40 CFR 190 COMPLIANCE ASSESSMENT

FOR

NRC LICENSED URANIUM RECOVERY FACILITIES

AS OF

DECEMBER 1, 1980

U.S. Nuclear Regulatory Commission

Division of Waste Management

Uranium Recovery Licensing Branch

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1. INTRODUCTION

Under Title 40, Code of Federal Regulations, Part 190, Subchapter F, Radiation Protection Programs, the U.S. Environmental Protection Agency (EPA) promulgated "Environmental Radiation Protection Standards for Nuclear Power Operations" which provides limits for the radiation doses received by members of the public in the general environment as the result of operations which are part of the nuclear fuel cycle. Effective December 1, 1980, each uranium milling facility* shall conduct its operations in such a manner to assure that the annual radiation dose equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public is not exceeded. The U.S. Nuclear Regulatory Commission (NRC) is responsible for implementing and enforcing this standard at its licensed facilities.

This report is issued in conjunction with orders amending the NRC licenses of uranium mill operators to establish programs of 40 CFR 190 compliance. It describes the NRC's Division of Waste Management-Uranium Recovery Licensing Branch (WMUR) evaluation of the best available information about the existing situation at each NRC licensed facility with regard to meeting the standard. It describes the specific licensing actions which are needed to meet the 40 CFR 190 standard.

The general conclusion of this evaluation is that it is likely each NRC facility is operating in such a fashion that the standard is being met. Over the past several years, mill operators have committed to tailings management programs which include controlling the blowing of tailings which is the greatest source of radiological releases from a milling facility. These controls are in addition to control of other mill emissions required to meet existing environmental protection regulations for the public health and safety (for example, 10 CFR 20 "as low as reasonably achievable" (ALARA) control requirements).**

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* All uranium extraction facilities, including mills, in situ operations and heap leach facilities. The Edgemont mill site and the other sites selected for remedial actions (i.e., at inactive mill sites designated by P.L. 95-604 or offsite areas where tailings have been used) have been excluded from 40 CFR 190 compliance during the remedial action work phase.

**NRC staff "Uranium Mill Tailings Management Performance Objectives," May 1977, required controlling the blowing of tailings. Final NRC milling regulations (Appendix A to 10 CFR 40, Criterion 8) which were effective on November 17, 1980, require that dusting from diffuse sources, such as tailings and ore pads, be controlled according to written operating procedures developed by operators. To supplement these requirements, the staff has been requiring that weekly inspections be performed by operators to determine that procedures are being followed and to evaluate the effectiveness of dust control measures.

On the basis of the analysis described in this report, the staff has identified no specific additional operational control measures required of licensees just to meet 40 CFR 190. However, because of the complex nature of the problem of firmly distinguishing radiological doses from the milling operation from those caused by sources not covered by the standard, full implementation will be accomplished by the phased program discussed below.

2. 40 CFR 190 IMPLEMENTATION PROGRAM

The NRC's program for implementing 40 CFR 190 is fully described in WMUR technical position paper "Compliance Determination Procedures for Environmental Radiation Protection Standards for Uranium Recovery Facilities 40 CFR 190, December 1980," hereafter referred to simply as CDP and attached as Enclosure 1. Briefly, compliance will be determined primarily through an environmental monitoring program (EMP) at each facility which provides data on actual radioactivity concentrations to which individuals near mills may be exposed. Because such individuals will be exposed to radioactivity from sources other than the mill which are not covered by 40 CFR 190,* the environmental monitoring programs also measure concentrations at background locations. These background measurements will then be used to determine the impacts which are occurring as a result of the mill operations alone. Predictive model estimates of offsite radioactivity concentrations involve making numerous assumptions and simplifications about important, but frequently uncertain, factors such as mill releases and atmospheric transport. However, environmental monitoring data should indicate directly what such actual concentrations are.** The primary burden of assessing monitoring data and determining compliance with standards lies with licensees. These assessments will be done periodically and reported to NRC for review.

It may realistically require as much as a year's worth of effluent and environmental monitoring to firmly establish whether compliance exists at mills particularly where they are close to the limit or where there are significant nearby sources of radioactive emissions such as uranium mines which are not covered by the Standard. (This period is termed Phase I of the several phase

*Releases not covered by 40 CFR 190 include: radon and radon daughters; natural background; mining operations and associated activities; transportation of ores; mill decommissioning and decontamination; accidental mill releases; and releases from the mill prior to December 1, 1980 and associated ground contamination.

**Predictive modeling is conducted by the staff in evaluating the effects of prospective licensing activities to identify potential problem areas and to help determine what mitigating and monitoring measures are needed. The predictive models may also be useful in interpreting monitoring data. For example, they can be used to model the impacts of mill releases alone. These models can, therefore, help in distinguishing the contributions to measured concentrations made by such releases from those made by operations not covered by 40 CFR 190.

40 CFR 190 implementation program described in the CDP.) At some mills, much of this time will have to be spent on the fine tuning of the monitoring and analysis program that is normally required in setting up such programs to assure they are operating properly and producing reliable data. Some time will also be required to sort out the contributions being made by other sources. In addition, some short-term, special environmental measurements and special studies of the effectiveness of selected emission control measures may also be required.

Within a year, it is anticipated that airborne concentration and/or dose action levels (which may be higher than 25 millirems accounting for contributions from other sources), in combination with specific operational control measures and levels, will be established as the threshold for determining compliance with the Standard. (This is Phase II of the implementation program described in the CDP.) The attainment of such dose action levels and simplified compliance determination procedures will reduce costs of implementation, eliminate uncertainty on the part of the licensee, regulatory agency and the public (particularly in cases where there are significant extraneous sources) and assure that the need for remedial action, if it exists, is identified most expeditiously.

3. DESCRIPTION OF ORDERS

In connection with its actions to upgrade uranium milling operations over the past several years and to meet broad requirements o[illegible] e National Environmental Policy Act (NEPA), the staff established requirements for comprehensive effluent and environmental monitoring programs at mills.* The operational status of such programs varies between mills depending largely upon when licensing environmental reviews were performed (that is, reviews in connection with license issuance, renewal or major amendment). The orders being issued in connection with this report are generally intended only to supplement the EMPs already required and to assure that adequate, comprehensive programs are in place and operating as soon as is practicable at all mills, and that operators are analyzing data from such programs to determine whether or not they are complying with the Standard. Specifically, the orders do the following:

- o establish detailed site-specific environmental monitoring programs where they have not already been established, or make needed minor modifications to existing programs.

- o establish schedules for installation of, or modification to, monitoring programs where needed.

*Staff technical positions on such monitoring programs were developed in 1978 and incorporated into formal NRC regulatory guidance (Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills") in April of 1980.

- invoke quality assurance requirements for monitoring programs where they do not now exist. Related to this, where the lower limits of detection (LLD) of existing monitoring programs are not adequate to determine compliance with the Standard, the required LLDs are specified.

- require assessment by operators of doses at the nearest residence using monitoring program data to determine whether mill operations are in compliance.

- require periodic reporting of monitoring data and dose assessments to NRC for review. During the initial phase (Phase I of CDP, Figure 1) of implementing the Standard, particularly close NRC followup will be required. Therefore, the reporting of operator assessments is being required as monitoring data is gathered (on a quarterly basis). (After the compliance status at each mill is finally determined [Phase II of CDP, Figure 1], less frequent reporting will be required). During the initial phase of 40 CFR 190 implementation, the requirement to provide notification of noncompliance (e.g., 10 CFR 20.405(c), when effective) is suspended.

- require the identification and characterization of all significant nearby sources of radioactivity not covered by the Standard. In several cases, this may involve conducting short-term monitoring programs to establish the precise contributions of such extraneous sources.

4. APPROACH TAKEN IN INITIAL ASSESSMENTS

4.1 General

In connection with the orders being issued and as the first step in implementing 40 CFR 190, the staff has assessed the situation at each mill with regard to meeting the Standard. While, as stated above, lack of sufficient environmental monitoring data has prevented making final and firm determinations of compliance, these assessments provide a solid base of information upon which the later assessments by mill operators and NRC staff (Phase I assessments) can be conducted. For example, they identify or emphasize the specific areas where environmental monitoring and related information gathering efforts should be directed. It was only by performing these assessments that the staff was able to determine what would be a reasonable way of implementing the Standard (that is, develop the program described in the CDP) and, more specifically, to develop the orders which are being issued. Furthermore, these assessments are intended to assist the public and other government agencies in understanding the status of efforts to comply with 40 CFR 190.

The assessments performed by the staff have considered all relevant information that was available at each facility. In a few cases, this has included some environmental monitoring data (e.g., airborne radioactivity concentrations at the nearest receptor and other locations near the mill). In all cases, some information about mill operations, about site features such as topography and meteorology, and about local land use has been available to permit initial interpretation of existing environmental monitoring data. This information has also permitted estimating offsite radioactivity concentrations by use of predictive models.

The staff began the process of assessing mills in terms of 40 CFR 190 several years ago during preparations of environmental impact statements and assessments for major licensing actions. These assessments were completed using predictive models since virtually no environmental data was available at that time. Eight mills were evaluated in this manner, and the results of these assessments have been incorporated directly into this report. Over the past six months, the staff has performed predictive model assessments for the six cases where licensing actions have not led to such previously documented assessments.

4.2 Radionuclides Considered

40 CFR 190 dose limits exclude contributions from radon and its daughters. It appears from the documents (e.g., "40 CFR 190 Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle-Final Environmental Statement"; EPA 520/4-76-016, 1976) prepared by the EPA in promulgating the Standard, that this exclusion was intended to apply strictly to radon, its short-lived daughters, and its long-lived daughters (lead and polonium) which grow in after radon is released. The latter case is distinguished from the release of lead and polonium directly from ore in stockpiles, ore being processed, or from the tailings disposal areas. The exclusion was made in recognition of the fact that there is no practicable way to capture radon in an operational situation since it is an inert gas.

The staff has excluded radon and all of its daughters from its assessments for two reasons: (1) by the plain reading of the Standard they are excluded, and the EPA documentation supporting it does not explicitly contradict this reading; and (2) in the real environment there is no way to distinguish between the radon daughters which grow in before or after release from the mill facility. While the distinction between daughters growing in before and after release could be made through use of predictive models, such models cannot and will not be the basis for determining compliance. Therefore, the same approach was taken in predictive assessments as was done with environmental monitoring data assessments--all radon daughters have been excluded.

4.3 Solution Recovery Facilities

In situ leaching and byproduct recovery facilities are uranium milling facilities covered by the 40 CFR 190 standard; however, no particulates are produced by the nature of the process where there is no yellowcake dryer. In these cases, as well as R&D facilities, compliance questions were resolved by virtue of the small scale of operation or the lack of applicable emissions. Because of the radically different nature of such facilities from conventional mills, they will not be required to explicitly follow the CDP to show compliance with the Standard. If yellowcake dryers are installed in such facilities, this position will have to be reconsidered.

4.4 EMP Data Assessment

Available monitoring data was examined for all facilities. Airborne radioactivity concentrations for offsite locations were summarized, and dose conversion factors (as detailed in Attachment A of the CDP) for the inhalation pathway were used to determine potential dose commitments to the nearest receptor. While data on radon daughters exists in some cases, these were not considered in this assessment.

4.5 Predictive Assessment

The assumptions, equations, and methods used by the staff in its predictive radiological assessments are presented in the "Generic Environmental Impact Statement (GEIS) for Uranium Milling" (NUREG-0706) and in U.S. NRC Draft Regulatory Guide RH 802-4, "Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operation," May 1979. MILDOS is a computer code developed by the staff to execute its radiological assessment methodology. It is described in the document "MILDOS Computer Code User's Manual" by G. N. Gnugnoli and D. E. Martin (May 1980). The basic assumptions, input and information needed to use MILDOS are summarized in Appendix 1.

One of the most significant assumptions in predictive modeling assessments is the estimation of releases of radioactivity from a facility. There is some uncertainty regarding such releases, particularly from the tailings impoundments and other diffuse dust-producing operations such as ore storage and handling. Unlike point source emissions which can be monitored with a relatively simple stack device, these emissions are not readily measured. Moreover, the effectiveness of stack emission control devices can be estimated (where no emission measurements are available) with reasonable accuracy based on a few easily obtained facts about mill operations and equipment design. Diffuse sources are also not easily determined because they are not steady emissions. Windblown surface emissions are episodic in nature; dusting occurs primarily during periods of high wind. Furthermore, the staff has limited information about the actual effectiveness of dust control measures that are being used. To deal with this uncertainty and to assure consistency in the predictive model assessments, the staff has adopted certain standard assumptions about control of emissions. For example, all facilities were credited with 80 percent control of areas susceptible to dusting. Available information concerning this matter is highlighted in the assessments which follow. In general, this is an area where close attention must be paid to 40 CFR 190 implementation at each mill.

In many cases, the most significant potential pathway of exposure is the ingestion pathway. In its assessments, the staff initially adopted the standard, conservative meat and vegetable consumption factors delineated in draft NRC Reg. Guide RH 802-4. One-hundred percent of an individual's meat and vegetable consumption is assumed to be produced near the mill and, therefore, subject to contamination from mill effluents. Grazing locations were first assumed to be in the near vicinity of (about 0.5 km from) the mill restricted area boundaries and not necessarily near the nearest receptor location. These conservative food production and consumption assumptions led in some cases to doses far in excess of 40 CFR 190 limits. Where this occurred and local conditions are known to be such that the assumed food consumption factors are likely to be unrealistic, these factors were adjusted. For example, it is not likely that cattle will graze very near the mill at all times, particularly where the controlling ranch itself is far from the mill. It is important that uncertainties which exist concerning the ingestion pathway (production and consumption patterns) be resolved in the initial 40 CFR 190 implementation efforts.

Airborne emissions only are considered by the staff in its assessments. There are no discharges of tailings solutions to surface streams from uranium mill facilities. Some seepage occurs from tailings impoundments and associated evaporation ponds, but in no case is there known consumption of contaminated groundwater. The environmental monitoring programs which have been established include monitoring of groundwater. Information on land use being required in connection with this and other recent licensing actions will provide needed information about use of wells near mills. These efforts will identify any problems, if they exist.

5. RESULTS OF INITIAL ASSESSMENTS

Table 1 provides the names and locations of the 15 NRC licensed uranium milling facilities of concern in this report.

The summary results of the predictive modeling assessments are presented in Table 2 and Table 3 provides the specific exposure pathway dose commitment evaluations. A complete discussion of the predictive modeling assessments for six facilities, which were not previously documented in a recent final environmental statement (FES), is provided in appendices, as follows:

Appendix 2:	Federal-American Partners, (FAP), Gas Hills, WY	Docket No. 40-4492
Appendix 3:	Pathfinder Mines, Gas Hills, WY	Docket No. 40-2259
Appendix 4:	Pathfinder Mines, Shirley Basin, WY	Docket No. 40-6622
Appendix 5:	Petrotomics, Shirley Basin, WY	Docket No. 40-6659
Appendix 6:	Rio Algom Humeca, Lisbon Valley, UT	Docket No. 40-8084
Appendix 7:	Exxon Minerals Highland, Converse Co., WY	Docket No. 40-8102

The general conclusion of the staff is that it is likely each of the NRC licensed facilities is meeting the Standard. In many cases, predictive modeling assessments using generally conservative assumptions and input parameters

Table 1 NRC licensed uranium recovery facilities

Name	Location	Docket Number	License Number	Expiration Date
1. Atlas Minerals	Moab, UT	40-3453	SUA-917	04-30-84
2. Bear Creek Uranium Co. (Rocky Mt. Energy Co.)	Converse Co., WY	40-8452	SUA-1310	07-31-82
3. Exxon Minerals Highland Mill	Converse Co., WY	40-8102	SUA-1139	07-31-78*
4. Federal-American Partners	Gas Hills, WY	40-4492	SUA-667	01-31-76*
5. Energy Fuels Nuclear White Mesa Mill & OBS**	Blanding, UT	40-8681	SUA-1358	08-31-84
6 Minerals Exploration Co. Sweetwater Mill	Sweetwater Co., WY	40-8584	SUA-1350	02-28-84
7. Pathfinder Mines	Gas Hills, WY	40-2259	SUA-672	01-31-83
8. Pathfinder Mines	Shirley Basin, WY	40-6622	SUA-442	09-30-82
9. Petrotomics Company	Shirley Basin, WY	40-6659	SUA-551	04-30-81
10. Plateau Resources	Shootering Canyon, UT	40-8698	SUA-1371	09-30-84
11. Rio Algom Humeca Mill	La Sal, UT	40-8084	SUA-1119	09-30-82
12. TVA***	Edgemont, SD	40-1341	SUA-816	09-29-76
13. Union Carbide Corp.	Gas Hills, WY	40-299	SUA-648	01-31-86
14. United Nuclear Corp. Morton Ranch	Converse Co., WY	40-8602	SUA-1356	05-31-84
15. Western Nuclear, Inc. Split Rock Mill	Jeffrey City, WY	40-1162	SUA-56	12-31-85

*Timely Renewal

**OBS denotes ore buying station.

***Not considered to be subject to 40 CFR 190 compliance since this facility has been inoperative, and the plans for site decommissioning and decontamination are being finalized and will be reported in an EIS.

Table 2 Composite 50-year dose commitments to the individual receiving maximum exposure, for one year, for each milling facility

Facility Name and Location	Operating Company And Docket Number	Composite Dose Commitments,* mrem Whole Body	Bone	Lung	Date and Method of Dose Prediction	Reference
1. Atlas Minerals Moab, Utah	Atlas Minerals Corp. 40-3453	2.4	34.6	74.8	January 1979, UDAD and HERMES Codes	FES NUREG-0453 Table 4.4
2. Bear Creek Converse Co., WY	Rocky Mt. Energy Co. 40-8452	0.486	6.14	0.782	July 1979, MILDOS Code	NRC Environmental Impact Appraisal for Amendment to License SUA-1310 July 31, 1980
3. Exxon Minerals Highland, Converse Co., WY	Exxon Minerals 40-8102	0.847	12.2	13.9	January 1981, MILDOS Code	Appendix 7
4. FAP, Gas Hills, WY	Federal-American Partners 40-4492	0.649	17.4	35.9	January 1981, MILDOS Code	Appendix 2
5. Energy Fuels Nuclear, White Mesa, Blanding, UT	Energy Fuels Nuclear 40-8681	1.40	15.0	2.24	May 1979, UDAD Code	FES NUREG-0556 Table 4.8
6. Minerals Exploration Sweetwater, Sweetwater Co., WY	Minerals Exploration Co. 40-8584	0.0081	0.0831	0.038	December 1978, UDAD Code	FES NUREG-0505 Table 4.3

*Composite dose commitments are the sum of direct exposure and the ingestion pathway exposure, as displayed in Table 3.

