State University in 1970
- Received an M.S. degree in ecology from the University of Tennessee in 1972
- Received a Ph.D. degree in ecology from the University of Tennessee in 1978

Affiliations:

- Hold membership in the Ecological Society of America, the American Council for Reclamation Research, the North American Benthological Society, the Entomological Society of America, the Cambridge Entomological Society, and the Association of Southeastern Biologists

Larry D. Voorhees
Environmental Sciences Division
Oak Ridge National Laboratory

Larry Voorhees, team leader for the nuclear fuel cycle projects in the Environmental Impact Program, joined the laboratory in 1976. In 1975 he was employed by North Dakota State University to coordinate and conduct fauna surveys in western North Dakota to assess the environmental impacts of construction and operation of a surface coal mine and gasification complex. His research has centered primarily on wildlife management. At Oak Ridge National Laboratory, he has participated in environmental impact assessments of biomass plantations; siting, construction, and operation of nuclear power plants; and various phases of the nuclear fuel cycle including uranium mining, ore-buying, milling, and fuel fabrication. The research and/or assessment activities have been in grasslands, deserts, and both coniferous and deciduous forests.

Education:

- Received a B.A. degree in biology from University of Minnesota at Morris in 1970
- Received an M.S. degree in zoology from North Dakota State University in 1972
- Received a Ph.D. degree in zoology from North Dakota State University in 1976

Affiliations:

- Holds membership in the Wildlife Society, the Ecological Society of America, Sigma Xi, and the North Dakota Natural Science Society
- Member of the Committee on Roadside Maintenance of the Transportation Research Board, National Research Council

In addition, the Environmental Statement was reviewed by cognizant members of the Nuclear Materials Safety and Safeguards staff and the NRC legal staff for conformance with NRC policy and regulatory guides.

The NRC Environmental Project Manager who has primary responsibility for all aspects of the proposed project is:

Frank S. Anastasi
U.S. Nuclear Regulatory Commission
Mail Stop 461-SS
Washington, DC 20555

6. LIST OF AGENCIES RECEIVING DRAFT ENVIRONMENTAL STATEMENT

The following Federal, State, and local agencies have been sent copies of and asked to comment on the Draft Environmental Statement:

Department of the Army, Corps of Engineers
Department of Commerce
Department of the Interior
Department of Health and Human Services
Federal Energy Regulatory Commission
Department of Energy
Department of Transportation
Environmental Protection Agency
Department of Agriculture
Advisory Council on Historic Preservation
Department of Housing and Urban Development
Office of the Governor, State of South Dakota
Department of Agriculture, State of South Dakota
Department of Game, Fish, and Parks, State of South Dakota
Department of Water and Natural Resources, State of South Dakota
Sixth District Council of Local Governments, Rapid City, South Dakota
Department of Environmental Protection, State of South Dakota
Bureau of Land Management

Appendix A

RESERVED FOR COMMENTS

Appendix B

ASSUMPTIONS UTILIZED FOR SOCIOECONOMIC IMPACT ASSESSMENTS

(4) The family size for both secondary and basic worker families will average about 3.5, including 2 spouses and 1.5 children.[2]

(5) About 58% of the children will be school-age (5-18 years).[2]

b. The following assumptions were used to calculate operation impacts:

(1) Each basic job was assumed to induce 1.2 to 1.5 secondary jobs.[1]

(2) Of the basic and secondary in-migrating workers, 25% would not be married.[2]

(3) About 67.5% of the nonlocal basic and secondary workers with families will bring their families with them (50% of the total work force).[2]

(4) The family size for all in-migrating workers will average about 3.5 — including 2 spouses and 1.5 children.[2]

(5) About 58% of the children will be school-age.[2]

4. To determine settlement patterns, the staff assumed, for simplification, that all of the in-migrating workers and families would live in either Hot Springs or Edgemont. Considering the distances between these communities and the project site s) and the relative sizes (comparative populations) of the communities, it would normally be expected that about 75% of the nonlocal workers would live in Edgemont and about 25% in Hot Springs.[2] However, because Edgemont lacks some of the services, such as medical, that are usually attractive to in-migrants, local planners predict that about 50% of development-induced in-migrants may choose to live in Hot Springs.[3] Therefore, to allow for all potentialities, the staff developed settlement ranges to assess impacts.

Because construction activities are short term (six months), the staff assumed that 75 to 90% of the basic work force would choose to live in Edgemont and only 10 to 25% in Hot Springs. However, the staff believes that construction-induced, nonlocal secondary workers will not have the same settlement patterns as basic worker in-migrants. Although short-term construction activities may be responsible for their jobs, secondary workers, who usually are employed in retail trade and services, will not ordinarily in-migrate unless employment appears to be reasonably long term. Therefore, the staff expects that their settlement patterns will be more like those of operation workers; that is, a larger percentage of secondary workers will choose to live in Hot Springs than would an equivalent basic construction work force. Consequently, it was assumed that from 50 to 75% of the nonlocal, construction-elicited secondary workers would settle in Edgemont and from 25 to 75% in Hot Springs.

It was assumed that 50 to 75% of the operation's basic and secondary work force would settle in Edgemont and 25 to 50% in Hot Springs.

5. To determine personal incomes, the staff assumed that basic construction and operation workers' earnings would average about $20,000 per year before taxes (1979 dollars).[1,2] Research has shown that only about 33 to 40% of total earnings was spent locally in similar western communities;[2] therefore, the staff assumed (via the utilization of basic consumption theory) that the income multiplier for construction would be about 1.6; the operation multiplier was assumed to be 1.65.

6. To calculate tax revenues (1979 dollars), the staff used the assumptions and methodology utilized for a similar purpose in ref. 3. The revenue estimates, which are based on the 1979 tax structure, are tenuous and for the latter years of the project, when tax structures may have changed considerably, may be erroneous.

Appendix B

ASSUMPTIONS UTILIZED FOR SOCIOECONOMIC IMPACT ASSESSMENTS

The staff combined information from a literature survey, discussions, and written communications with the applicant, planners, and other authorities in the Hot Springs-Edgemont area to develop assumptions for analyzing the socioeconomic impacts of the proposed decommissioning project. The socioeconomic environment in the affected region is very dynamic and, because of the small size of the communities, is therefore very sensitive to inflow and outflow of industrial activity. Because of this high degree of sensitivity, any of the assumptions used could be in error in the long term. For example, if national recessionary conditions were to worsen, causing the shutdown of an industry, the anticipated low unemployment and housing vacancy rates, upon which two of the major assumptions are based, may be erroneous. No sure method exists for an analyst or planner to forecast such occurrences. Therefore, the staff chose to calculate high and low ranges to quantify impacts as much as feasible, recognizing that some of the high-to-low ranges are necessarily fairly wide.

1. The staff assumed that Edgemont and Hot Springs, the closest communities to the project, and Fall River County would receive the brunt of the impacts.

2. The impacts on employment, population, housing, school enrollments, and some of the other impacts were calculated utilizing worst-case assumptions:

   a. Peak project employment will be ~80 during construction [first project calendar year (CY)] and ~90 during operation (third project CY).

   b. Because of very low unemployment rates currently prevailing in the area and the expected continuation of tight labor markets during the 1980s, the staff assumed that a high percentage of the project-related work force would consist of nonlocal workers. Thus, it was assumed that 80 to 100% of the basic workers for both construction and operation would have to in-migrate and that 80% of the secondary (or project-induced) jobs would be filled by nonlocal workers.

   c. None of the basic and secondary workers will be from the same family.

   d. All locally obtained employees were previously unemployed.

   e. All single in-migrants will require separate residences.

3. The staff subdivided the analysis into two basic components, (a) construction and (b) operation. Construction activities will be short-term. Operation activities will take place over a much longer period of time. Also, construction workers typically differ from operation workers in spending patterns, housing demands, and in other critical socioeconomic characterisitics.[1,2] Therefore, the assumptions utilized to assess construction impacts differed from those used to analyze operation impacts:

   a. The following assumptions were used to calculate construction impacts:

      (1) Each basic job was assumed to induce 0.6 to 0.8 secondary jobs.[1]

      (2) Of the basic and secondary in-migrating workers, 25% would not be married.

      (3) Only 13 to 27% of the nonlocal basic workers with families will bring their families with them (10 to 20% of the total basic work force); 50% of the secondary workers with families will bring their families with them.

REFERENCES FOR APPENDIX B

1. U.S. Nuclear Regulatory Commission, *Final Generic Environmental Impact Statement on Uranium Milling*, Report NUREG-0706, Washington, D.C., September 1980.

2. Old West Regional Commission, *Construction Worker Profile: Final Report*, Mountain West Research, Inc., Washington, D.C., December 1975.

3. Sixth District Council of Local Governments, "Fall River County 601 Designation Application," Rapid City, S.D., June 18, 1979.

Appendix C

DETAILED RADIOLOGICAL ASSESSMENT

The calculated value of the annual dusting rate M is 307.86 g/m^2·year. Annual curie releases from the tailings piles are then given by the following relationship:

$$S = MA(1 - f_c)f_t(C)(2.5 \times 10^{-12}) , \quad (C.2)$$

where

S = annual release for the particular beach area, Ci/year;

A = assumed beach area of the pile, m^2;

f_c = fraction of dusting rate controlled by mitigating actions, dimensionless;

f_t = fraction of ore content of particular nuclide present in the tails;

C = assumed raw ore activity, pCi/g;

2.5 = dust-to-tails activity ratio;

10^{-12} = Ci/pCi.

The total area of the Edgemont tailings impoundments is 86.2 ha (213 acres) with an additional estimated 32.4 ha (80 acres) of dispersed tailings from wind blowing the tailings piles. Also, the disposal site 3.6 km southeast of the site will consist of a 28.3-ha (70-acre) impoundment.

The assessment of the actual site was performed under the following assumptions:

1. No reduction factor caused by wetting or chemical agents was assumed.
2. A time period of 2.5 years was used for the duration of emission from reclamation activities.
3. After reclamation, emission levels are assumed to meet recommended cleanup standards (5 pCi/g or less in soil of U-238, Th-230, Ra-226, Pb-210; 2 pCi/m^2·s radon flux).

As appropriate, different values were used for tailings activity depending on the type of tailings in the particular area (i.e., shines, sands, or mixture).

C.2 ATMOSPHERIC TRANSPORT

The staff analysis of offsite air concentrations of radioactive materials has been based on two years of meteorological data collected at the Edgemont meteorological station during the period May 1, 1977, through Oct. 31, 1979 (ref. 3). Collected meteorological data are entered into the MILDOS code as input in the form of a joint frequency distribution by wind speed group and direction. Joint frequency data employed by the staff for this analysis are presented in Table C.2.

The dispersion model employed by the MILDOS code is the basic straight-line Gaussian plume model. Ground-level, sector-averaged concentrations are computed using this model and are corrected for decay and ingrowth in transit (for Rn-222 and daughters) and for depletion caused by deposition losses (for particulate matter). Area sources are treated using a virtual point source technique. Resuspension into the air of particulate material initially deposited on ground surfaces is computed using a resuspension factor that depends on the age of the deposited material and its particle size. For the isotopes of concern here, total air concentration including resuspension is about 1.6 times ordinary air concentration.

The assumed particle size distribution, particle density, and deposition velocities for each source are presented in Table C.3.

Appendix C

DETAILED RADIOLOGICAL ASSESSMENT

This assessment describes the models, data, and assumptions used by the staff to perform its radiological impact assessment of the Edgemont decommissioning. The primary calculational tool employed is MILDOS,[1] an NRC-modified version of the UDAD (Uranium Dispersion and Dosimetry) computer code originated at Argonne National Laboratory.[2]

C.1 ANNUAL RADIOACTIVE MATERIAL RELEASES

Table 4.9 lists estimated annual activity releases for the Edgemont decommissioning. All data except for the annual average dusting rate for exposed tailings sands are based on data and assumptions given in Table 4.8 and described in Sect. 4.1. This dusting rate is calculated in accordance with the following equation:

$$M = \frac{3.156 \times 10^7}{0.5} \sum R_s F_s \; , \qquad (C.1)$$

where

M = annual dust loss per unit area, g/m^2·year;

3.156×10^7 = number of seconds per year;

0.5 = fraction of total dust loss constituted by particles <20 μm diam, dimensionless;[1]

R_s = dusting rate for tailings sands at the average wind speed for wind speed group s for particles <20 μm diam, g/m^2·s;

F_s = annual average frequency of occurrence of wind speed group s, dimensionless.

The values of R_s and F_s used by the staff are as given in Table C.1.