Table 2 (continued)

Facility Name and Location	Operating Company And Docket Number	Composite Dose Commitments,* mrem Whole Body	Bone	Lung	Date and Method of Dose Prediction	Reference
7. Pathfinder Mines Gas Hills, WY	Pathfinder Mines Corp. 40-2259	0.599	11.4	15.7	January 1981, MILDOS Code	Appendix 3
8. Pathfinder Mines Shirley Basin, WY	Pathfinder Mines Corp. 40-6622	1.61	18.0	6.56	January 1981, MILDOS Code	Appendix 4
9. Petrotomics Shirley Basin, WY	Petrotomics Company 40-6659	0.696	9.75	9.58	January 1981, MILDOS Code	Appendix 5
10. Plateau Resources Shootering Canyon Garfield Co., UT	Plateau Resources Ltd. 40-8698	0.135	3.60	6.63	July 1979, UDAD Code	FES NUREG-0583, Table 4.7
11. Rio Algom Humeca, Lisbon Valley, UT	Rio Algom 40-8084	0.528	11.0	23.5	January 1981, MILDOS Code	Appendix 6
12. Union Carbide Gas Hills, WY	Union Carbide Corp. 40-299	0.97	12.4	1.81	July 1980, MILDOS Code	FES NUREG-0702 Table 4.6
13. United Nuclear Morton Ranch Converse Co., WY	United Nuclear Corp. 40-8602	0.08	0.34	0.28	February 1979, UDAD and HERMES Codes	FES NUREG-0532 Table 4.2
14. Western Nuclear Split Rock Jeffrey City, WY	Western Nuclear Inc. 40-1162	2.0	24.2	11.5	February 1980, UDAD and HERMES Codes	FES NUREG-0639 Table 4.9

Table 3 Direct exposure and ingestion exposure pathways dose commitments for each milling facility

Facility Name and Location	Location of Individual Receiving Maximum Direct Exposure	Direct Exposure Dose Commitment, mrem Whole Body	Bone	Lung	Location Corresponding to Maximum Ingestion Dose	Ingestion Exposure Dose Commitment, mrem Whole Body	Bone	Lung
1. Atlas Minerals Moab, UT	Tex's Tour Center, 8 km E	2.0	29.6	74.4	Grazing, 2.7 km SE-Meat	0.4	5.0	0.4
2. Bear Creek Converse Co., WY	Carson Ranch, 7.6 km NE	0.020	0.373	0.316	Vegetable ingestion 7.6 km NE; Grazing, 1.4 km NE-Meat	0.466	5.77	0.466
3. Exxon Minerals Highland Converse Co., WY	Fowler Ranch, 4.3 km NE	0.208	5.56	13.3	Grazing, .5 km W-Meat	0.639	6.62	0.639
4. FAP, Gas Hills, WY	FAP Housing Camp, 0.55 km WNW	0.624	17.1	35.9	Grazing, 1.24 km NE-Meat	0.025	0.258	0.025
5. Energy Fuels Nuclear, White Mesa, Blanding, UT	4.5 km NNE	0.06	1.09	0.90	Vegetable ingestion 4.5 km NNE; Grazing, 1.9 km N-Meat	1.34	14.0	1.34
6. Minerals Exploration Sweetwater, Sweetwater Co., WY	Bairoil, 35 km NE	0.0021	0.0071	0.032	Grazing, 2.5 km NE-Meat	0.006	0.076	0.006
7. Pathfinder Mines Gas Hills, WY	Lucky Mc Camp, 3.0 ENE	0.340	8.74	15.4	Vegetable ingestion, 3.0 km ENE; Grazing, 1.4 km NNE-Meat	0.259	2.65	0.259

Table 3 (continued)

Facility Name and Location	Location of Individual Receiving Maximum Direct Exposure	Direct Exposure Dose Commitment, mrem Whole Body	Bone	Lung	Location Corresponding to Maximum Ingestion Dose	Ingestion Exposure Dose Commitment, mrem Whole Body	Bone	Lung
8. Pathfinder Mines Shirley Basin, WY	Heward Ranch, 8.0 km E	0.092	2.53	5.04	Vegetable ingestion, 8.0 km E; Grazing, 1.47 km NNW-Meat	1.52	15.5	1.52
9. Petrotomics Shirley Basin, WY	Shirley Basin, 3.2 km S	0.168	4.23	9.05	Grazing, 1.68 km NE-Meat	0.528	5.52	0.528
10 Plateau Resources Shootering Canyon, Garfield Co., UT	Mining Camp, 5.6 km N	0.135	3.60	6.63	N/A	-	-	-
11 Rio Algom Humeca, Libson Valley, UT	Trailer Park, 2.5 km N	0.395	9.65	23.4	Vegetable ingestion, 2.5 km N; Grazing, 0.57 km SW-Meat	0.133	1.38	0.133
12 Union Carbide Gas Hills, WY	J&E Ranch, 8.7 km NE	0.03	0.65	0.87	Vegetable ingestion, 8.7 km NE; Grazing, 1.4 km ENE-Meat	0.94	11.7	0.94
13. United Nuclear Morton Ranch Converse Co., WY	Fowler Ranch, 10 km N	0.06	0.08	0.26	Vegetable ingestion, 10 km N; Grazing, 13 km NW-Meat	0.02	0.26	0.02
14. Western Nuclear Split Rock, Jeffrey City, WY	Claytor Ranch, 1.6 km E	Not Available			Vegetable ingestion, 16 km E; Grazing, 2.7 km ENE-Meat	Not Available		

indicate that the facilities are well within limits. In a few cases, computed doses are close to or in excess of the limit. This is believed to be the result of conservative assumptions made in the assessments; in these cases, the staff's generally positive conclusions are based on environmental monitoring data (albeit limited amount of data), and other site specific information which is available as discussed below. In any case, final determinations await the environmental monitoring data to be generated.

The following discusses only those facilities where a 40 CFR 190 predictive modeling assessment has been performed specifically in connection with this report. The assessments of other facilities are documented in the FES's cited in Table 2. Also discussed here are facilities where environmental data exist that were not previously documented in NRC environmental assessments. The following narratives highlight those areas where special attention must be paid in the environmental monitoring and data gathering efforts which will be required by the orders being issued at this time. Facilities to be discussed are:

- o Federal-American Partners (FAP) (40-4492)
- o Pathfinder Mines, Gas Hills (40-2259)
- o Pathfinder Mines, Shirley Basin (40-6622)
- o Atlas Minerals (40-3453)
- o Rio Algom Humeca (40-8084)
- o Petrotomics (40-6659)
- o Exxon Minerals Highland (40-8102)

This report discusses individual assessment results for each facility. However 40 CFR 190 limits exposures to any individual in the public from <u>all</u> facilities in the nuclear fuel cycle. Therefore, the staff has evaluated exposures in those regions where several or more mills are operating near each other. This situation exists in the Gas Hills and Shirley Basin regions of Wyoming. In both cases, staff computations indicate that the increase to dose at the nearest residence of a facility may be significantly impacted by other facilities. Notwithstanding this, it appears as though the Standard may still be met in such situations. Discussion of these regional situations is presented in Section 5.8.

The narratives which follow include: a brief description of the site; presentation of environmental monitoring data and predictive model assessment results; brief description of extraneous sources of radioactivity near the mill facility (i.e., those activities which are not covered by 40 CFR 190); and a discussion of the significance of available information with emphasis on those areas needing special attention in the initial implementation efforts.

5.1 Federal-American Partners (FAP)

Docket Number: 40-4492
Location: Gas Hills, Wyoming

5.1.1 Site Description

The FAP facility is located in the Gas Hills of Wyoming. This region is a heavy uranium milling and mining region, and is also used for livestock grazing and as a wildlife range. Other uranium processing facilities in the area are the Pathfinder Mines facility (2.4 km NE), the Union Carbide facility (13 km NE) and the Western Nuclear facility (35 km SW). The local area is characterized by rolling terrain, broken by dry washes typical of the Wyoming high plains. The nearest residence is located at the FAP housing camp (0.55 km W) which houses approximately 155 people who are primarily FAP facility employees and their families.

5.1.2 EMP Data and Results

The FAP monitoring program used continuous air samplers to monitor U-nat, Th-230, and Ra-226 concentrations at the North and South ends of the FAP camp (0.55 km W), and at the Puddle Springs Ranch (4.8 km WNW). The air samplers operated satisfactorily, but the laboratory analysis was not adequate to detect low concentrations of the radionuclides U-nat and Ra-226. The lowest level of detection (LLD) achieved for these radionuclides was 0.01 pCi/m^3, to be compared with the LLD of 0.0001 pCi/m^3 as recommended in NRC Regulatory Guide 4.14. These higher LLDs for uranium and radium (e.g., 0.01pCi/m^3) would result in lung dose estimates of 1.69 and 66.1 mrem, respectively; whereas, the more sensitive LLDs (e.g., 0.0001 pCi/m^3) would result in lung dose estimates of 0.0169 and 0.661 mrem, respectively. Therefore, only the Th-230 data were considered. The lower limits of detection for radium result in doses greater than the 40 CFR 190 limits. At the lower limits of detection for uranium, doses are much smaller than those corresponding to measured thorium concentrations.

The measured Th-230 airborne concentrations and corresponding computed organ doses from the FAP program are shown in Table 4.

Table 4 FAP (Docket No. 40-4492) environmental monitoring data assessment

Location	*Average Concentration (pCi/m^3)		50-Year Dose Commitment, mrem Whole Body	Bone	Lung
A. Puddle Springs Ranch, 4.8 km WNW	Th-230	0.0130	2.15	77.4	41.9
B. North End of FAP Camp, 0.51 km WNW	Th-230	0.0123	2.04	73.2	39.6
C. South End of FAP Camp 0.80 km SW	Th-230	0.0117	1.94	69.6	37.7

*Station A data averaged for period September 1979 to April 1980;
Station B data averaged for period September 1979 to April 1980;
Station C data averaged for period March to April 1980.

5.1.3 Predictive Assessment

The assumptions, inputs, and results of the predictive assessment are detailed in Appendix 2. The critical individuals are those living in the FAP housing camp. The ingestion values presented in Table 5 reflect site-specific information, such as local food production and consumption patterns. As can be seen, the major impact results from inhalation and external exposure and not from ingestion.

Table 5 Projected 50-year dose commitments resulting from one year of operation at the Federal-American Partners Facility

Location: FAP Housing Camp

Pathway	50-Year Dose Commitment, mrem Whole Body	Bone	Lung
Inhalation and External Exposure	0.624	17.1	35.9
Meat Ingestion*	0.025	0.258	0.025
Total Organ Doses	0.649	17.4	35.9

*These estimates assume that no more than 10% of an individual's meat intake can be produced in the immediate area.

5.1.4 Extraneous Sources of Radioactivity

Other sources of radioactivity, such as mining operations and raw ore storage areas, are prevalent throughout the Gas Hills region. In particular, several open-pit mines, as close as a quarter of a mile away, operate to the west-southwest and the southwest of the FAP camp. Winds blow from this area to the FAP Camp 45% of the time. In contrast, winds blow from the FAP mill and tailings pond towards the FAP housing camp about 14% of the time. No unusual terrain features exist in the area which would significantly affect pollutant transport.

5.1.5 Discussion

Concentrations presented in Table 4 are significant in that, considering thorium alone, doses greater than 25 mrem are computed. However, given the proximity and generally upwind location of mining activities, it is likely that the majority of the dose contribution is from such extraneous sources. Local meteorological data indicates that win[illegible] blow from mining operations towards the FAP camp about 45% of the time. The Puddle Springs Ranch location, 4.8 kilometers from the mill in a generally upwind direction, monitors background concentrations. The air sampler at the Puddle Springs Ranch measured background concentrations of Th-230 which are actually higher than those measured at either end of the FAP camp.

In evaluating the question of what is contributing to the measured concentrations, the staff has observed that a natural cementing effect is provided by gypsum in the tailings solids. As a consequence, surface dusting from the potentially greatest emission source at the mill is controlled to a large degree. This further indicates that emissions from the mill are likely much less of a contributor to measured concentrations than mining activities. On the other hand, computed doses exceed the Standard at this mill. The projected lung dose at the FAP camp of 35.9 mrem (see Table 5) results from several factors. The FAP camp is quite close to the mill (only 0.55 km away, albeit in the prevailing downwind direction). Lacking firm evidence to the contrary, ore storage, handling and crushing operations (see Appendix 2, Table 2.4) are assumed to be minimally controlled. Close attention will have to be paid to such operations during our initial 40 CFR 190 implementation phase (Phase I) at the FAP mill to assure adequate control measures are taken. In any event, ultimate determination that mill operations are in conformance will come from the environmental monitoring program to be conducted.

On the basis of the preceding discussion, it has been concluded that the licensee should be required to achieve the LLDs recommended in Regulatory Guide 4.14 in order to obtain more accurate EMP data. The licensee has also been required to conduct short-term air sampling at a location between the mines and the camp and to correlate the measured results with meteorological data in order to differentiate the milling from the predominant nonmilling sources.

5.2 Pathfinder Mines Corporation

Docket Number: 40-2259
Location: Gas Hills, Wyoming

5.2.1 Site Description

The Pathfinder Mines Corporation facility (PMGH) is located in the Gas Hills, Wyoming. This is a region of heavy uranium milling and mining, and is also used for livestock grazing and as a wildlife range. The other uranium processing facilities are the FAP (2.4 km SW), the Union Carbide facility (11 km NE) and the Western Nuclear facility (40 km SW). The local terrain is characterized by rolling terrain broken by washes typical of the Wyoming high plains. As shown in Appendix 3, winds are generally from SW and WSW 45% of the time in this area.

The PMGH housing camp (3.0 km ENE) is the nearest receptor to the mill facility. It is also downwind of several open-pit mines and ore storage pads. There is a steep anticline ridge between the mill tailings ponds (1-2 km N) and the housing facility. This ridge does not directly intercept the transport of pollutants between the mill and camp, but may alter wind direction patterns in the camp area. There are no other terrain features in the area that would greatly alter pollutant transport evaluations.

5.2.2 EMP Data and Results

Annual average concentrations and corresponding computed organ dose commitments for each monitoring location are shown in Table 6. Three low-volume air samplers were used in the 1979-80 monitoring program. Station A was located in an area representative of natural, undisturbed background conditions (i.e., there are no immediate mining or ore transportation activities). As expected, the measured concentrations were lowest for this sampler. Stations C and B are located at the north and south ends of the PMGH housing camp, respectively. Doses calculated based on the measured concentrations exceeded 40 CFR 190 limits for both of these stations.

Table 6 Pathfinder Mines Gas Hills (Docket No. 40-2259) environmental monitoring data assessment

Location	Average Concentration (pCi/m³)		50-Year Dose Commitment, mrem Whole Body	Bone	Lung
A. Station A,* 8 km SW of mill (Background)	U-nat	0.0027	0.0125	0.214	0.456
	Ra-226	0.00069	0.0216	0.216	4.63
	Th-230	0.0012	0.199	7.14	3.86
	Total		0.233	7.57	8.95
B. Station B,** South end of camp (Nearest receptor)	U-nat	0.0108	0.0499	0.858	1.87
	Ra-226	0.0060	0.185	1.85	39.7
	Th-230	0.0064	1.06	38.1	20.6
	Total		1.30	40.8	62.2
C. Station C,** North end of camp	U-nat	0.0062	0.0286	0.492	1.05
	Ra-226	0.0042	0.130	1.30	27.8
	Th-230	0.0022	0.355	13.1	7.08
	Total		0.524	14.9	35.9

*Data averaged for the entire year, 1979.
**Data averaged for the entire year, 1979 and for the 1st and 2nd Quarters of 1980.

5.2.3 Predictive Assessment

The assumptions, inputs, and results of the predictive assessment are detailed in Appendix 3. The critical individuals are those living in the PMGH housing camp. Based on site-specific information such as local food production and consumption patterns, the MILDOS ingestion values which assumed 100% local production and consumption were adjusted to reflect this more accurate information and are summarized in Table 7. Since the local food production and consumption is minimal, the major impact results from the inhalation and external exposure pathways and not from ingestion.

Table 7 Projected 50-year dose commitments resulting from one year of operation at the Pathfinder Mines Gas Hills Facility

Location: Pathfinder Mines Gas Hills Housing Camp

Pathway	50-Year Dose Commitment, mrem		
	Whole Body	Bone	Lung
Inhalation and External Exposure	0.183	5.22	7.79
Meat Ingestion*	0.14	1.75	0.14
Vegetable Ingestion*	0.036	0.43	0.036
Total Organ Doses	0.36	7.40	7.97

*These estimates are based on information which indicates that no more than 5% of an individual's vegetable intake and 10% of an individual's meat intake are produced in the immediate area.

5.2.4 Extraneous Sources of Radioactivity

There are several major nonmilling sources in the area nearby and upwind of the camp. Two open-pit mines and six low-grade ore dumps are located upwind (SW) of the housing camp less than a kilometer away. Winds blow from this mining area towards the PMGH camp 45% of the time. High-grade ore is stockpiled upwind (WSW) of the housing camp about two kilometers away.

5.2.5 Discussion

Information is available to conclude that such nonmill sources probably contribute the greater part of the radionuclide concentrations measured at the PMGH camp. As shown in Table 6, measured concentrations lead to dose estimates wh[illegible] exceed the Standard. Concentrations measured at the south end of the camp (at Station B) are about 50% higher than those measured at the north end (Station C). The winds blow from the direction of the mill and tailings for an equal period (no more than 15% of the time) toward Stations C and B. Consequently, Station B should not measure higher concentrations than Station C, if the mill or tailings pile were the major source of emissions. If, however, the mines and ore piles to the south of the camp were the major source of emissions, then the expected concentration trend would be as observed here; i.e., higher at Station B than at Station C.

It is not possible to accurately differentiate the exact percentage of dose due to milling versus nonmilling activities based on the existing monitoring program data because the background monitor does not pick up these nonmilling sources. In order to differentiate the amount of airborne radioactivity contributed by the mill and tailing ponds from that contributed by the mines and ore pad, the NRC has required short-term, supplemental monitoring studies to determine if the predominant contribution at the camp is from the mining and transportation activities, and not from mill effluent releases

As discussed in Appendix 3, the Pathfinder Mines Gas Hills mill (PMGH) uses a semiautogenous process that results in minimal emissions of ground ore. There is a high-efficiency wet-scrubber on the yellowcake stack. Tailings pond emissions are greatly reduced because the natural gypsum content causes natural cementing of the tailings solids which precludes the resuspension of tailings by wind. People live 3 km east of the mill in the PMGH housing camp which is downwind of the mill about 15% of the time. The tailings ponds are northwest of the camp, and winds from the northwest occur about 11% of the time. A steep ridge stands between the camp and the tailings pile; hence, releases from the tailings probably do not impact upon the PMGH camp. Based on these considerations, dose commitments to individuals due to mill releases would not be expected to exceed those allowable under 40 CFR 190. The computer results (see Appendix 3) also indicate that the projected offsite airborne radioactivity concentrations should be much less than were actually measured if milling activities were the only source of radioactivity.

The final compliance assessment must depend on information gathered from the licensee's revised environmental monitoring program. This program, which should be completed in early 1981, includes short-term air sampling at a location between the camp and the mining activities which are suspected as making the biggest contribution to exposure, and correlating wind speed and direction data with the measured results.

5.3 Pathfinder Mines Corporation

Docket Number: 40-6622
Location: Shirley Basin, WY

5.3.1 Site Description

Pathfinder Mines Corporation, Shirley Basin Uranium Mill is in an area of plains and rolling hills about 12 km (45 miles) south of Casper, Wyoming. Land use in Shirley Basin is dominated by mining and milling activities. General grazing and limited hunting occurs in the area but no farming activities are conducted [illegible] semidesert wilderness area. The nearest residents are at the Heward [illegible] (8.0 km E) and in the town of Shirley Basin (8.0 km S).

5.3.2 EMP Data and Results

There was no recent offsite environmental monitoring data available (e.g., data at the nearest receptor).

5.3.3 Predictive Modeling

The assumptions, inputs, and results of the predictive assessment are detailed in Appendix 4. As shown in Appendix 4, the inhalation and external exposure pathway dose commitments to individuals at the Heward Ranch are twice the dose commitments to individuals in the town of Shirley Basin. Also, the local prevailing wind direction is towards the Heward Ranch (twice as often in this direction than towards the Shirley Basin townsite). Therefore, it has been concluded that the critical individuals are those living at the Heward Ranch. The estimated dose equivalent from the direct exposure pathway and the ingestion pathway are given in Table 8. The bone dose of 18.0 mrem due to the ingestion pathway is the largest dose; however, this is based on the conservative assumption that all meat is obtained from locally grazed cattle.

Table 8 Projected 50-year dose commitments resulting from one year of operation at the Pathfinder Mines, Shirley Basin Facility

Location: Heward Ranch

Pathway	50-Year Dose Commitment, mrem		
	Whole Body	Bone	Lung
Inhalation and External Exposure	0.092	2.53	5.04
Ingestion	1.52	15.5	1.52
Total Organ Dose	1.61	18.0	6.56

5.3.4 Extraneous Sources of Radioactivity

There is an open-pit mine 0.75 km N of the mill. Another larger open-pit mine is 1.0 km E of the mill between the mine pits and the Heward Ranch which is 8.0 km E of the mill. The differentiation of the dose contribution due to these other extraneous sources from those due to milling has not been completed as of this date.

5.3.5 Discussion

Based on the preceding discussion of the predictive modeling, it appears that this facility will be in compliance with 40 CFR 190. However, in order to obtain confirmatory environmental monitoring data, the licensee has been required to conduct continuous airborne sampling at the nearest receptor (i.e., at the Heward Ranch).

5.4 Atlas Minerals

Docket Number: 40-3453
Location: Moab, Utah

5.4.1 Site Description

The Atlas Minerals facility is located in southern Utah. Mining and milling, potash production, the development of other energy sources (e.g., gas and oil), and tourism are the significant industries. Some agricultural and cattle raising activity exists in the area.

The mill is located just below the mouth of Moab Canyon. Cliffs border the mill on the west, and high barren sandstone formations are located to the north and east. The Colorado River flows along the east and southeast border of the mill. Onsite meteorology is available and indicates a prevailing westerly to southwesterly wind. This reflects the channeling effects of the surrounding topography.

The nearest receptor is located at Tex's Tour Center (0.8 km E) which frequently lies in the prevailing wind direction. The only other nearby receptor is at Arches National Park (2.4 km NW). The town of Moab (5 km SE) is the only major population center in the area and had an estimated population of 4,810 people in 1975.

5.4.2 EMP Data and Results

An airborne particulate monitoring station was established in 1980 at Tex's Tour Center, which is the nearest occupiable structure from the Atlas Mill site. Data from this sampling station is only available for the 3rd quarter, 1980. The only other complete and reliable monitoring data was for an air sampling station which was operated at the Arches National Park. Table 9 below summarizes the 3rd quarter, 1980 data for both of these locations and also shows the corresponding estimated organ doses due to the inhalation pathway.

Table 9 Atlas Minerals, Moab Mill (Docket No. 40-3453) environmental monitoring data assessment

Location	*Average Concentration (pCi/m^3)		50-Year Dose Commitment, mrem Whole Body	Bone	Lung
Tex's Tour Center 0.8 km E	U-nat	0.0233	0.11	1.85	3.94
	Th-230	0.0014	0.23	8.33	4.51
	Ra-226	0.0012	0.037	0.37	7.93
		Total	0.377	10.56	16.38
Arches National Park 2.4 km NW	U-nat	0.014	0.065	1.110	2.37
	Th-230	0.0015	0.249	8.925	4.83
	Ra-226	0.0004	0.0124	0.124	2.64
		Total	0.325	10.159	9.84

*The 3rd Quarter of 1980.

5.4.3 Predictive Modeling

The assumptions, inputs, and results of the predictive assessment for the Atlas Mineral mill are summarized in Table 10. The critical individuals are the residents of Tex's Tour Center (0.8 km E). But since there is a component of wind which channels towards Arches National Park Headquarters (2.4 km NW), this location was also considered.

Table 10 Projected 50-year dose commitment resulting from one year of operation at the Atlas Minerals Facility

Location: Tex's Tour Center

Pathway	50-Year Dose Commitment,* mrem		
	Whole Body	Bone	Lung
Inhalation and External Exposure	2.0	29.6	74.4
Meat Ingestion	0.4	5.0	0.4
Total Organ Doses	2.4	34.6	74.8

*Estimates taken from FES NUREG-0453.

5.4.4 Extraneous Sources of Radioactivity

Numerous uranium mines are located throughout Grand County. The major ore resource areas are the Uranium Mineral Belt (80 km ESE) and the Big Indian mining district of the Colorado Plateau (30 km SE).

5.4.5 Discussion

Impacts to the Arches National Park Headquarters were well below 40 CFR 190 limits and are presented in FES NUREG-0453. The predictive modeling dose commitments to individuals at Tex's Tour Center indicate that 40 CFR 190 exposure limits may be exceeded. However, the uncertainties in estimating pollutant dispersion in the Moab Valley with its drastic topographic variability weakens the results of the predictive methodology. Also, additional recent controls (such as keeping the surface of the tailings pond covered with solution and covering the embankments with natural materials to reduce windblowing of the tailings) were not considered in the FES NUREG-0453 assessment. It has been concluded that direct releases from nearby mining areas will have a small impact on individuals at Tex's Tour Center because of the great distances involved. Ambient concentrations measured at Tex's Tour Center probably reflect nonmilling sources since ore is transported via trucks that pass directly by Tex's Tour Center. The impact of the resuspension of ore due to transportation activities in this area may need to be further evaluated based on the results of future EMP data.

The 50-year dose commitments as shown in Table 9 are based on an entire year's exposure to the reported 3rd quarter, 1980 average airborne concentrations. The estimated lung dose to an individual who would be continuously exposed at Tex's Tour Center would be about 16.38 mrem, and about 9.84 mrem at the Arches National Park. Some earlier data indicated higher airborne concentrations were measured at Tex's Tour Center; however, as noted in licensee's reports, and confirmed by aerial photographs of the site, the licensee has recently taken effective control measures to minimize windblown tailings by covering the tailings pile embankments with natural soils, and also by keeping the exposed tailings surfaces in a wetted down condition by providing multiple perimeter discharge points. To assure the adequacy of these operational control measures, the licensee has been required to maintain continuous air sampling systems at both Tex's Tour Center and at the Arches National Park. Additional dose estimates shall be made as such supplemental monitoring data becomes available.

5.5 Rio Algom Humeca

Docket Number: 40-8084
Location: La Sal, Utah

5.5.1 Site Description

The Rio Algom Humeca mill (Rio Algom) is located in the Lisbon Valley, southeast of La Sal Junction. The major activities in the region are the mineral industry and tourism. The Lisbon Valley underground uranium mines are located to the south of the Rio Algom mill. These mines provide uranium ore to other milling facilities such as the Atlas Minerals mill (30 km NW) as well as to Rio Algom.

The area is characterized by rolling surface land with rock outcrops along the Lisbon Valley sides. The La Sal mountains (13 km N) dominate the area to the north, and the country gently rolls down to the valley which runs in a northwest to southeast direction. Onsite meteorology indicates a flushing effect in both directions along the valley (NW-SE) and a component from the southwest. The nearest residence of significant impact is a trailer park (2.5 km N). The Wilcox Ranch (4.0 km NNE), the Blankenagel Ranch (5.0 km WNW), and the Redd Ranch (5.3 km NNE) are the only other nearby residences.

5.5.2 EMP Data and Results

In 1979 and 1980, concentrations of natural uranium (U-nat) were grab sampled at the Blankenagel Ranch, Wilcox Ranch, and La Sal Junction. The measured concentrations of U-nat and corresponding dose estimates are shown in Table 11. The Rio Algom data are inadequate to permit a final assessment of compliance with 40 CFR 190 because only U-nat was measured and these were obtained by grab sampling as opposed to continuous monitoring. Doses computed based on concentrations of uranium only were minimal (e.g., 1.49 mrem to the lung); however, doses resulting from the inhalation of the other radionuclides (e.g., radium and thorium) could be appreciable.

Table 11 Rio Algom (Docket No. 40-8084) environmental monitoring data assessment

Location (Number of Grab Samples Taken)	Average Concentrations, (pCi/m^3)		50-Year Dose Commitment, mrem		
			Whole Body	Bone	Lung
La Sal Junction, 15 km NW (Background) (Average of 7 samples)	U-nat	0.006	0.0277	0.476	1.01
Blankenagel Ranch, 5.0 km WNW (Average of 7 samples)	U-nat	0.0088	0.0407	0.698	1.49
Wilcox Ranch, 4.0 km NNE (Average of 7 samples)	U-nat	0.0052	0.0240	0.413	0.879

5.5.3 Predictive Assessment

The assumptions, inputs, and results of the predictive assessment are detailed in Appendix 6. The maximum radiological impact from the Rio Algom milling facility was projected to occur for an individual living year-round at the Trailer Camp. This individual was assumed to consume meat taken from livestock grazed near the mill (i.e., 10% local meat intake) and vegetables (including fruits) grown in a garden at the Trailer Camp (i.e., 5% local vegetable intake). The maximum projected bone dose was 11.0 mrem and the resultant dose commitments for a resident of the Trailer Camp are summarized in Table 12.

Table 12 Project 50-year dose commitments resulting from one year of operation at the Rio Algom Humeca Facility

Location: Trailer Camp

Pathway	50-Year Dose Commitment, mrem		
	Whole Body	Bone	Lung
Inhalation and external exposure	0.395	9.65	23.4
Ingestion*	0.133	1.38	0.133
Total Organ Doses	0.528	11.0	23.5

*These estimates are based on information which indicates that no more than 5% of an individual's vegetable intake and 10% of an individual's meat intake are produced in the immediate area.

5.5.4 Extraneous Sources of Radioactivity

The Lisbon Valley uranium mines supply the uranium ore to the Rio Algom facility, as well as to the Atlas Minerals mill (30 km NE). The mine shafts for the various mines extend to the south-southwest of the mill site and the winds blow from this mining area towards the Trailer Camp approximately 26% of the time.

5.5.5 Discussion

The computer analysis indicates that the Standard is not exceeded at the Trailer Camp. The inhalation pathway is the major contributor to dose; lung dose is 23.5 mrem which is close to the limit. Credit for 80% control of dusting from the tailings area was given as discussed in Section 4.5. This may be an optimistic assumption at this mill at this time. Inactive tailings disposal areas appear from aerial photographs to be dry and susceptible to dusting. Given the closeness of nearby residences and the predictive model results, close monitoring of dust control efforts is essential. There is no actual monitoring data at the Trailer Camp but the licensee is required to install a comprehensive monitoring program of the type set forth in Regulatory Guide 4.14 which wi. include monitors at the Trailer Camp. This program will use continuous air samplers to monitor all radionuclides of concern (i.e., Ra-226 and Th-230, as well as U-nat which was the only nuclide previously monitored).

5.6 Petrotomics

Docket Number: 40-6659
Location: Shirley Basin, WY

5.6.1 Site Description

The Petrotomics' Shirley Basin Uranium Mill is located in a hilly area about 77 km (48 miles) south of Casper, in the eastern Shirley Basin area of Wyoming. The nearest residences are in the town of Shirley Basin (3.2 km S) and at the Heward Ranch (8 km NE).

5.6.2 EMP Data and Results

There was no available offsite environmental monitoring data (e.g., at the nearest receptor).

5.6.3 Predictive Modeling

The assumptions, inputs, and results of the predictive assessments for the Petrotomics facility is detailed in Appendix 5. The critical individuals are those living at the town of Shirley Basin (3.2 km S). The estimated dose equivalent from the direct exposure pathway and the ingestion pathway are given in Table 13. The bone dose of 9.75 mrem was estimated based on the conservative assumption that 100% of an individual's meat intake is produced in the immediate area. The projected lung dose of 9.58 mrem at the town of Shirley Basin was much higher than the lung dose projected at the Heward Ranch (8 km NE).

Table 13 Projected 50-year dose commitments resulting from one year of operation at the Petrotomics facility

Location: Shirley Basin (Town)

Pathway	50-Year Dose Commitment, mrem Whole Body	Bone	Lung
Inhalation and External Exposure	0.168	4.23	9.05
Ingestion	0.528	5.52	0.528
Total Organ Dose	0.696	9.75	9.58

5.6.4 Extraneous Sources of Radioactivity

Surface mining operations are conducted throughout this area; however, the environmental impact of these mining activities has not been evaluated to date.

5.6.5 Discussion

Based on the computer assessment as summarized in Table 13, the Petrotomics facility is projected to be within compliance limits for 40 CFR 190, since the estimated bone and lung doses were each below 10 mrem.

5.7 Exxon Minerals Highland

Docket Number: 40-8102
Location: Converse County, WY

5.7.1 Site Description

The Exxon Highland mine and mill complex is located in an area of rolling hills and stream valleys in the Powder River Basin region of Wyoming. The area in the immediate vicinity of the site is used primarily for sheep grazing. However, uranium mining and milling, as well as oil and gas production, have become significant factors in the county's economy. The nearest receptor downwind of the facility is the Fowler Ranch (4.3 km NE). Other ranches are located around the site, but none are in the downwind direction or as close as the Fowler Ranch

5.7.2 EMP Data and Results

There was no available offsite environmental monitoring data (e.g., at the nearest receptor).

5.7.3 Predictive Modeling

The assumptions, inputs, and results of the predictive assessment for the Exxon Minerals facility are detailed in Appendix 7. The critical individuals are those living at the Fowler Ranch (4.3 km NE). The estimated dose equivalent from the direct exposure pathway and the ingestion pathway are given in Table 14. The bone dose of 6.62 mrem was estimated based on information which indicates that no more than 10% of an individual's meat intake is produced in the immediate area.

Table 14 Projected 50-year dose commitments resulting from one year of operation at the Exxon Minerals Highland facility

Location: Fowler Ranch

Pathway	50-Year Dose Commitment, mrem Whole Body	Bone	Lung
Inhalation and External Exposure	0.208	5.56	13.3
Ingestion*	0.639	6.62	0.639
Total Organ Dose	0.847	12.2	13.9

*These estimates are based on information which indicates that no more than 10% of an individual's meat intake is produced in the immediate area.

5.7.4 Extraneous Sources of Radioactivity

Exxon operates both surface mines and the underground Golden Eagle Mine (5.5 km WNW) on the Highland site. However, the environmental impact of these mining activities has not been evaluated to date.

5.7.5 Discussion

Since there was no available offsite environmental monitoring data, only the dose estimates obtained from the MILDOS predictive modeling are available for this assessment. Based on the information that only 10% of an individual's meat intake is produced in the immediate area, the staff has concluded that the Exxon Minerals Highland facility is likely to be within the 40 CFR 190 limits. However, in order to obtain confirmatory environmental monitoring data, the licensee has been required to conduct continuous airborne sampling at the nearest receptor (e.g., the Fowler Ranch).

5.8 Cumulative Impacts from Multiple Uranium Milling Facilities

Currently, there are two major areas of concentrated uranium milling. These areas and the corresponding facilities are:

1. The Gas Hills Region, Wyoming

   Federal-American Partners (40-4492)
   Pathfinder Mines (40-2259)
   Union Carbide Corporation (40-299)

2. The Shirley Basin Region, Wyoming

   Pathfinder Mines (40-6622)
   Petrotomics Company (40-6659)

The 40 CFR 190 standard applies to the impact from all applicable uranium milling facilities to any member of the general public. Those locations which were suspected of receiving significant impacts from more than one facility were evaluated by summing the impacts from each facility as calculated in the individual assessments. When the ingestion impacts were modified by realistic consumption factors, impacts from the multiple mills did not result in any 40 CFR 190 concerns where these did not already exist. However, contributions from more than one mill can be significant to the point that they cannot be ignored. As with the individual facilities, the staff considers it is likely that the Standard will not actually be exceeded in such cumulative cases. This is believed to be the case notwithstanding that some computed doses are greater than 25 mrem, because generally conservative assumptions are made in the predictive assessments. As mentioned previously, the ultimate evaluation will be made with reliable monitoring of actual conditions at each receptor location.

5.8.1 Gas Hills, Wyoming

Under the assumption that the ingestion contributions to the dose to the local residents would reflect local consumption and production, the Standard was exceeded at the Federal-American Partners (FAP) Camp. However, the total cumulative lung dose commitment of 40 mrem was composed primarily (90%) of inhalation exposure from the FAP facility. In this case, the Pathfinder Mines facility contributed 10% of the total cumulative impact and the Union Carbide Corporation Facility a negligible amount. The Pathfinder Mines Camp exhibited cumulative doses below the 40 CFR 190 limit, although the FAP facility contributed as much as 18% of the total cumulative dose commitments to individuals at this Camp.

5.8.2 Shirley Basin, Wyoming

The two nearest resident locations are both within 8.0 km of both mills, although the town of Shirley Basin is only 3.2 km from the Petrotomics mill.

It should be noted that both mills contribute significantly to exposure at each of these locations. The critical pathway was meat ingestion to the cumulative bone dose commitment. The total cumulative impacts were not more than 29 mrem. The contribution from the meat ingestion pathway to the bone from the Pathfinder Mines operation alone accounted for over 50% of the total cumulative dose commitment from both mills. It was assumed that 100% of all vegetables and meat consumed by the local population is locally produced. Adjustments to the ingestion pathway were made for the impacts from the Gas Hills Region uranium facilties (see, for example, Appendices 2 and 3). If the same adjustments were made to the Shirley Basin Region uranium facilities, the total cumulative dose commitments would not exceed 40 CFR 190 limits. Combined lung doses were computed to be well within 40 CFR 190 limits.

Table 15 Cumulative 50-year projected dose commitments to individuals from the operation of multiple milling facilities

	Gas Hills Region, Wyoming					
	(FAP) Camp			Pathfinder Mines Camp		
Facility	Whole Body	Bone	Lung	Whole Body	Bone	Lung
FAP	0.65	17.4	35.9	0.10	2.14	3.54
Pathfinder Mines	0.26	3.73	4.07	0.60	11.4	15.7
Gas Hills Total Impact*	0.91	21.1	40.0	0.70	13.5	19.2

	Shirley Basin Region, Wyoming					
	Heward Ranch			Shirley Basin Town		
Facility	Whole Body	Bone	Lung	Whole Body	Bone	Lung
Pathfinder Mines	1.61	18.0	6.56	1.46	15.6	3.92
Petrotomics Co.	0.80	9.77	5.00	0.70	9.75	9.58
Shirley Basin Total Impact	2.41	27.8	11.6	2.16	25.4	13.5

*The Union Carbide Corporation Facility contributed a negligible impact to these locations.

6. SUMMARY

The Uranium Recovery Licensing Branch has evaluated the prospects for meeting the EPA Standard (40 CFR 190) at each NRC licensed facility. After rigorously reviewing all available environmental monitoring data and radiological assessments contained in the Final Environmental Statements, as well as some supplemental predictive modeling evaluations, it appears that implementation of the 40 CFR 190 Standard will be practicable.