Table C.1. Parameter values for calculation of annual dusting rate for exposed tailings sands[a]

Wind speed group (knots)	Average wind speed [km/h (mph)]	Dusting rate (g/m^2 ·s)	Annual frequency of occurrence
0–3	2.4 (1.5)	0	0
4–6	8.9 (5.5)	0	0
7–10	16.0 (10.0)	3.92E–7[b]	0.29960
11–16	24.9 (15.5)	9.68E–6	0.16610
17–21	34.6 (21.5)	5.71E–5	0.02770
>21	45.1 (28.0)	2.08E–4	0.00750

[a]Dusting rate as a function of wind speed is computed by the MILDOS code (ref. 1). Wind speed frequencies obtained from annual joint frequency data presented in Table C.2.

[b]Read as 3.92×10^{-7}, or 0.000000392.

and decay in transit (radon and daughters). To compute inhalation doses, the total air concentration of each isotope at each location, as a function of particle size, is computed as the sum of the direct air concentration and the resuspended air concentration:

$$C_{aip}(t) = C_{aipd} + C_{aipr}(t) \ , \qquad (C.3)$$

where

$C_{aip}(t)$ = total air concentration of isotope i, particle size p, at time t, pCi/m^3;

C_{aipd} = direct air concentration of isotope i, particle size p, for the time constant, pCi/m^3;

$C_{aipr}(t)$ = resuspended air concentration of isotope i, particle size p, at time t, pCi/m^3.

The resuspended air concentration is computed using a time-dependent resuspension factor $R_p(t)$, defined by

$$R_p(t) = (1/V_p)10^{-5}\, e^{-\lambda_R t} \quad \text{for } t \leq 1.82 \text{ years}$$

and

$$R_p(t) = (1/v_p)10^{-9} \quad \text{for } t > 1.82 \text{ years} \ , \qquad (C.4)$$

where

$R_p(t)$ = ratio of resuspended air concentration to ground concentration, for a ground concentration of age t years, of particle size p, m^{-1};

V_p = deposition velocity of particle size p, cm/s;

10^{-5} = initial value of the resuspension factor (for particles with a deposition velocity of 1 cm/s), m^{-1};

λ_R = assumed decay constant of the resuspension factor (equivalent to a 50-d half-life), 5.06 years;

1.82 = time required to reach the terminal resuspension factor, years;

10^{-9} = terminal value of the resuspension factor (for particles with a deposition velocity of 1 cm/s), m^{-1}.

The basic formulation of the above expression for the resuspension factor, the initial and final values, and the assigned decay constant derive from experimental observations.[4] The inverse relationship to deposition velocity eliminates mass balance problems involving resuspension of 100% of the initial ground deposition for the 35-μm particle size (see Table C.3). Based on this formulation, the resuspended air concentration is given by

$$C_{aipr}(t) = \left[0.01\, C_{aipd} \times 10^{-5}\right] \times \left\{\frac{1 - \exp[-(\lambda_i^* + \lambda_R)(t - a)]}{(\lambda_i^* + \lambda_R)} + 10^{-4}\delta(t)\, \frac{\exp[-\lambda_R^*(t - a)] - \exp(-\lambda_i^* t)}{\lambda_i^*}\right\} \times (3.1.56 \times 10^7) \ , \qquad (C.5)$$

Table C.2. Joint frequency data (in percent) from mill meteorogical station (stability class 4)

Wind direction	Wind speed [km/h (mph)]						
	2.4 (1.5)	8.9 (5.5)	16.0 (10.0)	24.9 (15.5)	34.6 (21.5)	45.1 (28.0)	Total
N	0.6500	0.7800	0.3700	0.0500	0.0000	0.0000	1.8500
NNE	0.8200	0.8000	0.1800	0.0900	0.0000	0.0000	1.8900
NE	0.8600	0.9700	0.4900	0.2000	0.0000	0.0000	2.5200
ENE	0.6800	1.0600	0.9300	0.8000	0.0200	0.0000	3.4900
E	0.5500	2.0800	4.2900	3.8900	0.4000	0.0000	11.2100
ESE	0.4800	2.0800	4.6400	2.7600	0.1300	0.0000	10.0900
SE	0.2900	2.3000	3.1200	1.0000	0.0700	0.0200	6.8000
SSE	0.8200	2.3900	1.4600	0.5100	0.0900	0.0200	5.2900
S	1.2400	2.3300	0.6000	0.1600	0.0000	0.0000	4.3300
SSW	0.3700	1.4900	0.4600	0.1500	0.0200	0.0000	2.7900
SW	0.3700	0.8800	0.4700	0.2600	0.0900	0.0000	2.0700
WSW	0.6800	1.1900	0.8900	0.5700	0.1800	0.0000	3.5100
W	1.2300	2.8300	1.6400	0.5300	0.1600	0.0000	6.3900
WNW	1.3500	5.5000	4.5100	2.1900	0.3700	0.2700	14.1900
NW	1.8800	6.1700	4.2500	2.8500	1.1100	0.3300	16.5900
NNW	1.7100	2.6800	1.6600	0.6000	0.1300	0.1100	6.8900
Total	14.2800	35.5300	29.9600	16.6100	2.7700	0.7500	99.9000

Table C.3. Physical characteristics assumed for particulate material releases

Activity source	Diameter (μm)	Density (g/cm^3)	Deposition velocity (cm/s)	AMAD[a] (μm)
Tailings				
30%	5.0	2.4	1.0	7.75
70%	35.0	2.4	8.8	54.2
Ingrown radon daughters	0	1.0	0.3	0.3

[a]Aerodynamic equivalent diameter, used in calculating inhalation doses (ref. 1).

C.3 CONCENTRATION IN ENVIRONMENTAL MEDIA

Information provided below describes the methods and data used by the staff to determine the concentrations of radioactive materials in the environmental media of concern in the vicinity of the site. These include concentrations in the air (for inhalation and direct external exposure), on the ground (for direct external exposure), and in meat and vegetables (for ingestion exposure). Concentration values are computed explicitly by the MILDOS code for U-238, Th-230, Ra-226, Rn-222 (air only), and Pb-210. Concentrations of Th-234, Pa-234, and U-234 are assumed to equal that of U-238. Concentrations of Bi-210 and Po-210 are assumed to equal that of Pb-210.