At some facilities, a review of available environmental monitoring data and the dose projections from the predictive analysis indicates that the estimated offsite exposures may be very close to the Standard. In some cases, critical measured concentrations at receptors nearest the mill convert to greater than 25 mrem exposure to the lung. However, the staff has concluded that nearby mining and ore transportation activities, which are excluded from the 40 CFR 190 Standard, are most likely the primary source of exposure to the nearest receptor rather than exposures due to releases from the milling process. In these cases, the immediate aim of the EMP will be to sort out contributions to measured concentrations made by various sources to determine what contribution is made by the mill alone. Orders being issued to all facilities will require quarterly dose assessment and reporting for the calendar year 1981 of the environmental monitoring program data to permit the definitive determination of compliance with the 40 CFR 190 Standard. The orders also, as necessary, require some upgrading of existing environmental monitoring programs to assure that data gathered are accurate and useful (for example, requiring that a quality assurance program be specified). Also, some changes in EMPs are being made to assure that they are capable of distinguishing regulated and nonregulated sources of measured concentrations (for example, some short-term monitoring studies at nearby mining activities are called for).

The 40 CFR 190 implementation program will not be disruptive or overly burdensome since operators are already required by license conditions imposed based on existing regulations related to the protection of public health and safety and the environment to apply controls at the mill that should be sufficient to meet the Standard. If it is later shown through analysis of the actual environmental monitoring data that the Standard is exceeded, some additional operational control measures will have to be developed and applied by the operator.

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Appendix 1

MILDOS Computer Code Analysis

The primary mechanism for executing the staff's predictive radiological assessment methodology is the MILDOS computer code. The MILDOS code is an NRC revision of the UDAD IV code developed by the Argonne National Laboratory. The staff's uranium mill radiological assessment methodology is available in the US NRC Draft Regulatory Guide, Task 802-4, and in the FINAL GEIS (NUREG-0706, September 1980). Documentation for the MILDOS code is provided in the "MILDOS Computer Code User's Manual," by G. N. Gnugnoli and D. E. Martin (May 1980). Table 1.1 presents a list of the necessary information used by the staff to prepare the input stream for the radiological assessment of any uranium facility.

One of the most significant assumptions in predictive modeling assessments is the estimation of releases of radioactivity from a facility. There is some uncertainty regarding such releases, particularly from the tailings impoundments and other diffuse dust producing operations such as ore storage and handling. Unlike point source emissions which can be monitored with a relatively simple stack device, these emissions are not readily measured. Moreover, the effectiveness of stack emission control devices can be estimated (where no emission measurements are available) with reasonable accuracy based on a few easily obtained facts about mill operations and equipment design. Diffuse sources are also not easily determined because they are not steady emissions. Wind-blown surface emissions are episodic in nature; dusting occurs primarily during periods of high wind. Furthermore, the staff has limited information about the actual effectiveness of dust control measures that are being provided. To deal with this uncertainty and to assure consistency in the predictive model assessments, the staff has adopted certain standard assumptions about control of tailings emissions. For example, all facilities were credited with 80 percent control of areas susceptible to dusting. Where there is available information which bears on this matter, it is highlighted in the assessments which follow. In general, this is an area where close attention must be paid to 40 CFR 190 implementation at each mill.

Airborne emissions only are considered by the staff in its assessments. There are no discharges of tailings solutions to surface streams from uranium mill facilities. Some seepage occurs from tailings impoundment and associated evaporation ponds, but in no case is there known consumption of contaminated groundwater. The environmental monitoring programs which have been established include monitoring of groundwater. Information on land use being required in connection with this and other recent licensing actions will provide needed information about use of wells near mills. These efforts will identify any problems, if they exist.

Once the input is prepared, the code models the transport of effluents and the mechanisms of deposition and resuspension to obtain environmental concentrations in air, soil, and vegetation. For the purposes of 40 CFR 190 compliance assessment, the following pathways of potential impact to human beings were considered:

Table 1.1 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	Percent of U_3O_8 in the ore
Secular equilibrium activity (in pCi/g) of U-238, Th-230 and Ra-226 in the ore	Average ore grade x 0.85 $\frac{gU}{gU_3O_8} \times 3.33 \times 10^5 \frac{pCi\ U\text{-}238}{gU}$
Annual ore processing rate	Metric tons of ore processed by the uranium facility per year
Yellowcake production rate	Metric tons of yellowcake produced by the uranium facility per year
Produ... purity	Percent of U_3O_8 in yellowcake
Amount of product released to atmosphere annually	0.1% of yellowcake product[1]
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	Yellowcake production rate x product purity x 0.001 x .85 $\frac{gU}{gU_3O_8} \times 3.33 \times 10^{-7} \frac{Ci\ U\text{-}238}{gU}$ $\times 10^6 \frac{g}{MT}$
Ratio of thorium to uranium released in yellowcake emission	0.005[1]
Ratio of radium to uranium released in yellowcake emission	0.001[1]
Uncontrolled emission rates from any one mill stack or vent	5.0×10^{-3} to 1.0×10^{-2} percent of annual ore processing rate[2]
Percent reduction factor from stack/vent emission control	Uncontrolled emission rates are reduced to account for emission control devices
Area of ore pad	Surface area of ore storage pad
Reduction factor for ore pad	Accounts for spraying of water or chemical agents to reduce dust loss from ore pad, ranging from 0% to 50%

Table 1.1 (continued)

Parameter	Description
Area(s) for tailings impoundment(s)	Surface area of total impoundment, including beach and pond
Reduction factor for tailings areas	Reduction of dust loss rates by liquid cover, chemical spraying, water spraying, gypsum-cementing, and so forth
Recovery rate	Percentage of U_3O_8 in ore which is retained in the yellowcake product
Activity of U-238, Th-230, and Ra-226 in solid tailings	Specific unit activity in pCi/g of each nuclide in tailings solids
U-238	(100%-recovery rate) x secular equilibrium ore activity
Th-230	99.5% x secular equilibrium ore activity
Ra-226	99.9% x secular equilibrium ore activity
Length of grazing season	Number of months per year in which meat or milk producing animals graze
Fraction of stored cattle feed which is grown locally	Percentage of contaminated feed which supplements grazing intake
Fraction of cattle feed which is pasture grazing	Percentage of contaminated intake which is from pasture in the immediate area around the mill.
Acreage required to graze one animal unit (450 kg) for one month	Amount of surface grazing acreage required to feed one cow and one calf (an animal unit) for one month. Units are in acres/AUM. (AUM = animal unit month)

Table 1.1 (continued)

Parameter	Description
Relative joint frequency of wind speed, direction, and stability class	Data reported by National Weather Service - The wind directions are ordered: N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW. - The wind speed classifications in knots[3] are: 0-3, 4-6, 7-10, 11-16, 17-21, > 21 - The six Pasquill stability classes in order are: 1. Extremely unstable 2. Moderately unstable 3. Slightly unstable 4. Neutral 5. Moderately stable 6. Very stable
Atmospheric mixing height	The height (in meters) above the surface through which relatively vigorous vertical mixing occurs[4]

[1] U.S. Nuclear Regulatory Commission. Final Generic Environmental Impact Statement on Uranium Milling. FGEIS NUREG-0706. September 1980.

[2] APCD Mining Worksheet, prepared by William Reef, Colorado Department of Health, for Enviro-Test, Ltd., March 1978.

[3] This is the breakdown utilized by the National Weather Service (NWS) in reporting data collected by NWS stations. In more conventional units of meters/sec, the wind speed groups are: 0.0-1.5, 1.6-3.2, 3.3-5.1, 5.2-8.2, 8.3-10.8, > 10.8. Averaged wind speeds assigned to each group in meters/sec are: 0.67, 2.46, 4.47, 6.93, 9.61 and 12.52, respectively.

[4] U.S. Environmental Protection Agency. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. No. AP-101. January 1972.

1. Inhalation of all radionuclides (e.g., U-nat., Th-230, and Ra-226) in air except for released radon and its daughters.

2. External exposure by cloud immersion.

3. External exposure by direct radiation from ground deposition.

4. Ingestion of locally produced meat and vegetables.

In many cases, the most significant potential pathway of exposure is the ingestion pathway. In its initial assessments, the staff adopted the standard conservative food consumption factors delineated in the USNRC Draft Regulatory Guide, Task 802-4. In particular, 100% of an individual's meat and vegetable consumption is assumed to be produced near the mill and, therefore, is subject to contamination from mill effluents. This conservative assumption resulted, in some cases, to impacts which were in excess of the 40 CFR 190 limits. However, whenever such cases did occur and the local conditions indicated that the food production and consumption factors were too high, these factors were adjusted. The reasoning behind these adjustments is as follows:

- o Grazing locations were assumed to be in the vicinity (about 0.5 km distance) of the nearest restricted area boundaries and not necessarily at the nearest individual's residence.

- o Individuals at trailer residences and nearby housing camps are primarily employed by the mills and do not raise their own cattle for meat consumption.

- o In most cases, locally produced meat is consumed at the cattle ranches where the grazing range of the cattle is, on the average, further from the mills than the conservative locations near the restricted area boundaries. The assumption stipulates that the cattle graze at these nearby locations 100% of the time.

For the above reasons, the staff has made adjustments when site conditions have indicated that more reasonable factors were warranted. However, the uncertainties which exist concerning the ingestion pathway, especially the local production and consumption patterns, are important issues to be resolved in the initial 40 CFR 190 implementation efforts.

The ingestion of locally produced milk was considered where this pathway was possible. But in most cases, the environment surrounding a uranium milling facility does not support vegetable or milk ingestion pathways to people to any significant extent and therefore, such milk and vegetation pathways have frequently been excluded.

The final step is the determination of the 50-year dose commitments (in millirem) to selected organs for each year of exposure to airborne concentrations at the nearest receptor for the potential exposure pathways as listed above. In the following section, uranium milling facilities were dealt with in a case-by-case manner to evaluate the situation at the mill with regard to compliance with

40 CFR 190 on the basis of site-specific as well as generic information. The primary organs of interest were: the bone, the "mass averaged lung" and the whole body. Dose commitments from inhalation, external exposure and ingestion pathways were computed for each organ. Each organ dose commitment is distinguished from any other by the specific dose conversion factor. Except for the "mass average lung," the dose conversion factors have been computed by the Argonne National Laboratory's UDAD computer code. Each pathway and organ have their appropriate dose conversion factor (see FGEIS NUREG-0706, Appendix G-5). The "mass average lung" dose conversion factor was obtained by mass averaging the dose conversion factors from the UDAD code for the nasopharyngeal, tracheobronchial, pulmonary and lymphatic systems. This average accounts for the lymph nodes' propensity for chronic radioactivity retention.

The MILDOS code modeled various sources of radioactive effluents and their impacts upon designated individuals at specified population locations. The primary transport assumption was the basic straight-line Gaussian plume model (FGEIS NUREG-0706, Appendix G-2). Airborne concentrations were calculated for U-238, Th-230 and Ra-226. Mechanisms such as the deposition of radioactive particles and the resuspension of ground deposited particles were all accounted for by the MILDOS computer code. The code thus computed concentrations of the radionuclides in the environment, whereupon the dose conversion factors were applied to determine the 50-year dose commitment to the various organs by the appropriate pathway. The multiple pathway dose commitments were then summed to obtain the total organ dose commitment for each year of exposure.

For the purposes of compliance with the 40 CFR 190 Standard, the input and options used in MILDOS were simplified for the following reasons:

1. Population doses were not considered in the standards.

2. 40 CFR 190 excludes doses due to the release of radon and its daughters.

3. Assessment is based on the exposure due to normal operations over a one year period and not over the projected lifetime of the uranium facility.

Appendix 2

Gas Hills Mill, Federal-American Partners
(Docket Number 40-4492)

The Federal-American Partners (FAP) Gas Hills Mill is in a hilly area of Wyoming, about 80 km (50 miles) east of Riverton. The mill is licensed to process 860 MT of ore per day. The Eluex process is used at the mill, with ion exchange carried out in a resin-in-pulp circuit. The mill processes ores from surface and underground mines operated by FAP in the Gas Hills area. Mill tailings are being pumped to a conventional aboveground impoundment formed by a peripheral earth dam. Free liquid from the pond is pumped to a decant pond. The tailings pond is projected to reach its maximum capacity by late 1981.

Results

Table 2.1 lists the dose commitments at the nearby Camp of the Federal-American Partners uranium facility. This camp had a population of 155 people as of 1980. Table 2.1 shows the impacts from inhalation and external exposure (direct exposure pathway) as well as impacts from meat ingestion. Parenthetical entries in Table 2.1 take into account a 90% reduction of the impact from meat ingestion. Information provided by the Fremont County agricultural office indicates that the meat ingestion dose contributions are conservative. Most of the cattle raised in the environs are shipped outside the region, and only a small number are culled from the herd for local consumption. Based on information confirmed by the licensee, it is still conservatively estimated that no more than 10% of the locally produced meat is consumed by any nearby resident. In addition there are no gardens at the FAP camp, so the vegetable ingestion pathway has been excluded from consideration. As can be seen, this adjustment has little effect on the total dose commitments in this case. Table 2.2 gives the breakdown of the dose commitments for the various pathways at the locations of the FAP Camp (0.55 km West) and the Pathfinder Mines Gas Hills uranium mill camp (4.5 km ENE). Doses from meat ingestion due to grazing of cattle in the area are also provided. Tables 2.3 and 2.4 respectively display the concentrations on the ground and in the air of the parent radionuclides of interest (U-238, Th-230, and Ra-226) at the FAP Camp. These tables also indicate the specific mill activity and its contribution to the total concentrations. Table 2.5 presents the ground concentrations at the assumed meat ingestion exposure grazing location. (Concentrations in forage were assumed to be mostly the result of foliar deposition, with a smaller contribution from root uptake from the soil.)

Discussion

On the basis of the computer assessment, the Federal-American Partners (FAP) facility is projected to exceed the 40 CFR 190 compliance limits. Tables 2.1 and 2.2 lists the contributions from inhalation, external exposure, and ingestion to nearby individuals. Despite a 90% reduction of the impact to individuals through the me t ingestion pathway, the dose commitments to individuals in the FAP camp still exceed the 25 mrem limit to any organ since the lung dose was projected to be 35.9 mrem. The gypsum in the tailings

Table 2.1 Results of MILDOS computer code evaluation

Mill Name: FAP Docket Number: 40-4492

Date of Evaluation: January 1981

Residence of individual(s) receiving maximum dose: FAP Camp, 0.55 km W

*Direct Exposure Pathway (mrem):

Whole Body	0.624
Bone	17.1
Lung	35.9

Grazing location corresponding to maximum meat ingestion dose: 1.24 km NE

**Ingestion Pathway (mrem):

Whole Body	0.253 (0.025)***
Bone	2.58 (0.258)
Lung	0.253 (0.025)

Composite Pathway Dose Totals (mrem):

Whole Body	0.877 (0.649)
Bone	19.7 (17.4)
Lung	36.2 (35.9)

*The direct exposure pathway is the sum of inhalation, and gamma radiation exposure due to ground deposition and cloud immersion.

**Doses from the meat ingestion pathway are based on meat from locally grazed cattle.

***Parenthetical values account for only 10% of individuals' meat consumption due to locally produced meat.

Table 2.2 The 50-year adult dose commitments by pathway to each organ

Facility name. FAP Docket number: 40-4492

Location	Pathway	Dose Commitments (mrem)		
		Whole Body	Bone	Lung
FAP Camp 0.55 km West	Inhalation	0.610	17.1	35.9
	Ground Exposure	0.014	0.014	0.014
	Cloud Exposure	negl.	negl.	negl.
Lucky Mc Camp 4.5 km ENE	Inhalation	0.069	1.88	3.51
	Ground Exposure	0.002	0.002	0.002
	Cloud Exposure	negl.	negl.	negl.
Grazing Site 1	Meat Ingestion	0.253 (0.025)[a]	2.58 (0.258)	0.253 (0.025)
Grazing Site 2	Meat Ingestion	0.187 (0.019)	1.91 (0.191)	0.187 (0.019)
Grazing Site 3	Meat Ingestion	0.132 (0.013)	1.36 (0.136)	0.132 (0.013)
Grazing Site 4	Meat Ingestion	0.112 (0.011)	1.14 (0.114)	0.112 (0.011)

[a]Parenthetical values account for 10% of individuals' meat intake from local production.

Table 2.3 Radionuclide concentrations projected to occur on ground at residence of individual receiving maximum dose

Facility name: FAP — Docket number: 40-4492

Location of Maximum Individual: FAP Camp, 0.55 km W

Type of Particle	Mean Diameter, μm.	Density, g/cm^3	Radionuclide Concentrations, pCi/m^2		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.117E+03	1.059E+01	2.116E+01
Ground Ore	1.0	2.4	8.373E+02	8.373E+02	8.370E+02
Coarse Windblown Ore or Tailings	5.0	2.4	7.431E+00	5.058E+01	5.072E+01
Coarse Windblown Ore or Tailings	35.0	2.4	1.040E+02	6.349E+02	6.869E+02

Table 2.4 Airborne radionuclide concentrations projected to occur at residence of individual receiving maximum dose

Facility name: FAP

Docket number: 40-4492

Location of Maximum Individual: FAP Camp, 0.55 km W

Type of Particle	Mean Diameter, μm.	Density, g/cm³	Radionuclide Concentrations, pCi/m³ U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	5.515E-03	2.757E-05	5.515E-05
Ground Ore	1.0	2.4	2.181E-03	2.181E-03	2.181E-03
Coarse Windblown Ore or Tailings	5.0	2.4	1.936E-05	1.317E-04	1.322E-04
Coarse Windblown Ore or Tailings	35.0	2.4	3.071E-05	2.023E-04	2.029E-04

Table 2.5 Radionuclide concentrations projected to occur on the ground at grazing location corresponding to maximum meat ingestion dose

Facility name: FAP

Docket number: 40-4492

Location of Maximum Meat Ingestion Pathway: 1.24 km NE

Type of Particle	Mean Diameter, μm.	Density, g/cm^3	Radionuclide Concentrations, pCi/m^2 U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.526E+03	7.628E+00	1.525E+01
Ground Ore	1.0	2.4	4.921E+02	4.921E+02	4.919E+02
Coarse Windblown Ore or Tailings	5.0	2.4	4.059E+01	3.556E+02	3.566E+02
Coarse Windblown Ore or Tailings	35.0	2.4	5.527E+02	4.878E+03	4.893E+03

solids results in a cementing effect. Quantitative estimates of the effect of the reduction of tailings emssions because of the gypsum have not been documented. Therefore, no additional reduction was used in the predictive assessment.

The NRC staff has made assumptions about exposure pathways and residence times in the mill environs which are conservative, yet reasonable, in light of the NRC's responsibility to maintain public safety. As additional environmental data become available, a firm determination can be made concerning 40 CFR 190 compliance at this mill.

Assumptions for Computer Prediction

Table 2.6 presents the basic parameters and assumptions made in modeling the FAP facility. Control factors, yellowcake emissions and tailings activities are presented with other parameters affecting the emission of radioactivity. Table 2.7 displays the emission (Curies/year) of the parent radionuclides in secular equilibrium from the transporting of ore, to the grizzly and up to the fine ore storage bins. From the ball mill crushing to the yellowcake precipitation, the process is wet and enclosed, and the NRC staff assumed only negligible radioactive emissions. Table 2.8 lists the tailings pond parameters and radionuclide activity in the solid tailings (U-238 is usually depleted at this point of the cycle). In addition, the high content of gypsum in the raw ore causes a natural cementing effect of the tailings sands. This restricts suspension of particulates into the air and subsequent dispersion. This mitigation of suspension of tailings solids was not quantitatively included in the computer assessment, beyond the nominal mitigation by pond cover (80%). Table 2.9 is the wind frequency data, which provides the site-specific mechanism for transport of radioactivity to offsite locations. The meteorological data originates from Casper, Wyoming which is 107 km away, but was judged to be appropriate for this region in Wyoming.