C.3.1 Air concentrations

Ordinary, direct air concentrations are computed by the MILDOS code for each receptor location from each activity source by particle size (for particulates). Direct air concentrations computed by MILDOS include depletion by deposition (particulates) or the effects of ingrowth

radionuclide for which the ground concentration is explicitly calculated. For Pb-210, ingrowth from deposited Ra-226 can be significant. The concentration of Pb-210 on the ground caused by Ra-226 deposition is calculated by the staff, using the standard Bateman formulation and assuming that Ra-226 decays directly to Pb-210. If i = 6 for Ra-226 and i = 12 for Pb-210 (ref. 1), the following equation is obtained.

$$C_{g12}(Pb \leftarrow Ra) = \frac{\lambda_{12} D_{d6}}{\lambda_6^*} \left[\frac{1 - \exp(-\lambda_{12}^* t)}{\lambda_{12}^*} + \frac{\exp(-\lambda_6^* t) - \exp(-\lambda_{12}^* t)}{\lambda_6^* - \lambda_{12}^*} \right] , \quad (C.8)$$

where

$C_{g12}(Pb \leftarrow Ra)$ = incremental Pb-210 ground concentration resulting from Ra-226 deposition, pCi/m^2;

λ_n^* = effective rate constant for loss by radioactive decay and migration of a ground-deposited radionuclide and = $\lambda_n + \lambda_e$, s^{-1}.

C.3.3 Vegetation concentrations

Vegetation concentrations are derived from ground concentrations and total deposition rates. Total deposition rates are given by the following summation:

$$D_i = \sum_p C_{aip} V_p , \quad (C.9)$$

where D_i is the total deposition rate (including deposition of resuspended activity of radionuclide i, $pCi/m^2 \cdot s$.

Concentrations of released particulate materials can be environmentally transferred to the edible portions of vegetables or to hay or pasture grass consumed by animals by two mechanisms: direct foliar retention and root uptake. Five categories of vegetation are treated by the staff: edible above-ground vegetables, potatoes, other edible below-ground vegetables, pasture grass, and hay. Vegetation concentrations are computed using the following equation:

$$C_{vi} = D_i F_r E_v \left[\frac{1 - \exp(-\lambda_w t_v)}{Y_v \lambda_w} \right] + C_{gi}(B_{vi}/P) , \quad (C.10)$$

where

C_{vi} = resulting concentration of isotope i in vegetation v, pCi/kg;

F_r = fraction of total deposition retained on plant surfaces, 0.2, dimensionless;

E_v = fraction of foliar deposition reaching edible portions of vegetation v, dimensionless;

λ_w = decay constant accounting for weathering losses (equivalent to a 14-d half-life), 5.73×10^{-7} per s;

t_v = assumed duration of exposure while growing for vegetation v, s;

Y_v = assumed yield density of vegetation v, kg/m^2;

B_{vi} = soil-to-plant transfer factor for isotope i, vegetation type v, dimensionless;

P = assumed areal soil density for surface mixing, 240 kg/m^2.

where

$a = (t - 1.82)$ if $t < 1.82$ years;

$\delta(t) = 0$ if $t < 1.82$ and is unity otherwise, dimensionless;

$\lambda_i^* =$ effective decay constant for isotope i on soil, $year^{-1}$;

0.01 = deposition velocity for the particle size for which the initial resuspension factor value is 10^{-5} per meter, m/s;

3.156×10^7 = s/year.

Total air concentrations are computed using Eqs. (C.3) and (C.5) for all particulate effluents. Radon daughters that grow from released radon are not depleted because of deposition losses and are therefore not assumed to resuspend.

C.3.2 Ground concentrations

Radionuclide ground concentrations are computed from the calculated airborne particulate concentrations arising directly from onsite sources (not including air concentrations resulting from resuspension). Resuspended particulate concentrations are not considered for evaluating ground concentrations. The direct deposition rate of radionuclide i is calculated using the following relationship:

$$D_{di} = \sum_p C_{adip} V_p , \qquad (C.6)$$

where

D_{di} = resulting direct deposition rate of radionuclide i, $pCi/m^2 \cdot s$;

C_{adip} = direct air concentration of radionuclide i, particle size p, pCi/m^3;

V_p = deposition velocity of particle size p, m/s (see ref. 4).

The concentration of radionuclide i on a ground surface resulting from constant deposition at the rate D_{di} over time interval t is obtained from

$$C_{gi}(t) = D_{di} \left[\frac{1 - \exp(-\lambda_i + \lambda_e)t}{\lambda_i + \lambda_e} \right] , \qquad (C.7)$$

where

$C_{gi}(t)$ = ground surface concentration of radionuclide i at time t, pCi/m^2;

λ_i = radioactive decay constant[5] for radionuclide i, s^{-1};

λ_e = assumed rate constant for environmental loss, 5^{-1};

t = time interval over which deposition has occurred, s.

The environmental loss constant λ_e corresponds to an assumed half-time for loss of environmental availability of 50 years.[4] This parameter accounts for downward migration in soil and loss of availability caused by chemical binding. It is assumed to apply to all radionuclides deposited on the ground.

Ground concentrations are explicitly computed only for U-238, Th-230, Ra-226, and Pb-210. For all other radionuclides, the ground concentration is assumed equal to that of the first parent

C.4.1 Inhalation doses

Inhalation doses have been computed using air concentrations obtained by Eq. (C.3) (resuspended air concentrations are included) for particulate materials and the dose conversion factors presented in Table C.5.

Table C.5. Inhalation dose conversion factors

Values are given in millirems per year per picoCurie per cubic meter

Organ	U-238	U-234	U-230	Ra-226	Pb-210	Po-210
			Particle size = 0.3 μm			
Whole body					7.46E+0[a]	1.29E+0
Bone					2.32E+2	5.24E+0
Kidney					1.93E+2	3.87E+1
Liver					5.91E+1	1.15E+1
Mass average lung					6.27E+1	2.66E+2
			Particle size = 1.0 μm			
Whole body	9.82E+0	1.12E+1	1.37E+2	3.58E+1	4.66E+0	5.95E+1
Bone	1.66E+2	1.81E+2	4.90E+3	3.58E+2	1.45E+2	2.43E+0
Kidney	3.78E+1	4.30E+1	1.37E+3	1.26E+0	1.21E+2	1.79E+1
Liver	0	0	2.82E+2	4.47E−2	3.69E+1	5.34E+0
Mass average lung	1.07E+3	1.21E+3	2.37E+3	4.88E+3	5.69E+2	3.13E+2
			Particle size = 1.0 μm			
Whole body	4.32E+0	4.92E+0	1.66E+2	3.09E+1	4.36E+0	4.71E−1
Bone	7.92E+1	7.95E+1	5.95E+3	3.09E+2	1.35E+2	1.92E+0
Kidney	1.66E+1	1.89E+1	1.67E+3	1.09E+0	1.13E+2	1.42E+1
Liver	0	0	3.43E+2	3.87E−2	3.45E+1	4.22E+0
Mass average lung	1.58E+2	1.80E+2	3.22E+3	6.61E+3	7.72E+3	4.20E+2
			Particle size = 5.0 μm			
Whole body	1.16E+0	1.32E+0	1.01E+2	4.00E+1	4.84E+0	7.10E−1
Bone	1.96E+1	2.14E+1	3.60E+3	4.00E+2	1.50E+2	2.89E+0
Kidney	4.47E+0	5.10E+0	1.00E+3	1.41E+0	1.25E+2	2.13E+1
Liver	0	0	2.07E+2	4.97E−2	3.83E+1	6.36E+0
Mass average lung	1.24E+3	1.42E+3	1.38E+3	2.84E+3	3.30E+2	1.88E+2
			Particle size = 35.0 μm			
Whole body	7.92E−1	9.02E−1	5.77E+1	3.90E+1	4.43E+0	7.28E−1
Bone	1.34E+1	1.46E+1	2.07E+3	3.90E+2	1.38E+2	2.96E+0
Kidney	3.05E+0	3.47E+0	5.73E+2	1.38E+0	1.15E+2	2.19E+1
Liver	0	0	1.19E+2	4.85E−2	3.51E+1	6.52E+0
Mass average lung	3.33E+2	3.80E+2	3.71E+2	7.64E+2	8.70E+1	5.75E+1

[a] Read as 7.46 × 10^0, or 7.46.

Sources: M. Momeni et al., *Uranium Dispersion and Dosimetry (UDAD) Code*, Report NUREG/CR-0553 (ANL/ES-72), Argonne National Laboratory, Chicago, Ill., May 1979; D. R. Kalkwarf, *Solubility Classification of Airborne Products from Uranium Ores and Tailings Piles*, Report NUREG/CR-0530 PNL-2830, Pacific Northwest Laboratory, Richland, Wash., January 1979.

The value of Ev is assumed to be 1.0 for all above-ground vegetation and 0.1 for all below-ground vegetables.[6] The value of t_v is taken to be 60 d, except for pasture grass, where a value of 30 d is assumed. The yield density Y_v is taken to be 2.0 kg/m^2, except for pasture grass, where a value of 0.75 kg/m^2 is applied. Values of the soil-to-plant transfer coefficients, B_{vi}, are provided in Table C.4.

Table C.4. Environmental transfer coefficients

Material	U	Th	Ra	Pb
Plant/soil, B_{vi}				
Edible above ground	2.5E-3[a]	4.2E-3	1.4E-2	4.0E-3
Potatoes	2.5E-3	4.2E-3	3.0E-3	4.0E-3
Other below ground	2.5E-3	4.2E-3	1.4E-2	4.0E-3
Pasture grass	2.5E-3	4.2E-3	1.8E-2	2.8E-2
Stored feed (hay)	2.5E-3	4.2E-3	8.2E-2	3.6E-2
Beef/feed, F_{bi}, pCi/kg per pCi/d	3.4E-4	2.0E-4	5.1E-4	7.1E-4

[a]Read as 2.5×10^{-3}, or 0.0025.

Source: U.S. Nuclear Regulatory Commission, *Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Operations*, Report Task RH 802-4, Washington, D.C., May 1979.

C.3.4 Meat concentrations

Radioactive materials can be deposited on grass, hay, or silage, all of which are eaten by meat animals, which are, in turn, eaten by man. The assumption has been made that meat animals obtain their entire feed requirement by grazing six months per year and by eating nonlocally grown stored feed for the remainder of the year. The equation used to estimate meat concentrations is

$$C_{bi} = QF_{bi}(0.50C_{pgi} + 0.50C_{hi}) , \qquad (C.11)$$

where

C_{bi} = resulting concentration of isotope i in meat, pCi/kg;

Q = assumed feed ingestion rate, 50 kg/d;

F_{bi} = feed-to-meat transfer factor for isotope i, pCi/kg per pCi/d (see Table C.4);

0.50 = fraction of total annual feed requirement assumed to be satisfied by pasture grass;

C_{pgi} = concentration of isotope i in pasture grass, pCi/kg;

0.50 = fraction of the total annual feed requirement assumed to be satisfied by locally grown stored feed (hay);

C_{hi} = concentration of isotope i in hay (or other stored feed), pCi/kg.

C.4 DOSES TO INDIVIDUALS

Doses to individuals have been calculated for inhalation, external exposure to air and ground concentrations, and ingestion of vegetables and meat. Internal doses are calculated by the staff using dose conversion factors that yield the 50-year dose commitment, that is, the entire dose insult received over a period of 50 years following either inhalation or ingestion. Annual doses given are the 50-year dose commitments resulting from a one-year exposure period. The one-year exposure period was taken to be the final year of mill operation when environmental concentrations resulting from plant operations are expected to be near their highest level.

Table C.6. Dose conversion factors for external exposure

Isotope	Skin	Whole body
For air concentration doses (millirems per year per picoCurie per cubic meter)		
U-238	1.05E−5[a]	1.57E−6
Th-234	6.63E−5	5.24E−5
Pa(m)-234	8.57E−5	6.64E−5
U-234	1.36E−5	2.49E−6
Th-230	1.29E−9	3.59E−6
Ra-226	6.00E−5	4.90E−5
Rn-222	3.46E−0	2.83E−6
Po-218	8.18E−7	6.34E−7
Pb-214	2.06E−3	1.67E−3
Bi-214	1.36E−2	1.16E−2
Po-214	9.89E−7	7.66E−7
Pb-210	4.17E−5	1.43E−3
For ground concentration doses (millirems per year per picoCurie per square meter)		
U-238	2.13E−6	3.17E−7
Th-234	2.10E−6	1.66E−6
Pa(m)-234	1.60E−6	1.24E−6
U-234	2.60E−6	4.78E−7
Th-230	2.20E−6	6.12E−7
Ra-226	1.16E−6	9.47E−7
Rn-222	6.15E−8	5.03E−8
Po-218	1.42E−8	1.10E−8
Pb-214	3.89E−5	3.16E−5
Bi-214	2.18E−4	1.85E−4
Po-214	1.72E−8	1.33E−8
Pb-210	6.65E−6	2.27E−6

[a] Read as 1.05 × 10^{-5}, or 0.0000105.