Table 2.6 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	0.10%
Secular equilibrium activity (in pCi/g) of U-238, Th-230, and Ra-226 in the ore	283.4
Annual ore processing rate	293,000 MT/year
Yellowcake production rate	278. MT/year
Product purity	96% U_3O_8
Amount of product released to atmosphere annually	0.278 MT/year

Table 2.6 (continued)

Parameter	Description
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	7.56×10^{-2} Ci/year
Thorium released in yellowcake emission	3.78×10^{-4} Ci/year
Radium released in yellowcake emission	7.56×10^{-4} Ci/year
Uncontrolled emission rates from any one mill stack or vent	See Table 2.7
Percent reduction factor from stack/vent emission control	See Table 2.7
Area of ore pad	4.6 acres
Reduction factor for ore pad	0%
Areas for tailings impoundments	
Tailings Pile 1	18 acres
Tailings Pile 2	62 acres
Reduction factor for tailings areas	80%
Recovery rate	91%
Activity of U-238, Th-230, and Ra-226 in solid tailings (pCi/g)	
U-238	25.5
Th-230	282.1
Ra-226	283.1
Length of grazing season	6 months
Fraction of stored cattle feed which is grown locally	0.0%
Fraction of cattle feed which is pasture grazing	100%
Acreage required to graze one animal unit (450kg) for one month	9.0 acres
Relative joint frequency of wind speed, direction, and stability class	Table 2.9
Atmospheric mixing height	598.3 meters

Table 2.7 Natural ore emissions

Mill Name: FAP

Docket Number: 40-4492

Process Causing Emissions	Mass Loss Rate, lb/ton	Control Measures	Control Efficiency, %	Effective Mass Loss Rate, lb/ton	Annual Emissions, Ci/yr
Dump to Grizzly	.05	None	0.0	.05	.00517
Crusher	.2	Rotoclone Dust Collector	93.6%	.013	.00132
Grinder	.2	Rotoclone Dust Collector	93.6%	.013	.00132
Conveyors (2)	.2	Rotoclone Dust Collector	93.6%	.013	.00132
Fine Ore Bin and Handling	.1	Rotoclone Dust Collector	93.6%	.006	.00066
Ore Pad Handling	.15	None	0.0%	.15	.01551
				TOTAL	.02533

Annual Mass Loss = (Effective Mass Loss Rate) ÷ 2000 · (Ore Throughput)

Activity Emission = (Annual Mass Loss) · (2.5) · (Ore Quality) ÷ 100 · (.2824 $\frac{Ci}{MT}$ of U_3O_8)

Table 2.8 Tailings pond parameters

Mill Name: FAP

Docket Number: 40-4492

Tailings Source Area Number	Area (km^2)	Activity Content of Tailings (pCi/g)		
		U^{238}	Th^{230}	Ra^{226}
1	.075	25.5	282.1	283.1
2	.25	25.5	282.1	283.1

Table 2.9 Meteorological data for FAP mill

(Docket Number: 40-4492)

JOINT FREQUENCY IN PERCENT, DIRECTION INDICATED AS THE WIND IS FROM

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	.0069	.0240	.0103	.0240	.0171	.0103	.0069	.0411	.0137	.0206	.0240	.0240	.0377	.0171	.0206	.0103	.3086
5.5	.0137	.0274	.0206	.0069	.0137	.0206	.0137	.0411	.0069	.0206	.0069	.0274	.0548	.0343	0.0050	.0206	.3498
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.0206	.0514	.0309	.0309	.0308	.0309	.0276	.1026	.0206	.0412	.0309	.0514	.0925	.0514	.0206	.0309	.6584
STABILITY CLASS 2																	
1.5	.0554	.0507	.0374	.0421	.0960	.0428	.0665	.0651	.0477	.0410	.0618	.0445	.1126	.0482	.0248	.0644	.9386
5.5	.0959	.1233	.0685	.0411	.1233	.1165	.1302	.1165	.2126	.1028	.1516	.1370	.1370	.0959	.0548	.1096	1.8224
10.0	.0685	.0617	.0685	.0411	.0617	.0206	.0548	.0274	.0548	.0685	.0822	.1096	.1781	.0685	.0754	.0822	1.1236
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.2198	.2357	.1744	.1243	.2810	.1795	.2515	.2090	.3649	.2123	.3012	.2911	.4277	.2046	.1510	.2562	3.0846
STABILITY CLASS 3																	
1.5	.0186	.0133	.0115	.0110	.0366	.0186	.0127	.0037	.0282	.0186	.0186	.0292	.0179	.0273	.0164	.0028	.3018
5.5	.0459	.1370	.0459	.1028	.1781	.0559	.1233	.0822	.1561	.0459	.0459	.1713	.2398	.1302	.0156	.0617	1.5329
10.0	.2535	.1850	.1576	.1713	.2329	.1918	.1233	.0822	.1233	.1987	.3694	.6439	.4727	.2261	.1640	.1576	3.7582
15.5	.0274	.0137	.0137	.0137	.0381	.0341	.0137	0.0000	.0343	.0459	.2055	.1713	.1918	.0383	.0411	.0685	.9935
21.5	0.0000	.0069	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0137	.0069	.0343	.0343	.0411	.0206	0.0000	0.0000	.1578
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0069	.0137	.0069	0.0000	0.0000	0.0000	.0275
ALL	.3954	.3559	.2781	.2996	.4819	.3406	.2730	.1681	.3502	.4160	.7311	1.0637	.9702	.4385	.3120	.2906	7.1664
STABILITY CLASS 4																	
1.5	.0732	.1053	.0859	.0741	.0598	.0592	.0548	.0268	.0548	.0336	.0411	.0530	.0679	.0816	.0430	.1809	1.0295
5.5	.5412	.5823	.4453	.3220	.4110	.3220	.1918	.1302	.1918	.1233	.2055	.3357	.3357	.2346	.1438	.4521	4.9736
10.0	1.1400	1.4249	1.0207	.6768	.9248	.4932	.3014	.1370	.2126	.6302	1.4180	2.1304	1.7466	.5412	.520[illegible]	.5081	14.0223
15.5	1.1097	1.4865	1.0275	.6508	1.0001	.5480	.1987	.0548	.3699	3.0826	4.5820	5.1993	1.9318	.9453	.5891	.4042	25.1483
21.5	.2809	.3768	.1713	.0617	.2261	.0822	.0411	.0137	.1781	2.6716	5.0015	2.2126	.9248	.4042	.2398	.1028	12.9952
28.0	.1028	.1028	.0274	0.0000	.0137	.0069	0.0000	0.0000	.0411	1.4797	2.2469	.97[illegible]7	.5206	.1165	.0411	.0343	5.7065
ALL	3.2576	4.0786	2.7776	1.9859	2.6355	1.5115	.7878	.3625	1.0481	8.0210	15.4610	10.9037	5.5276	2.3280	1.5715	1.5944	63.6586
STABILITY CLASS 5																	
1.5	.3725	.1600	.1431	.1104	.1608	.1124	.0635	.0583	.1221	.1128	.1988	.2996	.5746	.2607	.2023	.2808	3.1887
5.5	1.1098	.8974	.6439	.5480	.6238	.3561	.3083	.1919	.3014	.3152	.5215	1.2741	2.8140	.9865	.9062	.9933	11.9952
10.0	.3425	.3014	.2809	.2877	.4042	.3083	.1165	.0480	.0548	.4042	1.0892	2.8223	1.9644	.4042	.2466	.2603	9.2755
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	1.8246	1.3656	1.0673	.9461	1.1884	.7770	.4883	.2502	.4783	.8318	1.7615	4.3960	4.4930	1.6514	1.3551	1.5142	24.4356
STABILITY CLASS 6																	
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	5.7162	6.0672	4.3245	3.3063	4.6176	2.8395	1.8212	1.1406	2.2621	9.5223	18.2061	16.7059	11.5110	4.6745	3.4151	3.6863	100.0034

Appendix 3

Gas Hills Mill, Pathfinder Mines Corporation (Docket Number 40-2259)

The Gas Hills Uranium Mill (formerly the Lucky Mc Mill) is operated by Pathfinder Mines Corporation (formerly Lucky Mc Corporation) in the Gas Hills region of Fremont County, Wyoming, about 40 km (25 miles) northeast of Jeffrey City. The mill capacity is assumed to be 4.8 x 10^5 MT of ore per year (NUREG-0357). The average ore grade is about 0.15% U_3O_8. Although mines adjacent to the mill also could provide fresh water for ore processing, availability of hot [57°C (135°F)] well water at the site makes it advantageous from a process standpoint to use well water in the mill and to treat mine water for discharge.

The tailings system consists of six retention areas which are situated sequentially in a small natural ravine north-northwest of the mill and are dug into an underlying shale formation. Three of the six retention areas now contain tailings covering a total tailings area of approximately 223 acres. Two of the remaining three retention areas are now used for solution evaporation, while the third has been drained and is under construction to upgrade and enlarge the retention structure.

Results

Table 3.1 lists the dose commitments at the nearby Pathfinder Mines Gas Hills camp. This camp had a population of 185 people as of 1979. Table 3.1 shows the impacts from inhalation and external exposure (direct exposure pathway) as well as impacts from vegetable and meat ingestion. Parenthetical entries in Table 3.1 reflect a 90% reduction of meat ingestion dose commitments and a 95% reduction of vegetable ingestion dose commitments. As in the case for the FAP facility (see Appendix 2), information provided by the Fremont County agricultural office indicates that these reductions still provide a reasonably conservative estimate of local consumption and production patterns. Because most of the cattle are shipped outside the region, the 90% reduction adjustment to the dose commitments is a reasonably conservative estimate. Gardens exist in the surrounding environment, but the growing season is short, and the production is very low. Adjustment of the ingestion pathway contribution, in this case, significantly affects the predicted total dose commitments, especially in regard to the 40 CFR 190 limits. Table 3.2 gives the breakdown of the dose commitments along the various pathways at the nearest locations of Pathfinder Mines Gas Hills camp (3.0 km ENE), Federal-American Partners camp (3.1 km WSW), and Puddle Springs Ranch (6.1 km West). Doses from meat ingestion due to grazing of cattle in the area are also provided. Tables 3.3 and 3.4 respectively display the concentrations on the ground and in the air of the radionuclides of interest (U-238, Th-230 and Ra-226) at the Pathfinder Camp. These tables also indicate the specific mill activity and its contribution to the total concentrations. Table 3.5 presents the ground concentrations at the assumed meat ingestion exposure grazing location. (Concentrations in forage were assumed to be mostly the result of foliar deposition, with a smaller contribution from root uptake from the soil.)

Table 3.1 Results of MILDOS computer code evaluation

Mill Name: Pathfinder Mines Gas Hills Docket Number: 40-2259

Date of Evaluation: January 1981

Residence of individual(s) receiving maximum dose: Pathfinder Mines Gas Hills Camp, 3.0 km ENE

*Direct Exposure Pathway (mrem):

Whole Body	0.340
Bone	8.74
Lung	15.4

Grazing location corresponding to maximum meat ingestion dose: 1.44 km NNE

**Ingestion Pathway (mrem):

Whole Body	3.27 (0.259)***
Bone	33.5 (2.65)
Lung	3.27 (0.259)

Composite Pathway Dose Totals (mrem):

Whole Body	3.61 (0.599)
Bone	42.2 (11.4)
Lung	18.7 (15.7)

*The direct exposure pathway is the sum of inhalation and gamma radiation exposure due to ground deposition and cloud immersion.

**The ingestion pathway includes the maximum dose due to ingestion of meat from locally grazed cattle and ingestion of vegetables grown at the residence location.

***Parenthetical values account for 5% of an individual's vegetable intake and 10% of an individual's meat intake being locally produced.

Table 3.2 50-year adult dose commitments by pathway to each organ

Facility name: Pathfinder Mines Gas Hills Docket number: 40-2259

Location	Pathway	Dose Commitments (mrem) Whole Body	Bone	Lung
Pathfinder Mines Gas Hills Camp 3.0 km ENE	Inhalation	0.326	8.73	15.4
	Ground Exposure	0.014	0.014	0.014
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	1.36 (0.068)*	14.1 (0.705)*	1.36 (0.068)*
FAP Housing Camp 3.1 km WSW	Inhalation	0.064	1.73	3.87
	Ground Exposure	0.002	0.002	0.002
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.111 (0.006)*	1.17 (0.059)*	0.111 (0.006)*
Puddle Springs Ranch 6.1 km West	Inhalation	0.023	0.623	1.36
	Ground Exposure	0.001	0.001	0.001
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.044 (0.002)*	0.458 (0.023)*	0.044 (0.002)*
Grazing Site 1	Meat Ingestion	1.91 (0.191)**	19.4 (1.94)**	1.91 (0.191)**
Grazing Site 2	Meat Ingestion	1.89 (0.189)**	19.2 (1.92)**	1.89 (0.189)**
Grazing Site 3	Meat Ingestion	0.342 (0.034)**	3.50 (0.350)**	0.342 (0.034)**
Grazing Site 4	Meat Ingestion	0.310 (0.031)**	3.18 (0.318)**	0.310 (0.031)**
Grazing Site 5	Meat Ingestion	0.132 (0.013)**	1.35 (0.135)**	0.132 (0.013)**

*These values in parentheses are based on the 95% reduction due to local vegetable production and consumption.

**These values in parentheses are based on the 90% reduction due to local meat production and consumption.

Table 3.3 Radionuclide concentrations projected to occur on ground at residence of individual receiving maximum dose

Facility name: Pathfinder Mines Gas Hills Docket number: 40-2259

Location of Maximum Individual: Pathfinder Mines Gas Hill Camp, 3.0 km ENE

Type of Particle	Mean Diameter, μm.	Density, g/cm³	Radionuclide Concentrations, pCi/m² U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.012E+03	5.058E+00	1.011E+00
Ground Ore	1.0	2.4	2.260E+02	2.260E+02	2.259E+02
Coarse Windblown Ore or Tailings	5.0	2.4	2.694E+01	2.139E+02	2.145E+02
Coarse Windblown Ore or Tailings	35.0	2.4	3.002E+02	2.386E+03	2.395E+03

Table 3.4 Airborne radionuclide concentrations projected to occur at residence of individual receiving maximum dose

Facility name: Pathfinder Mines Gas Hills — Docket number: 40-2259

Location of Maximum Individual: Pathfinder Mines Gas Hills Camp, 3.0 km ENE

Type of Particle	Mean Diameter, µm.	Density, g/cm³	Radionuclide Concentrations, pCi/m³		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.635E-03	1.318E-05	2.635E-06
Ground Ore	1.0	2.4	5.888E-04	5.888E-04	5.887E-04
Coarse Windblown Ore or Tailings	5.0	2.4	7.018E-05	5.571E-04	5.590E-04
Coarse Windblown Ore or Tailings	35.0	2.4	8.865E-05	7.053E-04	7.077E-04

Table 3.5 Radionuclide concentrations projected to occur on the ground at grazing location corresponding to maximum meat ingestion dose

Facility name: Pathfinder Mines Gas Hills Camp   Docket number: 40-2259

Location of Maximum Meat Ingestion Pathway: 1.44 km NNE

Type of Particle	Mean Diameter, μm.	Density, g/cm³	Radionuclide Concentrations, pCi/m² U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.728E+03	8.630E+00	1.727E+00
Ground Ore	1.0	2.4	4.363E+02	4.353E+02	4.361E+02
Coarse Windblown Ore or Tailings	5.0	2.4	3.329E+02	2.854E+03	2.862E+03
Coarse Windblown Ore or Tailings	35.0	2.4	4.665E+03	4.013E+04	4.025E+04

Discussions

Based on the computer assessment as shown in Table 3.1, the Pathfinder Mines facility was projected to exceed compliance limits for 40 CFR 190, primarily due to the bone dose commitment of 42.2 mrem. However, it should be noted that almost 80% (33.5 mrem) of the bone dose commitment results from the ingestion pathway. Specifically, 14.1 mrem of the bone dose resulted from vegetable ingestion, and 19.4 mrem of the bone dose resulted from ingestion of locally produced meat (see Table 3.2). These contributions represent 33% and 46% of the total bone dose commitment, respectively. These figures are based on the assumption that 100% of an individual's meat and vegetable intake is locally produced. A general explanation of the methodology used in the ingestion pathway is given in Appendix 1 of this report.

Dose commitments which incorporate site-specific county base estimates for consumption of locally produced vegetables and meat are presented parenthetically in Tables 3.1 and 3.2. This adjustment reduces consumption of local vegetables by 95% and consumption of locally produced meat by 90%. The county base estimates indicate that these reductions are still reasonably conservative. As a result of this adjustment, the bone dose commitment is 11.4 mrem; and the lung dose commitment is the most significant at 15.7 mrem, most of which (98%) is from the inhalation pathway.

The NRC staff has made assumptions about exposure pathways, residence times and consumption patterns in the mill environs which are conservative, yet reasonable, in light of the NRC's responsibility to maintain public safety. With additional environmental data, further determinations can be made concerning these assumptions, and ultimately the environmental impact of this mill.

Assumptions for Computer Prediction

Table 3.6 presents the basic parameters and assumptions made in modeling the facility. Control factors, yellowcake emissions and tailings activities are presented with other parameters affecting the emission of radioactivity. Table 3.7 displays the emission (Curies/year) of the radionuclides in secular equilibrium from the handling of ore and the grizzly operation. From the rod mill crushing to the yellowcake precipitation, the process is wet and enclosed, and the NRC staff assumes only negligible radioactive emissions. Table 3.8 lists the tailings impoundment and radionuclide activity in the solid tailings (U-238 is usually depleted at this point of the cycle). NRC staff onsite visits confirm the natural cementing effect of the gypsum in the tailings solids. This mitigates, to a great extent, the surficial suspension of sands into the air for subsequent dispersal, but no quantitative estimates of the extent of emission reduction have been documented. Hence, no additional reduction because of the gypsum has been made. Table 3.9 presents the wind frequency data, which provides the site-specific mechanism for transport of radioactivity to offsite locations. The meteorological data originates from Casper, Wyoming, which is 101 km away, but was found to be in close agreement with the onsite meteorological profile.

Table 3.6 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	0.15%
Secular equilibrium activity (in pCi/g) of U-238, Th-230 and Ra-226 in the ore	423.6
Annual ore processing rate	480,000 MT/year
Yellowcake production rate	710 MT/year
Product purity	90% U_3O_8
Amount of product released to atmosphere annually	0.710 MT/year
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	0.181 Ci/year
Thorium released in yellowcake emission	9.05×10^{-4} Ci/year
Radium released in yellowcake emission	1.81×10^{-4} Ci/year
Uncontrolled emission rates from any one mill stack or vent	See Table 3.7
Percent reduction factor from stack/vent emission control	See Table 3.7
Area of ore pad	10 acres
Reduction factor for ore pad	0.0%
Areas for tailings impoundment(s)	
Tailings Pile 1	.211 km^2
Tailings Pile 2	.300 km^2
Tailings Pile [illegible]	.393 km^2
Reduction factor for tailings areas	80%
Recovery rate	89%
Activity of U-238, Th-230 and Ra-226 in solid tailings	See Table 3.8

Table 3.6 (continued)

Parameter	Description
Length of grazing season	6 months
Fraction of stored cattle feed which is grown locally	0.0
Fraction of cattle feed which is pasture grazing	100%
Acreage required to graze one animal unit (450kg) for one month	9.0 acres
Relative joint frequency of wind speed, direction, and stability class	Table 3.9
Atmospheric mixing height	598.3 meters

Table 3.7 Natural ore emissions

Mill Name: Pathfinder Mines Gas Hills

Docket Number: 40-2259

Process Causing Emissions	Mass Loss Rate, lb/ton	Control Measures	Control Efficiency, %	Effective Mass Loss Rate, lb/ton	Annual Emissions, Ci/yr
Handling of Ore	.05	None	0.0	.05	.0127
Trucking of Ore	.10	None	0.0	.10	.0254
Grizzly	.05	None	0.0	.05	.0127
				TOTAL	.0508

Annual Mass Loss = (Effective Mass Loss Rate) ÷ 2000 · (Ore Throughput)

Activity Emission = (Annual Mass Loss) · (2.5) · (Ore Quality) ÷ 100 · (.2824 $\frac{Ci}{Mt}$ of U_3O_8)

Table 3.8 Tailings pond parameters

Mill Name: Pathfinder Mines Gas Hills Docket Number: 40-2259

Tailings Pond Number	Area (km^2)	Activity Content of Tailings (pCi/g) U^{238}	Th^{230}	Ra^{226}
1	.211	96.3	871.5	874.6
2	.300	67.1	607.3	609.4
2a	.393	67.1	607.3	609.4

Table 3.9 Meteorological data for Pathfinder Mines Gas Hill Mill

(Docket Number: 40-2259)

JOINT FREQUENCY IN PERCENT, DIRECTION INDICATES WHERE THE WIND IS FROM

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	.0069	.0240	.0103	.0240	.0171	.0103	.0069	.0411	.0137	.0206	.0240	.0240	.0377	.0171	.0206	.0103	.3086
5.5	.0137	.0274	.0206	.0069	.0137	.0206	.0137	.0617	.0069	.0206	.0069	.0274	.0548	.0343	0.0000	.0206	.3498
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.0206	.0514	.0309	.0309	.0308	.0309	.0206	.1028	.0205	.0412	.0309	.0514	.0925	.0514	.0206	.0309	.6584
STABILITY CLASS 2																	
1.5	.0554	.0507	.0374	.0421	.0960	.0428	.0685	.0651	.0477	.0410	.0618	.0445	.1126	.0482	.0208	.0644	.9386
5.5	.0959	.1233	.0685	.0411	.1233	.1165	.1302	.1165	.2124	.1028	.1576	.1370	.1370	.0959	.0548	.1096	1.8224
10.0	.0685	.0617	.0685	.0411	.0617	.0206	.0548	.0274	.0548	.0685	.0822	.1096	.1781	.0685	.0754	.0822	1.1236
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.2198	.2357	.1744	.1243	.2810	.1795	.2515	.2090	.3649	.2123	.3016	.2911	.4277	.2046	.1510	.2562	3.8846
STABILITY CLASS 3																	
1.5	.0186	.0133	.0115	.0110	.0366	.0186	.0127	.0037	.0282	.0186	.0186	.0292	.0174	.0273	.0320	.0028	.3016
5.5	.0959	.1370	.0959	.1028	.1781	.0959	.1233	.0822	.1567	.0459	.0459	.1713	.2398	.1302	.0754	.0617	1.9320
10.0	.2535	.1850	.1576	.1713	.2329	.1918	.1233	.0822	.1233	.1987	.3699	.6439	.4727	.2261	.1644	.1576	3.7542
15.5	.0274	.0137	.0137	.0137	.0343	.0343	.0137	0.0000	.0343	.0959	.2055	.1713	.1918	.0343	.0411	.0685	.9935
21.5	0.0000	.0069	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0137	.0069	.0343	.0343	.0411	.0206	0.0000	0.0000	.1578
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0069	.0137	.0069	0.0000	0.0000	0.0000	.0275
ALL	.3954	.3559	.2787	.2996	.4819	.3466	.2730	.1681	.3562	.4160	.7311	1.0637	.9762	.4385	.3129	.2906	7.1666
STABILITY CLASS 4																	
1.5	.0792	.1053	.0354	.0741	.0598	.0592	.0548	.0268	.0546	.0336	.0411	.0530	.0679	.0810	.0430	.1009	1.0205
5.5	.5412	.5823	.4453	.3220	.4110	.3220	.1914	.1302	.1918	.1233	.2055	.3157	.3357	.2398	.1439	.4521	4.5730
10.0	1.1440	1.4249	1.0207	.6760	.9248	.4932	.3614	.1370	.2124	.6302	1.4160	2.1304	1.7466	.5812	.5206	.5001	14.0225
15.5	1.1097	1.4865	1.0275	.6568	1.0001	.5480	.1467	.0548	.3649	3.0826	6.5420	5.1491	1.9318	.9453	.5091	.4042	25.1403
21.5	.2809	.3768	.1713	.0617	.2261	.0822	.0411	.0137	.1761	2.6716	5.0075	2.2126	.9248	.4042	.2398	.1028	12.9952
28.0	.1028	.1028	.0278	0.0000	.0137	.0069	0.0000	0.0000	.0411	1.4797	2.2469	.9727	.5206	.1165	.0411	.0343	5.7065
ALL	3.2578	4.0786	2.7770	1.9854	2.6355	1.5115	.7870	.3625	1.0461	8.0210	15.4610	10.9037	5.5276	2.3206	1.5775	1.5944	63.6586
STABILITY CLASS 5																	
1.5	.3723	.1669	.1431	.1104	.1004	.1124	.0635	.0583	.1221	.1124	.1440	.2996	.5746	.2607	.2023	.2606	3.1647
5.5	1.1098	.6974	.6439	.5480	.6234	.3563	.3603	.1919	.3014	.3152	.5275	1.2741	2.0140	.9865	.9042	.4933	11.9952
10.0	.3425	.3014	.2809	.2877	.4042	.1083	.1165	.0480	.0548	.4042	1.0892	2.4223	1.3049	.4042	.2466	.2603	9.2755
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	1.8246	1.3656	1.0679	.9461	1.1464	.7776	.4803	.2982	.4783	.8318	1.7615	4.3960	4.4930	1.6514	1.3531	1.5142	24.4354
STABILITY CLASS 6																	
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	5.7182	6.0872	4.3295	3.3863	4.6176	2.8395	1.8212	1.1406	2.2621	9.5223	18.2861	16.7059	11.5110	4.6745	3.4151	3.6663	100.0034

Appendix 4

Shirley Basin Mill, Pathfinder Mines Corporation (Docket Number 40-6622)

Pathfinder Mines Corp. (formerly Lucky Mc Uranium Corp.) operates the Shirley Basin Uranium Mill in an area of plains and rolling hills about 72 km (45 miles) south of Casper, Wyoming. The mill is autogenous, with no preliminary crushing. There are no conveyors in the plant. Static-bed resin columns extract uranium following acid leaching. The mill throughout is 1630 MT of ore per day. The present tailings pond covers about 61 ha (150 acres).

Results

Table 4.1 lists the dose commitments at the Heward Ranch and shows the impacts from inhalation and external exposure (direct exposure pathway), as well as impacts from vegetable and meat ingestion. Table 4.2 gives the breakdown of the dose commitments for the various pathways at the town of Shirley Basin (8.0 km S) and the Heward Ranch (8.0 km E). Doses from meat ingestion due to grazing of cattle in the area are also provided. Tables 4.3 and 4.4 respectively display the concentrations on the ground and in the air of the parent radionuclides of interest (U-238, Th-230 and Ra-226). These tables also indicate the specific mill activity and its contribution to the total concentrations. Table 4.5 presents the ground concentrations at the assumed meat ingestion exposure grazing location. (Concentrations in forage were assumed to be mostly the result of foliar deposition, with a smaller contribution from root uptake from the soil.)

Discussion

Based on the computer assessment as shown in Table 4.1, the Pathfinder Mines Shirley Basin facility was projected to comply with limits for 40 CFR Part 190. The NRC staff has made assumptions about exposure pathways, and residence times in the mill environs which are conservative, yet reasonable, in light of the NRC's responsibility to maintain public safety. As additional environmental data become available, further determinations can be made concerning the environmental impact of this mill. The largest organ dose was the bone dose (18.0 mrem), but over 85% of this dose resulted from ingestion. In fact, 77% of the total bone dose results from meat ingestion. The assumption that 100% of an individual's meat supply is locally produced tends to be conservative. A general explanation of this assumption and other facets of the methodology used in the predictive assessment relating to the ingestion pathway can be found in Appendix 1 of this report. The total impacts may be conservative; and as more information becomes available concerning local food production, estimates will be revised accordingly.

Assumptions for Computer Prediction

Table 4.6 presents the basic parameters and assumptions made in modeling the Pathfinder Mines Shirley Basin facility. Control factors, yellowcake emissions and tailings activities are presented with other parameters affecting the emission of radioactivity. Table 4.7 displays the emission (Curies/year) of the parent radionuclides in secular equilibrium from ore pad handling and

Table 4.1 Results of MILDOS computer code evaluation

Mill Name: Pathfinder Mines Shirley Basin   Docket Number: 40-6622

Date of Evaluation: January 1981

Residence of individual(s) receiving maximum dose: Heward Ranch, 8.0 km E

*Direct Exposure Pathway (mrem):

Whole Body	0.092
Bone	2.53
Lung	5.04

Grazing location corresponding to maximum meat ingestion dose: 1.47 km NNE

**Ingestion Pathway (mrem):

Whole body	1.52
Bone	15.5
Lung	1.52

Composite Pathway Dose Totals (mrem):

Whole Body	1.61
Bone	18.0
Lung	6.56

*The direct exposure pathway is the sum of inhalation, and gamma radiation exposure due to ground deposition and cloud immersion.

**The ingestion pathway considers the maximum dose due to the ingestion of meat from locally grazed cattle and ingestion of vegetables grown at the residence location.

Table 4.2 50-year adult dose commitments by pathway to each organ

Facility name: Pathfinder Mines Shirley Basin Docket number: 40-6622

Location	Pathway	Dose Commitments (mrem) Whole Body	Bone	Lung
Heward Ranch 8.0 km E	Inhalation	0 090	2.53	5.04
	Ground Exposure	0.C02	0.002	0.002
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.159	1.67	0.159
Shirley Basin (Town) 8.0 km S	Inhalation	0.043	1.20	2.50
	Ground Exposure	0.001	0.001	0.001
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.056	0.595	0.056
Grazing Site 1	Meat Ingestion	1.36	13.8	1.36
Grazing Site 2	Meat Ingestion	0.622	6.32	0.622
Grazing Site 3	Meat Ingestion	0.572	5.84	0 572
Grazing Site 4	Meat Ingestion	0.156	1.61	0.156

Table 4.3 Radionuclide concentrations projected to occur on ground at residence of individual receiving maximum dose

Facility name: Pathfinder Mines Shirley Basin   Docket number: 40-6622

Location of Maximum Individual: Heward Ranch, 8.0 km E

Type of Particle	Mean Diameter, µm.	Density, g/cm³	Radionuclide Concentrations, pCi/m² U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.934E+02	1.467E+00	2.933E-01
Ground Ore	1.0	2.4	1.112E+02	1.112E+02	1.112E+02
Coarse Windblown Ore or Tailings	5.0	2.4	1.894E+00	2.328E+01	2.336E+01
Coarse Windblown Ore or Tailings	35.0	2.4	1.715E+01	1.921E+02	1.928E+02

Table 4.4 Airborne radionuclide concentrations projected to occur at residence of individual receiving maximum dose

Facility name: Pathfinder Mines Shirley Basin | Docket number: 40-6622

Location of Maximum Individual: Heward Ranch, 8.0 km E

Type of Particle	Mean Diameter, µm	Density, g/cm^3	Radionuclide Concentrations, pCi/m^3		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	7.642E-04	3.821E-06	7.642E-07
Ground Ore	1.0	2.4	2.898E-04	2.898E-04	2.897E-04
Coarse Windblown Ore or Tailings	5.0	2.4	4.933E-06	6.064E-05	6.087E-05
Coarse Windblown Ore or Tailings	35.0	2.4	5.064E-06	5.674E-05	5.695E-05

Table 4.5 Radionuclide concentrations projected to occur on the ground at grazing location corresponding to maximum meat ingestion dose

Facility name: Pathfinder Mines Shirley Basin | Docket number: 40-6622

Location of Maximum Meat Ingestion Pathway: 1.47 km NNE

Type of Particle	Mean Diameter, μm.	Density, g/cm^3	Radionuclide Concentrations, pCi/m^2 U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.210E+03	1.105E+01	2.209E+00
Ground Ore	1.0	2.4	9.304E+02	9.304E+02	9.300E+02
Coarse Windblown Ore or Tailings	5.0	2.4	9.738E+01	2.030E+03	2.037E+03
Coarse Windblown Ore or Tailings	35.0	2.4	1.362E+03	2.795E+04	2.805E+04

Table 4.6 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	0.2%
Secular equilibrium activity (in pCi/g) of U-238, Th-230, and Ra-226 in the ore	565.0
Annual ore processing rate	533,000 MT/year
Yellowcake production rate	1137 MT/year
Product purity	90% U_3O_8
Amount of product released to atmosphere annually	1.137 MT/year
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	0.289 Ci/year
Thorium released in yellowcake emission	1.45×10^{-3} Ci/year
Radium released in yellowcake emission	2.89×10^{-4} Ci/year
Uncontrolled emission rates from any one mill stack or vent	See Table 4.7
Percent reduction factor from stack/vent emission control	See Table 4.7
Area of ore pad	14 acres
Reduction factor for ore pad	0.0%
Areas for tailings impoundments	
Tailings Pile 1	12[illegible] acres
Tailings Pile 2	12[illegible] acres
Reduction factor for tailings areas	80%

Table 4.6 (continued)

Parameter	Description
Recovery rate	96%
Activity of U-238, Th-230 and Ra-226 in solid tailings (pCi/g)	
U-238	22.6
Th-230	562.2
Ra-226	564.4
Length of grazing season	6 months
Fraction of stored cattle feed which is grown locally	0.0
Fraction of cattle feed which is pasture grazing	100%
Acreage required to graze one animal unit (450kg) for one month	9.0 acres
Relative joint frequency of wind speed, direction, and stability class	Table 4.9
Atmospheric mixing height	598.2 meters

Table 4.7 Natural ore emissions

Mill Name: Pathfinder Mines Shirley Basin

Docket Number: 40-6622

Process Causing Emissions	Mass Loss Rate, lb/ton	Control Measures	Control Efficiency, %	Effective Mass Loss Rate, lb/ton	Annual Emissions, Ci/yr
Crusher & Grinder	.2	Autogenous	100%	.00	0.0
Dump to Grizzly	.2	None	0%	.20	.07528
Ore Pad Handling	.15	None	0%	.15	.05646
				TOTAL	.13174

Annual Mass Loss = (Effective Mass Loss Rate) ÷ 2000 · (Ore Throughput)

Activity Emission = (Annual Mass Loss) · (2.5) · (Ore Quality) ÷ 100 · (.2824 $\frac{Ci}{MT}$ of U_3O_8)

receiving. From the cascade mill crushing to the yellowcake precipitation, the process is wet and enclosed, and the NRC staff assumed only negligible radioactive emissions. Table 4.8 lists the tailings impoundment and radionuclide activity in the solid tailings (U-238 is usually depleted at this point of the cycle). Table 4.9 is the wind frequency data, which provides the site-specific mechanism for transport of radioactivity to offsite locations. The meteorological data originates from Casper, Wyoming which is 77 km away, but was the only available data for this region in Wyoming.

Table 4.8 Tailings pond parameters

Mill Name: Pathfinder Mines Shirley Basin Docket Number: 40-6622

Tailings Source Area Numbers	Area (km^2)	Activity Content of Tailings		
		U^{238}	Th^{230}	Ra^{226}
1	0.5	22.6	562.2	564.4
2	0.5	22.6	562.2	564.4

Table 4.9 Meteorological data for Pathfinder Mines Shirley Basin Mill

(Docket Number: 40-6622)

JOINT FREQUENCY IN PERCENT, DIRECTION INDICATES AS THE WIND IS FROM

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	.0069	.0240	.0103	.0240	.0171	.0103	.0069	.0411	.0137	.0206	.0240	.0240	.0377	.0171	.0206	.0103	.3086
5.5	.0137	.0274	.0206	.0069	.0137	.0206	.0137	.0617	.0069	.0206	.0069	.0274	.0548	.0343	0.0090	.0240	.3498
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.0206	.0514	.0309	.0309	.0308	.0309	.0206	.1028	.0206	.0412	.0309	.0514	.0925	.0514	.0206	.0189	.6584
STABILITY CLASS 2																	
1.5	.0554	.0547	.0274	.0421	.0960	.0424	.0685	.0651	.0477	.0410	.0616	.0443	.1126	.0662	.0408	.0688	.9388
5.5	.0959	.1233	.0685	.0411	.1233	.1165	.1302	.1165	.2126	.1028	.1576	.1370	.1370	.0956	.0548	.1096	1.8228
10.0	.0685	.0617	.0805	.0411	.0617	.0206	.0548	.0274	.0548	.0685	[illegible]	.1096	.1781	.0685	.0754	.0822	1.1236
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.2198	.2397	.1764	.1243	.2810	.1795	.2515	.2090	.3649	.2123	.3016	.2911	.4277	.2046	.1510	.2562	3.8856
STABILITY CLASS 3																	
1.5	.0146	.0171	.0115	.0116	.0366	.0166	.0127	.0037	.0262	.0166	.0166	.0446	.0174	.0523	.0156	.0078	.4016
5.5	.0959	.1370	.0959	.1028	.1761	.0659	.1233	.0622	.1567	.0459	.0554	.1713	.2396	.1562	.0756	.0617	1.9128
10.0	.2535	.1490	.1576	.1713	.2329	.1914	.1233	.0822	.1233	.1407	.3699	.4939	.4727	.2261	.1648	.1516	3.1592
15.5	.0274	.0137	.0137	.0137	.0343	.0343	.0137	0.0000	.0343	.0459	.2655	.1713	.1914	.0343	.0411	.0685	.9915
21.5	0.0000	.0069	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0137	.0069	.0343	.0137	.0411	.0206	0.0000	0.0000	.1378
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0030	.0069	.0137	.0065	0.0000	0.0000	0.0000	.0274
ALL	.1954	.3559	.2787	.2996	.4619	.3406	.2730	.1481	.3502	.4160	.7311	1.0637	.9763	.4385	.3129	.2906	7.1668
STABILITY CLASS 4																	
1.5	.0792	.1053	.0854	.0741	.0598	.0592	.0548	.0268	.0548	.0319	.0411	.0510	.0679	.0816	.0616	.1004	1.0605
5.5	.5412	.5823	.4453	.3220	.4110	.3220	.1919	.1102	.3918	.3233	.2055	.3357	.3357	.3346	.1919	.4521	5.2338
10.0	1.1840	1.4249	1.0207	.8760	.9246	.4532	.3014	.1370	.2124	.6342	1.4160	2.1300	1.7466	.3413	.5206	.5061	14.0223
15.5	1.1097	1.4965	1.0275	.6504	1.0001	.5446	.1567	.0548	.3699	1.0826	4.5420	5.1993	1.9318	.0651	.5091	.4002	25.1001
21.5	.2804	.3768	.1713	.0617	.2261	.0822	.0411	.0137	.1761	2.6716	5.0075	2.2126	.9204	.4002	.2390	.1028	12.5956
28.0	.1024	.1028	.0214	0.0000	.0137	.0069	0.0000	0.0000	.0411	1.4747	2.2469	.9121	.5206	.1165	.0911	.0343	5.7065
ALL	3.2578	4.0788	2.7776	1.9859	2.6355	1.5115	.7874	.3625	1.4481	6.0216	15.4310	10.9037	5.5276	2.1186	1.5715	1.5944	61.6586
STABILITY CLASS 5																	
1.5	.3723	.1660	.1411	.1104	.1604	.1124	.0635	.0583	.1221	.1149	.1456	.2996	.3786	.4067	.2023	.2096	3.1947
5.5	1.1094	.6974	.6439	.5480	.6234	.3563	.3041	.1914	.3014	.3152	.5275	1.2741	.6140	.9865	.5942	.5933	10.4952
10.0	.3425	.3014	.2809	.2477	.4042	.3083	.1165	.0480	.0540	.0082	.0642	2.8221	1.9048	.2588	.7569	.2603	9.2155
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	1.8246	1.3656	1.0679	.9061	1.1884	.7770	.4861	.2962	.4781	.0318	1.7615	4.3968	4.6930	1.6510	1.3531	1.5142	26.4356
STABILITY CLASS 6																	
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	5.7182	6.0672	4.3295	3.3663	4.6176	2.8395	1.8212	1.1406	2.2121	9.5223	18.2861	16.7059	11.5110	4.6745	3.0151	3.6663	100.0030

Appendix 5

Shirley Basin Mill, Petrotomics
(Docket Number 40-6659)

Petrotomics' Shirley Basin Uranium Mill is located in a hilly area about 77 km (48 miles) south of Casper in the eastern Shirley Basin area of Wyoming. The mill capacity is 910 MT of ore per day. The tailings retention system currently consists of the main tailings pond [65 ha (160 acres)] and three catchment basins and emergency dams which collect and return lateral seepage or overflow from the tailings area.