Source: U.S. Nuclear Regulatory Commission, *Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations*, Report Task RH 802-4, Washington, D.C., May 1979.

Table C.7. Assumed food ingestion rates[a]

	Infant	Child	Teen	Adult
Vegetables, kg/year		48	76	105
Edible above ground		17	29	40
Potatoes		27	42	60
Other below ground		3.4	5.0	5.0
Meat (beef, fresh pork, and lamb), kg/year		28	45	78

[a] Ingestion rates are averages for typical rural farm households. No allowance is credited for portions of year when locally or homegrown food may not be available.

Source: J. F. Fletcher and W. L. Dotson, *HERMES—A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry*, Report HEDL-TME-71-168, Hanford Engineering Development Laboratory, Hanford, Wash., December 1971.

Dose to the bronchial epithelium from Rn-222 and short-lived daughters were computed based on the assumption of indoor exposure at 100% occupancy. The dose conversion factor for bronchial epithelium exposure from Rn-222 is derived as follows:

1. 1 pCi/m^3 Rn-222 = 5×10^{-6} working levels (WL).*

2. Continuous exposure to 1 WL = 25 cumulative working level months (WLM) per year.

3. 1 WLM = 5000 millirems.

Therefore,

$$(1\ pCi/m^3\ Rn\text{-}222) \times \left(5 \times 10^{-6}\ \frac{WL}{pCi/m^3}\right) \times \left(25\ \frac{WLM}{WL}\right) \times \left(5000\ \frac{millirems}{WLM}\right) = 0.625\ millirem\ , \quad (C.12)$$

and the Rn-222 bronchial epithelium dose conversion factor is taken to be 0.625 millirems per year per pCi/m^3.

C.4.2 External doses

External doses from air and ground concentrations are computed using the dose conversion factors provided in Table C.6 (ref. 1.). Doses are computed based on 100% occupancy at the particular location. Indoor exposure is assumed to occur 14 h/d at a dose rate of 70% of the outdoor dose rate.

C.4.3 Ingestion doses

Ingestion doses are computed for vegetables and meat (beef and lamb) on the basis of concentrations obtained using Eqs. (C.9) through (C.12), ingestion rates given in Table C.7, and dose conversion factors given in Table C.8 (ref. 1). Vegetable ingestion doses were computed assuming an average 50% activity reduction caused by food preparation.[4] Ingestion doses to children and teenagers were computed but were found to be equal to or less than doses to adults.

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*One WL concentration is defined as any combination of short-lived radioactive decay products on Rn-222 in 1 L of air that will release 1.3×10^5 MeV of alpha particle energy during radioactive decay to Pb-210.

Table C.8. Ingestion dose conversion factors

Values are in millirem per picoCurie ingested

Age group	Organ	Isotope							
		U-238	U-234	Th-234	Th-230	Ra-226	Pb-210	Bi-210	Po-210
Infant	Whole body	3.33E–4	3.80E–4	2.00E–8	1.06E–4	1.07E–2	2.38E–3	3.58E–7	7.41E–4
	Bone	4.47E–3	4.88E–3	6.92E–7	3.80E–3	9.44E–2	5.28E–2	4.16E–6	3.10E–3
	Liver	0	0	3.77E–8	1.90E–4	4.76E–5	1.42E–2	2.68E–5	5.93E–3
	Kidney	9.28E–4	1.06E–3	1.39E–7	9.12E–4	8.72E–4	4.33E–2	2.08E–4	1.26E–2
Child	Whole body	1.94E–4	2.21E–4	9.88E–9	9.91E–5	9.87E–3	2.09E–3	1.69E–7	3.67E–4
	Bone	3.27E–3	3.57E–3	3.42E–7	3.55E–3	8.76E–2	4.75E–2	1.97E–6	1.52E–3
	Liver	0	0	1.51E–8	1.78E–4	1.84E–5	1.22E–2	1.02E–5	2.43E–3
	Kidney	5.24E–4	5.98E–4	8.01E–8	8.67E–8	4.88E–4	3.67E–2	1.15E–4	7.56E–3
Teenager	Whole body	6.49E–5	7.39E–5	3.31E–9	6.00E–5	5.00E–3	7.01E–4	5.66E–8	1.23E–4
	Bone	1.09E–3	1.19E–3	1.14E–7	2.16E–3	4.09E–2	1.81E–2	6.59E–7	5.09E–4
	Liver	0	0	6.68E–9	1.23E–4	8.13E–6	5.44E–3	4.51E–6	1.07E–3
	Kidney	2.50E–4	2.85E–4	3.81E–8	5.99E–4	2.32E–4	1.72E–2	5.48E–5	3.60E–3
Adult	Whole body	4.54E–5	5.17E–5	2.13E–9	5.70E–5	4.60E–3	5.44E–4	3.26E–8	8.59E–5
	Bone	7.67E–4	8.36E–4	8.01E–8	2.06E–3	4.60E–2	1.53E–2	4.61E–7	3.56E–4
	Liver	0	0	4.71E–9	1.17E–4	5.74E–6	4.37E–3	3.18E–6	7.56E–4
	Kidney	1.75E–4	1.99E–4	2.67E–8	5.65E–4	1.63E–4	1.23E–2	3.83E–5	2.52E–3

Sources: U.S. Nuclear Regulatory Commission, *Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations*, Report Task RH 802-4, Washington, D.C., May 1979; G. R. Hoenes and J. K. Soldat, *Age-Specific Radiation Dose Conversion Factors for a One-Year Chronic Intake*, Report NUREG-0172, Battelle Pacific Northwest Laboratories, Richland, Wash., November 1977.

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*Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, DC 20555, and the National Technical Information Service, Springfield, VA 22161.