Results

Table 5.1 lists the dose commitments at the nearby town of Shirley Basin and shows the impacts from inhalation and external exposure (direct exposure pathway), as well as impacts from vegetable and meat ingestion. This town had a population of 710 people as of 1970. Table 5.2 gives the breakdown of the dose commitments along the various pathways at both of the nearest locations of Shirley Basin (3.2 km S) and the Heward Ranch (8 km NE). Doses from meat ingestion due to grazing of cattle in the area are also provided. Tables 5.3 and 5.4 respectively display the concentrations on the ground and in the air of the parent radionuclides of interest (U-238, Th-230 and Ra-226) that contribute to the exposures presented in Table 5.1. These tables also indicate the specific mill activity and its contribution to the total concentrations. Table 5.5 presents the ground concentrations at the assumed meat ingestion exposure grazing location. (Concentrations in forage were assumed to be mostly the result of foliar deposition, with a smaller contribution from root uptake from the soil.)

Discussion

Based on the computer assessment as shown in Table 5.1, the Petrotomics facility is projected to be within compliance limits for 40 CFR Part 190, since the estimated bone and lung doses were both below 10 mrem. The NRC staff has made assumptions about exposure pathways and residence times in the mill environs which are conservative, yet reasonable, in light of the NRC's responsibility to maintain public safety (see Appendix 1 of this report). As additional environmental data become available, further determinations can be made concerning the environmental impact of this mill.

Assumptions for Computer Prediction

Table 5.6 presents the basic parameters and assumptions made in modeling the Petrotomics facility. Control factors, yellowcake emissions and tailings activities are presented with other parameters affecting the emission of radioactivity. Table 5.7 displays the emission (Curies/year) of the parent radionuclides in secular equilibrium from the transporting of ore to the grizzly up to the fine ore storage bins. From the rod mill crushing through the solvent extraction circuit, the process is wet and enclosed, and the NRC staff assumed only negligible radioactive emissions. Table 5.8 lists the tailings impoundment and radionuclide activity in the solid tailings (U-238 is

Table 5.1 Results of MILDOS computer code evaluation

Mill Name: Petrotomics Docket Number: 40-6659

Date of Evaluation: January 1981

Residence of individual(s) receiving maximum* dose: Shirley Basin (Town), 3.2 km S

**Direct Exposure Pathway (mrem):

Whole Body	0.168
Bone	4.23
Lung	9.05

Grazing location corresponding to maximum meat ingestion dose: 1.68 km NE

***Ingestion Pathway (mrem):

Whole body	0.528
Bone	5.52
Lung	0.528

Composite Pathway Dose Totals (mrem):

Whole Body	0.696
Bone	9.75
Lung	9.58

*Shirley Basin (Town) showed a 92% higher lung dose than the Heward Ranch, but showed a 0.2% lower bone dose.

**The direct exposure pathway is the sum of inhalation, and gamma radiation exposure due to ground deposition and cloud immersion.

***The ingestion pathway considers the maximum dose due to the ingestion of meat from locally grazed cattle, and ingestion of vegetables grown at the residence location.

Table 5.2 The 50-year adult dose commitments by pathway to each organ

Facility name: Petrotomics Docket number: 40-6659

Location	Pathway	Dose Commitments (mrem)		
		Whole body	Bone	Lung
Shirley Basin (Town) 3.2 km S	Inhalation	0.151	4.21	9.03
	Ground Exposure	0.017	0.017	0.017
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.184	1.96	0.184
Heward Ranch 8.0 km NE	Inhalation	0.092	2.55	4.29
	Ground Exposure	0.016	0.016	0.016
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.348	3.64	0.348
Grazing Site 1	Meat Ingestion	0.344	3.56	0.344
Grazing Site 2	Meat Ingestion	0.249	2.59	0.249
Grazing Site 3	Meat Ingestion	0.117	1.21	0.117
Grazing Site 4	Meat Ingestion	0.065	0.677	0.065
Grazing Site 5	Meat Ingestion	0.057	0.589	0.057

Table 5.3 Radionuclide concentrations projected to occur on ground at residence of individual receiving maximum dose

Facility name: Petrotomics | Docket number: 40-6659

Location of Maximum Individual: Shirley Basin (Town), 3.2 km S

Type of Particle	Mean Diameter, µm	Density, g/cm³	Radionuclide Concentrations, pCi/m²		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.678E+03	1.345E+01	2.672E+00
Ground Ore	1.0	2.4	9.693E+02	9.693E+02	9.673E+02
Coarse Windblown Ore or Tailings	5.0	2.4	1.194E+01	6.112E+02	6.119E+01
Coarse Windblown Ore or Tailings	35.0	2.4	1.237E+02	6.099E+02	6.107E+02

Table 5.4 Airborne radionuclide concentrations projected to occur at residence of individual receiving maximum dose

Facility name: Petrotomics | Docket number: 40-6659

Location of Maximum Individual: Shirley Basin (Town), 3.2 km S

Type of Particle	Mean Diameter, µm	Density, g/cm³	Radionuclide Concentrations, pCi/m³		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.475E-03	7.410E-06	1.475E-06
Ground Ore	1.0	2.4	5.341E-04	5.341E-04	5.341E-04
Coarse Windblown Ore or Tailings	5.0	2.4	6.578E-06	3.368E-05	3.379E-05
Coarse Windblown Ore or Tailings	35.0	2.4	7.730E-06	3.811E-05	3.823E-05

Table 5.5 Radionuclide concentrations projected to occur on the ground at grazing location corresponding to maximum meat ingestion dose

Facility name: Petrotomics

Docket number: 40-6659

Location of Maximum Meat Ingestion Pathway: 1.68 km NE

Type of Particle	Mean Diameter, μm.	Density, g/cm³	Radionuclide Concentrations, pCi/m²		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.333E+04	6.694E+01	1.330E+01
Ground Ore	1.0	2.4	4.826E+03	4.826E+03	4.816E+03
Coarse Windblown Ore or Tailings	5.0	2.4	4.847E+02	2.269E+03	2.271E+03
Coarse Windblown Ore or Tailings	35.0	2.4	6.384E+03	2.833E+04	2.836E+04

Table 5.6 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	0.155%
Secular equilibrium activity (in pCi/g) of U-238, Th-230, and Ra-226 in the ore	438.0
Annual ore processing rate	582,000 MT/year
Yellowcake production rate	863.0 MT/year
Product purity	94% U_3O_8
Amount of product released to atmosphere annually	0.863 MT/year
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	0.229 Ci/year
Thorium released in yellowcake emission	1.15×10^{-3} Ci/year
Radium released in yellowcake emission	2.29×10^{-4} Ci/year
Uncontrolled emission rates from any one mill stack or vent	See Table 5.7
Percent reduction factor from stack/vent emission control	See Table 5.7
Area of ore pad	22 acres
Reduction factor for ore pad	0.0%
Areas for tailings impoundments	
Tailings Pile 1	80 acres
Tailings Pile 2	80 acres
Reduction factor for tailings areas	80%

Table 5.6 (continued)

Parameter	Description
Recovery rate	90%
Activity of U-238, Th-230, and Ra-226 in solid tailings (pCi/g)	
U-238	43.8
Th-230	435.8
Ra-226	437.6
Length of grazing season	6 months
Fraction of stored cattle feed which is grown locally	0.0%
Fraction of cattle feed which is pasture grazing	100%
Acreage required to graze one animal unit (450kg) for one month	9.0 acres
Relative joint frequency of wind speed, direction, and stability class	Table 5.9
Atmospheric mixing height	598.2 meters

Table 5.7 Natural ore emissions

Mill Name: Petrotomics

Docket Number: 40-6659

Process Causing Emissions	Mass Loss Rate, lb/ton	Control Measures	Control Efficiency, %	Effective Mass Loss Rate, lb/ton	Annual Emissions, Ci/yr
Crushing and Grinding	0.2	Baghouse	95	0.01	.00319
Conveyor	0.1	Rain Hood	50	0.05	.0159
Dump to Grizzly	0.05	None	0	0.05	.0159
Ore Pad Handling and Unloading	0.15	None	0	0.15	.0478
TOTAL				TOTAL	.0829

Annual Mass Loss = (Effective Mass Loss Rate) ÷ 2000 · (Ore Throughput)

Activity Emission = (Annual Mass Loss) · (2.5) · (Ore Quality) ÷ 100 · (.2824 $\frac{Ci}{MT}$ of U_3O_8)

Table 5.8 Tailings pond parameters

Mill Name: Petrotomics Docket Number: 40-6659

Tailings Source Area Number	Area (km^2)	Activity Content of Tailings (pCi/g) U^{238}	Th^{230}	Ra^{226}
1	.325	43.8	435.8	437.6
2	.325	43.8	435.8	437.6

usually depleted at this point of the cycle). Table 5.9 is the wind frequency data, which provides the site-specific mechanism for transport of radioactivity to offsite locations. The meteorological data originates from Casper, Wyoming, which is 77 km away, but was the only available data for this region in Wyoming.

Table 5.9 Meteorological data for Petrotomics Mill

(Docket Number: 40-6659)

JOINT FREQUENCY IN PERCENT, DIRECTION INDICATES WHERE WIND IS FROM

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	.0069	.0240	.0103	.0240	.0171	.0103	.0069	.0411	.0137	.0206	.0240	.0240	.0377	.0171	.0206	.0103	.3086
5.5	.0137	.0274	.0206	.0069	.0137	.0206	.0137	.0617	.0069	.0206	.0069	.0274	.0549	.0343	0.0000	.0206	.3498
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.0206	.0514	.0309	.0309	.0308	.0309	.0206	.1028	.0206	.0412	.0309	.0514	.0925	.0514	.0206	.0309	.6584
STABILITY CLASS 2																	
1.5	.0554	.0507	.0374	.0421	.0966	.0428	.0665	.0651	.0977	.0410	.0610	.0685	.1126	.0402	.0208	.0688	.9386
5.5	.0959	.1233	.0685	.0411	.1233	.1165	.1302	.1165	.2124	.1028	.1576	.1370	.1370	.0959	.4548	.1096	2.0224
10.0	.0685	.0617	.0685	.0411	.0617	.0206	.0548	.0274	.0548	.0685	.0622	.1096	.1781	.0685	.0754	.0822	1.1236
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.2198	.2357	.1744	.1243	.2810	.1795	.2515	.2090	.3649	.2123	.2816	.2911	.4277	.2046	.1510	.2562	3.8846
STABILITY CLASS 3																	
1.5	.0186	.0133	.0115	.0116	.0366	.0180	.0127	.0037	.0282	.0186	.0186	.0292	.0174	.0273	.0144	.0028	.3014
5.5	.0659	.1370	.0659	.1028	.1781	.0659	.1233	.0822	.1507	.0459	.0459	.1713	.2398	.1302	.0754	.0617	1.9329
10.0	.2535	.1450	.1576	.1713	.2329	.1918	.1233	.0822	.1233	.1487	.3644	.6439	.4727	.2261	.1644	.1576	3.7562
15.5	.0274	.0137	.0137	.0137	.0343	.0343	.0137	0.0000	.0343	.0959	.2055	.1713	.1918	.0343	.0411	.0685	.9935
21.5	0.0000	.0069	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0137	.0069	.0343	.0343	.0411	.0206	0.0034	0.0006	.1578
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0069	.0069	.0137	.0064	0.0000	0.0005	0.0000	.0215
ALL	.3459	.3559	.2787	.2996	.4819	.3466	.2730	.1681	.3502	.4160	.7311	1.0637	.9762	.6365	.3179	.2856	7.1664
STABILITY CLASS 4																	
1.5	.0792	.1053	.0654	.0741	.0590	.0592	.0548	.0268	.0548	.0336	.0411	.0530	.0679	.0816	.0430	.1069	1.0205
5.5	.5412	.5823	.4453	.3220	.4110	.3220	.1918	.1102	.1918	.1233	.2055	.3357	.3357	.2398	.1439	.4521	4.9738
10.0	1.1440	1.4249	1.0207	.8768	.9249	.4932	.3014	.1370	.2124	.6302	1.4160	2.1384	1.7463	.5812	.5206	.5001	14.0225
15.5	1.1097	1.4865	1.6275	.6508	1.0001	.5480	.1967	.0548	.3649	3.0826	6.5420	5.1496	1.9314	.4453	.5091	.4042	25.1403
21.5	.2809	.3768	.1713	.0617	.2261	.0822	.0411	.0137	.1781	2.4716	5.0075	2.2126	.9240	.4632	.2398	.1028	12.9952
28.0	.1028	.1028	.0274	0.0000	.0137	.0069	0.0000	0.0000	.0411	1.4737	2.2469	.9727	.5206	.1165	.0411	.0343	5.7065
ALL	3.2578	4.0786	2.7770	1.9654	2.6355	1.5115	.7878	.3425	1.0481	8.0216	15.4610	10.9037	5.5276	2.3288	1.5715	1.5940	63.6586
STABILITY CLASS 5																	
1.5	.3723	.1600	.1431	.1104	.1608	.1124	.0635	.0583	.1221	.1124	.1898	.2956	.5766	.2607	.2023	.2606	3.1697
5.5	1.1094	.8974	.6439	.5480	.6234	.3563	.3083	.1914	.3016	.3152	.5275	3.2741	2.0140	.9865	.9042	.9933	13.1952
10.0	.3425	.3014	.2809	.2877	.4042	.3083	.1165	.0480	.0544	.4042	1.0842	2.8223	1.9444	.4042	.2466	.2603	9.2155
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	1.8246	1.3656	1.0679	.9461	1.1884	.7770	.4883	.2962	.4783	.8316	1.7615	4.3960	4.4950	1.6514	1.3531	1.5142	24.4354
STABILITY CLASS 6																	
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	5.7122	5.0872	4.3245	3.3863	4.6176	2.8395	1.8212	1.1406	2.2621	9.5223	18.2061	16.7659	11.5110	4.6745	3.4151	3.6863	100.0034

Appendix 6

Rio Algom Humeca Mill (Docket Number 40-8084)

The Rio Algom Humeca mine-mill complex is located in a valley in a mountainous region in Utah, about 48 km (30 miles) southeast of Moab. Ore is obtained from underground mines located adjacent to the mill. The mill capacity is about 680 MT of ore per day.

The tailings impoundment consists of two tailings ponds situated in a west-trending drainage area of slightly more than a square mile. At of the end of 1979, about 1.6×10^6 MT (1.8×10^6 ST) of ore had been processed at the mill, resulting in about 1.1×10^6 m^3 (940 acre-ft) of tailings contained in the two tailings ponds.

Results

Table 6.1 lists the dose commitments at the closest trailer camp residence and shows the impacts from inhalation and external exposure (the direct exposure pathway), as well as impacts from vegetable and meat ingestion. Table 6.2 gives the breakdown of the dose commitments along the various pathways at the locations of the closest trailer, the Redd Ranch (5.33 km NNE) and the Blankenagel Ranch (5.00 km WNW). Doses from meat ingestion due to grazing of cattle in the area are also provided. Table 6.1 and 6.2 also present parenthetical values which reflect a 90% reduction of ingestion of locally produced meats and a 95% reduction of locally produced vegetables. These adjustments appear to be reasonable in the western uranium mining and milling regions such as Wyoming and Utah. However, dairy animals are located at the local ranches, and Table 6.2 reflects that the total milk intake at the ranches is produced at the ranch locations. Information on the regional agricultural industry indicates that these adjustments are still reasonably conservative. Further explanation of the ingestion pathway methodology is presented in Appendix 1 of this report. Tables 6.3 and 6.4 respectively display the concentrations on the ground and in the air of the parent radionuclides of interest (U-238, Th-230, and Ra-226). These tables also indicate the specific mill activity and its contribution to the total concentrations. Table 6.5 presents the ground concentrations at the assumed meat ingestion exposure grazing location. (Concentrations in forage were assumed to be mostly the result of foliar deposition, with a smaller contribution from root uptake from the soil.)

Discussion

Based on the computer assessment as shown in Table 6.1, the Rio Algom Humeca facility is projected to comply with 40 CFR 190. The NRC staff has made assumptions about exposure pathways, and residence times in the mill environs which are conservative, yet reasonable, in light of the NRC's responsibility to maintain public safety. Tables 6.1 and 6.2 indicate that the two primary concerns are inhalation impacts to the lung and ingestion impacts to the bone to the nearest resident. The ingestion pathway contribution is two-thirds of the total bone exposure. However, adjustments to reflect the inherent

Table 6.1 Results of MILDOS computer code evaluation

Mill Name: Rio Algom Humeca　　　　Docket Number: 40-8084

Date of Evaluation: January 1981

Residence of individual(s) receiving maximum dose: Trailer Camp, 2.5 km N

*Direct Exposure Pathway (mrem):

Whole Body	0.395
Bone	9.65
Lung	23.4

Grazing location corresponding to maximum meat ingestion dose: 0.57 km SW

**Ingestion Pathway (mrem):

Whole body	1.82 (0.133)***
Bone	19.0 (1.38)
Lung	1.82 (0.133)

Composite Pathway Dose Totals (mrem):

Whole Body	2.22 (0.528)
Bone	28.7 (11.0)
Lung	25.2 (23.5)

*Direct exposure results from inhalation, and gamma radiation exposure due to ground deposition and cloud immersion.