Appendix D

CALCULATION OF GAMMA RADIATION ATTENUATION FOR RECLAIMED TAILINGS DISPOSAL AREA

Appendix D

CALCULATION OF GAMMA RADIATION ATTENUATION FOR RECLAIMED TAILINGS DISPOSAL AREA

Assuming soil is composed mainly of SiO_2, the mass attenuation coefficient for a 1- to 2-MeV gamma ray is 0.0518 cm^2/g (ref. 1). (Most of the dose rate from a typical natural emitter is in this range.[2]) The highest gamma radiation rate measured[3] on the site was 33 R/year (3780 μR/h) on pond 1. Assuming that the bulk density of the soil is 1.6 g/cm^3, the effect of 3.05 m (10 ft) of soil materials would reduce the gamma radiation to $\sim 3.6 \times 10^{-7}$ mR/year.

$$I/I_o = \exp[-(\mu_{en}/\rho)\rho x] = \exp[-(0.0518\ cm^2/g)(1.6\ g/cm^3(305\ cm)] = 1.1 \times 10^{-11} ;$$

$$I = (1.1 \times 10^{-11})(33\ R/year) = 3.6 \times 10^{-7}\ mR/year .$$

The background radiation dose for the Western Great Plains from all sources of radioactivity, including the contribution from fallout, is about 153 mR/year.[4] Thus, the gamma radiation from the deposited tailings after reclamation would be insignificant compared with the natural background radiation.

REFERENCES FOR APPENDIX D

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4. G. L. Montet et al., *Descriptions of United States Uranium Resource Areas, A Supplement to the Generic Environmental Impact Statement on Uranium Milling*, Report NUREG/CR-0597, ANL/ES-75, prepared by Argonne National Laboratory for the U.S. Nuclear Regulatory Commission, June 1979, pp. 16-1 and 16-2.

Appendix E

CALCULATION OF THICKNESS OF REQUIRED COVER MATERIAL

D_0 = effective bulk diffusion coefficient for radon in the tailings, cm^2/s;

P_0 = porosity or void fraction in tailings solids, dimensionless.

The values for computing the bare tailings flux for the Edgemont decommissioning facility are [Ra] = 705.2 pCi/g, ρ = 1.6 g/cm^3, E = 0.2, and D_0/P_0 = 0.0112 cm^2/s. The factor of 10^4 converts square centimeters to square meters, and the value of D_0/P_0 = 0.0112 cm^2/s was obtained from Eq. (E.1) based on a tailings residual moisture of 8.6%. Substitution of the above values yields

$$J_0 = (705.2 \text{ pCi/g})(1.6 \text{ g/cm}^3)(0.2) \times (2.1 \times 10^{-6} \text{ s}^{-1} \times 0.0112 \text{ cm}^2\text{/s})^{1/2} \times 10^4 \text{ cm}^2\text{/m}^2$$

$$= 346.08 \text{ pCi/m}^2 \cdot \text{s}.$$

Equation (E.2) assumes effectively infinite depth of tailings. A factor given by tanh $[\sqrt{\lambda/D_0/P_0}X_0]$, where X_0 is the depth of tailings, is used to account for finite depth of tailings. However, in cases where the average depth of tailings is 3 m or more, the factor is effectively unity.

E.3 MINIMUM COVER CALCLUATION

The procedure for determining the minimum thickness of cover materials for tailings is established in Appendix P of ref. 2. The reclamation plan stipulates 3, 7, and 0.6 ft of compacted clay, overburden, and topsoil, respectively. Several types of clay occur in the environment.[3] The staff has assumed that a clay soil profile of 12.3% moisture content should be reasonably conservative in estimating the long-term moisture of the clay layer. High moisture in the surrounding soils indicates that a 9.7% moisture for silty soils is observable.[3] The staff assumes that the topsoil and the overburden will maintain this level of moisture because the surrounding environment support these conditions. The tailings cover serves two main purposes:

1. to stabilize and isolate the uranium tailings wastes from contact with the environment, whether by intrusion or extrusion, and

2. to mitigate radon exhalation to a level below 2 $pCi/m^2 \cdot s$ Rn-222 above natural background.

The second purpose concerns this segment of the analysis.

The following equation is used to estimate radon flux from the surface of the clay cover:

$$J_1 = \frac{2J_0\exp(-b_1x_1)}{\left(1 + \frac{P_0}{P_1}\left[\frac{D_0/P_0}{D_1/P_1}\right]^{1/2}\right) + \left(1 - \frac{P_0}{P_1}\left[\frac{D_0/P_0}{D_1/P_1}\right]^{1/2}\right)\exp(-2b_1x_1)} , \quad (E.3)$$

where

$b_1 = (\lambda P_1/D_1)^{1/2}$;

x_1 = thickness of the clay layer, cm;

P_0 = porosity of the tailings;

P_1 = porosity of the clay material.

Using Eq. (E.1), the following D/P values are computed:

D_0/P_0 = 0.0112 cm^2/s tailings (8.6% moisture);

D_1/P_1 = 0.0043 cm^2/s clay layer (12.3% moisture).

Appendix E

CALCULATION OF THICKNESS OF REQUIRED COVER MATERIAL

E.1 INTRODUCTION

The calculation of the thicknesses of cover materials required to attenuate radon flux to near-background levels is based on diffusion theory. The effectiveness of a particular cover material in attenuating radon depends on the material's ability to restrict the diffusion of radon through it so that the radon gas decays to a solid daughter product before reaching the surface.

Material properties used to determine radon attenuation are the effective bulk diffusion coefficients (D) and porosities (P) of the cover material and of the tailings. Values of D may be measured experimentally for a given material at its ambient moisture level and expected degree of compaction. Alternatively, D can be estimated solely from the moisture content and porosity of the material, because the large variation (four orders of magnitude) in D from moisture content obscures the much smaller effects on the value of D from other soil properties.[1] Thus, the most important characteristic of cover soils is their ability to retain moisture.

With the moisture concentration in the cover soils, D may be estimated from the following empirical correlation of laboratory data:[1]

$$D/P = 0.106 \exp(-0.261\ M)\ , \tag{E.1}$$

where M is the weight percent of soil moisture and D has units of cm^2/s. Equation (E.1) can also be used to express radon attenuation in terms of porosities and moistures of the tailings and cover. This correlation, mainly based on a limited amount of laboratory data, could possibly be modified slightly as additional data become available. Basic parameters characterizing the soils are the diffusion coefficient and the porosity. The equations given in the next section are expressed in terms of D and P; but for convenience, Eq. (E.1) is used in select cases to give the moisture dependence explicitly. The converted equations may undergo slight modification as more research is conducted by the Nuclear Regulatory Commission (NRC) and other organizations.

E.2 CALCULATION OF BARE RADON FLUX

Radon flux from the bare tailings source, J_0, is calculated from an equation given in Appendix G-1 of ref. 2:

$$J_0 = [Ra]\rho E(\lambda D_0/P_0)^{1/2} \times 10^4\ , \tag{E.2}$$

where

[Ra] = concentration of Ra-226 in the tailings solids, pCi/g;

ρ = density of the tailings solids, g/cm^3;

E = emanating power of tailings, dimensionless;

Now

$$h = \left[1 - \frac{1}{b_1 x_1} \ln f\right]^{-2}$$

$$= \left[1 - \frac{1}{(0.0221) \times 91.44} \ln(0.7683)\right]^{-2}$$

$$= 0.7826$$

and

$$a_1 = \left(\frac{2.1 \times 10^{-6}\ s^{-1}}{0.0043\ cm^2/s \times 0.7826}\right)^{1/2} = 0.0250\ .$$

Equation (E.6) now becomes

$$\frac{D_{s2}}{P_{s2}} = 0.0112(0.1017) + 0.0043(1 - 0.1017) = 0.0050\ cm^2/s.$$

At this point, the composite flux $J_1 = 35.23$ and the composite diffusion coefficient $D_{s2}/P_{s2} = 0.0050$.

Given the above quantities, the following equation yields the minimum required depth of overburden-topsoil in addition to the clay layer:

$$x = \left[\frac{D_1/P_1}{\lambda}\right]^{1/2} \left[\ln(2J_0/J_1) - \ln\left[\left(1 + \frac{P_0}{P_1}\left[\frac{D_0/P_0}{D_1/P_1}\right]^{1/2}\right) + \left(1 - \frac{P_0}{P_1}\left[\frac{D_0/P_0}{D_1/P_1}\right]^{1/2}\right)(J_1/J_0)^2\right]\right], \qquad (E.7)$$

where

$D_0/P_0 = 0.0050\ cm^2/s$,

$P_0/P_1 = 1$,

$J_1 = 2\ pCi/m^2 \cdot s$,

$J_0 = 35.23\ pCi/m^2 \cdot s$,

$D_1/P_1 = 0.106 \exp(-0.261 \times 9.7\%) = 0.0084\ cm^2/s$.

The moisture content of the oberburden-topsoil is 9.7%, as mentioned previously. Substituting these values into Eq. (E.7), the value of $x = 189.11$ cm or $\chi = 1.89$ m of overburden-topsoil. The total cover needed to achieve the minimum radon flux of 2 $pCi/m^2 \cdot s$ is

0.91 m clay + 1.89 m overburden-topsoil = 2.80 m total cover .

Assume that the porosities are equivalent for all materials. This assumption is reasonable because long-term reclamation is the topic. Using the above values and the previously calculated radon flux, Eq. (E.3) yields J_1 = 35.23 pCi/m²·s. Equation (E.3) can be written as

$$J_1 = J_0 f \exp(-b_1 x_1) \ , \tag{E.4}$$

where

$$f = \frac{2}{\left(1 + \frac{P_0}{P_1}\left[\frac{D_0/P_0}{D_1/P_1}\right]^{1/2}\right) + \left(1 - \frac{P_0}{P_1}\left[\frac{D_0/P_0}{D_1/P_1}\right]^{1/2}\right)\exp(-2b_1 x_1)} \ . \tag{E.5}$$

The function f is useful in calculating the composite diffusion coefficient, which is computed by the following equation:

$$\frac{D_{sm}}{P_{sm}} = \sum_{i=0}^{m-1} \frac{D_i}{P_i} [1 - \exp(-a_i x_i)] \exp\left(- \sum_{j=i+1}^{m-1} a_j x_j\right) \ , \tag{E.6}$$

where

$$a_i = (\lambda P_i / D_i h)^{1/2},$$

X_i = depth of the *i*th cover soil,

$$\exp(-a_0 x_0) = 0$$

$$h = \left[1 \ \ \frac{1}{b_1 x_1} \ln f\right]^{-2} \ .$$

Thus, the composite D/P is computed as:

$$\frac{D_{s2}}{P_{s2}} = D_0/P_0 \times [-\exp(-a_1 x_1)] + D_1/P_1 \times [1 - \exp(-a_1 x_1)] \ ,$$

where

D_0/P_0 = 0.0112 cm²/s,

a_1 = [2.1 x 10^{-6} s^{-1}/(0.0043 cm²/s x h)],

x_1 = 91.44 cm,

D_1/P_1 = 0.0043 cm²/s.

Should differential settlement or significant drying of the clay layer occur, the soil layer would have to suffice to maintain the required attenuation of radon gas. Because the applicant is planning to put down 7.6 ft of overburden-topsoil in addition to the 3 ft of clay, at least a total of 10.6 ft of overburden and soil mixed with clay to cover the tailings can be assumed.

Using Eq. (E.3) with the values

J_0 = 346.08 pCi/m^2·s;

$b_1 = [(2.1 \times 10^{-6}\ s^{-1})/(0.0084\ cm^2/s)]^{1/2}$; the attenuation coefficient of the soil cover;

D_0/P_0 = 0.0112 cm^2/s, the diffusion coefficient of the tailings;

D_1/P_1 = 0.0084 cm^2/s, the diffusion coefficient of the silty soil (9.7% moisture); and

x_1 = 323.09 cm (10 ft), the depth of cover;

then

J_1 = 1.96 pCi/m^2·s.

The calculated resultant flux is approximately the limit of 2 pCi/m^2·s.

The above model and calculations do not present a significant departure from the previous NRC approach to mitigation of radon exhalation from tailings piles. The revisions consist mostly of making the diffusion coefficients more sensitive to moisture and depth. Appendix P of ref. 2 highlights the techniques used here as well as a more simplified approach for single layers.

REFERENCES FOR APPENDIX E

1. V. C. Rogers et al., *Characterization of Uranium Tailings Cover Materials for Radon Flux Reduction*, NUREG/CR-1081, U.S. Nuclear Regulatory Commission, Washington, D.C., March 1980.

2. U.S. Nuclear Regulatory Commission, *Final Generic Environmental Impact Statement on Uranium Milling*, Report NUREG-0706, Washington, D.C., July 1980.

3. Francis-Meador-Gellhaus, *Subsurface Soil Exploration for Proposed Edgemont Uranium Waste Disposal Site*, June 1980, Fig. 9.