**The ingestion pathway considers the maximum dose due to the ingestion of meat from locally grazed cattle, and the ingestion of vegetables grown at the residence location.

***Parenthetical values account for 5% of an individual's vegetable intake and 10% of an individual's meat intake being locally produced.

Table 6.2 50-year adult dose commitments by pathway to each organ

Facility name: Rio Algom Humeca

Docket number: 40-8084

Location	Pathway	Dose Commitments (mrem) Whole Body	Bone	Lung
Trailer Camp 2.5 km North	Inhalation	0.380	9.64	23.4
	Ground Exposure	0.015	0.015	0.015
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.993 (0.050)	10.04 (0.520)	0.993 (0.050)*
Redd Ranch 5.33 km NNE	Inhalation	0.072	1.93	4.06
	Ground Exposure	0.002	0.002	0.002
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.187 (0.009)*	1.96 (0.098)	0.187 (0.009)*
	Milk Ingestion	0.175	1.78	0.175
Blankenagel Ranch 5.00 km WNW	Inhalation	0.055	1.40	3.96
	Ground Exposure	0.002	0.002	0.002
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.034 (0.002)*	0.421 (0.021)*	0.034 (0.002)*
	Milk Ingestion	0.007	0.073	0.007
Grazing Point 1	Meat Ingestion	0.830 (0.083)**	8.55 (0.855)**	0.830 (0.083)**
Grazing Site 2	Meat Ingestion	0.584 (0.058)**	5.99 (0.599)**	0.584 (0.0584)**
Grazing Site 3	Meat Ingestion	0.418 (0.042)**	4.38 (0.438)**	0.418 (0.042)**
Grazing Site 4	Meat Ingestion	0.243 (0.024)**	2.50 (0.250)**	0.243 (0.024)**

*These values in parentheses are based on the 95% reduction due to local vegetable production and consumption.

**These values in parentheses are based on the 90% reduction due to local meat production and consumption.

Table 6.3 Radionuclide concentrations projected to occur on ground at residence of individual receiving maximum dose

Facility name: Rio Algom Humeca

Docket number: 40-8084

Location of Maximum Individual: Trailer Camp, 2.5 km North

Type of Particle	Mean Diameter, μm	Density, g/cm^3	Radionuclide Concentrations, pCi/m^2		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.265E+03	1.133E+01	2.264E+00
Ground Ore	1.0	2.4	2.899E+02	2.899E+02	2.898E+02
Coarse Windblown Ore or Tailings	5.0	2.4	1.402E+01	1.374E+02	1.379E+02
Coarse Windblown Ore or Tailings	35.0	2.4	1.635E+02	1.603E+03	1.609E+03

Table 6.4 Airborne radionuclide concentrations projected to occur at residence of individual receiving maximum dose

Facility name: Rio Algom Humeca

Docket number: 40-8084

Location of Maximum Individual: Trailer Camp, 2.50 km N

Type of Particle	Mean Diameter, μm.	Density, g/cm^3	Radionuclide Concentrations, pCi/m^3		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	5.900E-03	2.950E-05	5.900E-06
Ground Ore	1.0	2.4	7.551E-04	7.551E-04	7.551E-04
Coarse Windblown Ore or Tailings	5.0	2.4	3.651E-05	3.579E-04	3.593E-04
Coarse Windblown Ore or Tailings	35.0	2.4	4.830E-05	4.735E-04	4.753E-04

Table 6.5 Radionuclide concentrations projected to occur on the ground at grazing location corresponding to maximum meat ingestion dose

Facility name: Rio Algom Humeca

Docket number: 40-8084

Location of Maximum Meat Ingestion Pathway: 0.57 km SW

Type of Particle	Mean Diameter, μm.	Density, g/cm³	Radionuclide Concentrations, pCi/m² U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.740E+04	8.698E+01	1.739E+01
Ground Ore	1.0	2.4	1.398E+04	1.398E+04	1.397E+04
Coarse Windblown Ore or Tailings	5.0	2.4	3.191E+01	3.052E+02	3.062E+02
Coarse Windblown Ore or Tailings	35.0	2.4	4.427E+02	4.213E+03	4.228E+03

conservatism of the ingestion pathway, as described in the results section, show that this contribution is likely to be as little as 13% of the total impact. The lung inhalation exposure is still extremely close to the 40 CFR 140 Standard, and the results of the EMP will be used to resolve any uncertainties raised by the predictive assessment.

Among the assumptions adopted for all of the facilities is the reduction of emissions from tailings impoundments because of control measures. A standard degree of mitigation was pre-established as 20% of the available emission. However, there is some uncertainty that this level of mitigation is achieved at this particular site. The results of the environmental monitoring program will be used to resolve this and any other uncertainties in the initial 40 CFR 190 implementation efforts.

Assumptions for Computer Prediction

Table 6.6 presents the basic parameters and assumptions made in modeling the facility. Control factors, yellowcake emissions and tailings activities are presented with other parameters affecting the emission of radioactivity. Table 6.7 displays the emission (Curies/year) of the parent radionuclides in secular equilibrium from the unloading of ore, through to the grizzly and up to the fine ore storage bins. From the ball mill crushing to the yellowcake precipitation, the process is wet and enclosed, and the NRC staff assumed only negligible radioactive emissions. Table 6.8 is the wind frequency data, which provides the site-specific mechanism for transport of radioactivity to offsite locations. The meteorological data originates from Hanksville, Utah which, although 130 km away, provided the most compatible data available for this region in Utah.

Table 6.6 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	0.36%
Secular equilibrium activity (in pCi/g) of U-238, Th-230, and Ra-226 in the ore	1017
Annual ore processing rate	248,510 MT/year
Yellowcake production rate	604.6 MT/year
Product purity	90% U_3O_8
Amount of product released to atmosphere annually	0.895 MT/year
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	0.228 Ci/year

Table 6.6 (continued)

Parameter	Description
Thorium released in yellowcake emission	1.14×10^{-3} Ci/year
Radium to released in yellowcake emission	2.28×10^{-4} Ci/year
Uncontrolled emission rates from any one mill stack or vent	See Table 6.7
Percent reduction factor from stack/vent emission control	See Table 6.7
Area of ore pad	2.4 acres
Reduction factor for ore pad	50%
Area for tailings impoundment	127 acres
Reduction factor for tailings area	80%
Recovery rate	90%
Activity of U-238, Th-230, and Ra-226 in solid tailings (pCi/g)	
U-238	101.7
Th-230	1012
Ra-226	1016
Length of grazing season	6 months
Fraction of stored cattle feed which is grown locally	0.0
Fraction of cattle feed which is pasture grazing	100%
Acreage required to graze one animal unit (450kg) for one month	9.0 acres
Relative joint frequency of wind speed, direction, and stability class	Table 6.8
Atmospheric mixing height	537.9 meters

Table 6.7 Natural ore emissions

Mill Name: Rio Algom Humeca

Docket Number: 40-8084

Process Causing Emissions	Mass Loss Rate, lb/ton	Control Measures	Control Efficiency, %	Effective Mass Loss Rate, lb/ton	Annual Emissions, Ci/yr
Coarse Ore Bin	.05	Dust Collector	95%	.0025	.00079
Transfer (2)	.2	Dust Collector	95%	.01	.00316
Crusher	.2	Dust Collector	95%	.01	.00316
Dump to Grizzly	.05	Water Spraying	50%	.025	.00790
Conveyors (2)	.2	Rain Coverhoods	50%	.1	.03159
Fine Ore Bin and Handling	.05	None	0%	.05	.01580
Ore Pad Handling	.15	Water Spraying	50%	.075	.02369
				TOTAL	.08609

Annual Mass Loss = (Mass Loss Rate) ÷ 2000 · (Ore Throughput)

Activity Emission = (Annual Mass Loss) · (2.5) · (Ore Quality) ÷ 100 · (.2824 $\frac{Ci}{MT}$ of U_3O_8)

Table 6.8 Meteorological data for Rio Algom Humeca Mill

(Docket Number: 40-8084)

JOINT FREQUENCY IN PERCENT, DIRECTION INDICATES WHERE WIND IS FROM. [illegible]

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STABILITY CLASS 2																	
1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STABILITY CLASS 3																	
1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STABILITY CLASS 4																	
1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STABILITY CLASS 5																	
1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STABILITY CLASS 6																	
1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.0000

Appendix 7

Exxon Minerals Highland Mill
(Docket Number 40-8102)

Exxon's Highland mine and mill complex is in an area of rolling hills and stream valleys 97 km (60 miles) northeast of Casper, Wyoming in the Powder River Basin. The uranium ore processed at the mill is currently extracted from Exxon's surface mines and underground mine on the Highland property. The mill also produces uranium concentrate from solutions and slurries containing uranium recovered from tailings solutions, and from a pilot in situ leaching process operated at Highland. The Highland mill processes approximately 1,600,000 MT per year of ore. The tailings pond covers an area of about 70 ha (170 acres).

Results

Table 7.1 lists the dose commitments at the Fowler Ranch. Moreover, Table 7.1 shows the impacts from inhalation and external exposure (the direct exposure pathway), as well as impacts from vegetable and meat ingestion. Table 7.2 gives the breakdown of the dose commitments along the various pathways at the nearest locations, which are the Fowler Ranch (4.3 km NE) and the Golden Eagle Mine (5.5 km WNW). Doses from meat ingestion due to grazing of cattle in the area are also provided. Tables 7.3 and 7.4 respectively display the concentrations on the ground and in the air of the parent radionuclides of interest (U-238, Th-230, and Ra-226) at the Fowler Ranch. These tables also indicate the specific mill activity and its contribution to the total concentrations. Table 7.5 presents the ground concentrations at the assumed meat ingestion exposure grazing location. (Concentrations in forage were assumed to be mostly the result of foliar deposition, with a smaller contribution from root uptake from the soil.)

Discussion

Based on the computer assessment as shown in Table 7.1, the Exxon Minerals Highland facility initially appears to exceed compliance limits for 40 CFR Part 190 primarily due to the bone dose commitment. However, the contributions from inhalation, vegetable ingestion, and meat ingestion were respectively 12% (5.55 mrem), 6% (2.69 mrem), and 83% (39.3 mrem) of the total bone dose commitment. County estimates in the Gas Hills region of Wyoming indicated that less than 10% of any resident's meat intake is locally produced. Should the same estimate be valid in Converse County, the total bone dose commitment would decrease to 12.2 mrem, as opposed to the 47.6 mrem estimated. The estimated dose commitments from ingestion (see Table 7.2) are based on the assumption that 100% of an individual's meat and vegetable intake is locally produced. Parenthetical values in Tables 7.1 and 7.2 reflect the 90% reduction factor in the meat ingestion pathway. It is unlikely that an individual's meat intake is totally supplied by local meat production. Based on this 90% reduction, the Exxon Highland facility would then comply with the 40 CFR 190 Standard. An explanation of the methodology used in the ingestion pathway portion of the predictive assessment is presented in Appendix I of this report. The NRC

Table 7.1 Results of MILDOS computer code evaluation

Mill Name: Exxon Minerals Highland Docket Number: 40-8102

Date of Evaluation: January 1981

Residence of individual(s) receiving maximum dose: Fowler Ranch, 4.3 km NE

*Direct Exposure Pathway (mrem):

Whole Body	0.208
Bone	5.55
Lung	13.3

Grazing location corresponding to maximum meat ingestion dose: 3.28 km E

**Ingestion Pathway (mrem):

Whole body	4.12 (0.639)***
Bone	42.0 (6.62)
Lung	4.12 (0.639)

Composite Pathway Dose Totals (mrem):

Whole Body	4.33 (0.847)
Bone	47.6 (12.2)
Lung	17.4 (13.9)

*The direct exposure pathway is the sum of inhalation, and gamma radiation exposure due to ground deposition and cloud immersion.

**The ingestion pathway considers the maximum dose due to the ingestion of meat from locally grazed cattle and ingestion of vegetables grown at the residence location.

***Parenthetical values account for an individual consuming no more than 10% of the locally produced meat.

Table 7.2 50-year adult dose commitments by pathway to each organ

Facility name: Exxon Minerals Highland   Docket number: 40-8102

Location	Pathway	Dose Commitments (mrem)		
		Whole Body	Bone	Lung
Fowler Ranch 4.3 km NE	Inhalation	0.207	5.55	13.3
	Ground Exposure	0.006	0.006	0.006
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.252	2.69	0.252
Golden Eagle Uranium Mine 5.54 km WNW	Inhalation	0.111	2.97	7.27
	Ground Exposure	0.003	0.003	0.003
	Cloud Exposure	negl.	negl.	negl.
	Vegetable Ingestion	0.108	1.16	0.108
Grazing Site 1	Meat Ingestion	3.87 (0.387)*	39.3 (3.93)	3.87 (0.387)
Grazing Site 2	Meat Ingestion	2.53 (0.253)	25.7 (2.57)	2.53 (0.253)
Grazing Site 3	Meat Ingestion	0.438 (0.044)	4.58 (0.458)	0.438 (0.044)
Grazing Site 4	Meat Ingestion	0.409 (0.041)	4.17 (0.417)	0.409 (0.041)
Grazing Site 5	Meat Ingestion	0.149 (0.015)	1.54 (0.154)	0.149 (0.015)
Grazing Site 6	Meat Ingestion	0.108 (0.011)	1.11 (0.111)	0.108 (0.011)

*Parenthetical values represent a 90% reduction factor due to individuals consuming only 10% of the locally produced meat.

Table 7.3 Radionuclide concentrations projected to occur on ground at residence of individual receiving maximum dose

Facility name: Exxon Minerals Highland

Docket number: 40-8102

Location of Maximum Individual: Fowler Ranch, 4.3 km NE

Type of Particle	Mean Diameter, μm.	Density, g/cm^3	Radionuclide Concentrations, pCi/m^2		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	1.058E+03	5.299E+00	1.059E+00
Ground Ore	1.0	2.4	2.484E+02	2.484E+02	2.483E+02
Coarse Windblown Ore or Tailings	5.0	2.4	8.744E+00	1.933E+01	1.937E+01
Coarse Windblown Ore or Tailings	35.0	2.4	1.129E+02	2.337E+02	2.341E+02

Table 7.4 Airborne radionuclide concentrations projected to occur at residence of individual receiving maximum dose

Facility name: Exxon Minerals Highland

Docket number: 40-8102

Location of Maximum Individual: Fowler Ranch, 4.3 km NE

Type of Particle	Mean Diameter, μm.	Density, g/cm³	Radionuclide Concentrations, pCi/m³ U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.757E-03	1.380E-05	2.761E-06
Ground Ore	1.0	2.4	6.471E-04	6.471E-04	6.471E-04
Coarse Windblown Ore or Tailings	5.0	2.4	2.278E-05	5.035E-05	5.047E-05
Coarse Windblown Ore or Tailings	35.0	2.4	3.334E-05	6.902E-05	6.917E-05

Table 7.5 Radionuclide concentrations projected to occur on the ground at grazing location corresponding to maximum meat ingestion dose

Facility name: Exxon Minerals Highland

Docket number: 40-8102

Location of Maximum Meat Ingestion Pathway: 3.28 km E

Type of Particle	Mean Diameter, μm.	Density g/cm³	Radionuclide Concentrations, pCi/m²		
			U^{238}	Th^{230}	Ra^{226}
Yellowcake Dust	1.0	8.9	2.807E+03	1.405E+01	2.809E+00
Ground Ore	1.0	2.4	6.811E+02	6.811E+02	6.808E+02
Coarse Windblown Ore or Tailings	5.0	2.4	1.919E+02	4.565E+03	4.582E+03
Coarse Windblown Ore or Tailings	35.0	2.4	3.439E+03	8.281E+04	8.312E+04

staff has made assumptions about exposure pathways, and residence times in the mill environs which are conservative, yet reasonable, in light of the NRC's responsibility to maintain public safety. As additional environmental data become available, further determinations can be made concerning the environmental impact of this mill.

Assumptions for Computer Prediction

Table 7.6 presents the basic parameters and assumptions made in modeling the Exxon Minerals Highland facility. Control factors, yellowcake emissions and tailings activities are presented with other parameters affecting the emission of radioactivity. Table 7.7 displays the emission (Curies/year) of the parent radionuclides in secular equilibrium from the unloading of ore, through to the grizzly and up to the fine ore storage bins. From the rod mill crushing to the yellowcake precipitation, the process is wet and enclosed, and the NRC staff assumes only negligible radioactive emissions. Table 7.8 is the wind frequency data, which provides the site-specific mechanism for transport of radioactivity to offsite locations. The meteorological data originates from Bear Creek, Wyoming which is 20 km away, but was compatible to wind profiles taken at the site.

Table 7.6 Basic parameters used for MILDOS input

Parameter	Description
Average ore grade	0.16%
Secular equilibrium activity (in pCi/g) of U-238, Th-230, and Ra-226 in the ore	460
Annual ore processing rate	1,610,300 MT/year
Yellowcake production rate	2980 MT/year
Product purity	95% U_3O_8
Amount of product released to atmosphere annually	2.980 MT/year
Emission activity (in Ci/year) of U-238 released to the atmosphere from yellowcake operations	0.799 Ci/year
Thorium released in yellowcake emission	0.004 Ci/year
Radium released in yellowcake emission	0.0008 Ci/year
Uncontrolled emission rates from any one mill stack or vent	See Table 7.7

Table 7.6 (continued)

Parameter	Description
Percent reduction factor from stack/vent emission control	See Table 7.7
Area of ore pad	20 acres
Reduction factor for ore pad	0.0%
Areas for tailings impoundments	170 acres
Reduction factor for tailings area	80%
Recovery rate	96%
Activity of U-238, Th-230, and Ra-226 in solid tailings (pCi/g)	
U-238	18.4
Th-230	457.7
Ra-226	459.5
Length of grazing season	6 months
Fraction of stored cattle feed which is grown locally	0.0
Fraction of cattle feed which is pasture grazing	100%
Acreage required to graze one animal unit (450kg) for one month	9.0 acres
Relative joint frequency of wind speed, direction, and stability class	Table 7.8
Atmospheric mixing height	528.0 meters

Table 7.7 Natural ore emissions

Mill Name: Exxon Minerals Highland

Docket Number: 40-8102

Process Causing Emissions	Mass Loss Rate, lb/ton	Control Measures	Control Efficiency, %	Effective Mass Loss Rate, lb/ton	Annual Emissions, Ci/yr
Crusher	.2	Vane Wet Scrubber	95%	.01	.00909
Dump to Grizzly	.05	None	0%	.05	.04547
Conveyors	.1	Wet Scrubber	95%	.005	.00455
Fine Ore Bin and Handling	.15	Wet Scrubber	95%	.0075	.00682
Ore Pad Handling	.15	None	0%	.15	.13642
				TOTAL	.20235

Annual Mass Loss = (Effective Mass Loss Rate) ÷ 2000 · (Ore Throughput)

Activity Emission = (Annual Mass Loss) · (2.5) · (Ore Quality) ÷ 100 · $(.2824 \frac{Ci}{MT}$ of $U_3O_8)$

Table 7.8 Meteorlogical data for Exxon Minerals Higland Mill

(Docket Number: 40-8102)

JOINT FREQUENCY IN PERCENT, DIRECTION INDICATES WHERE THE WIND IS FROM

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	0.0000	0.0000	.0168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0168
5.5	.0168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0336
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.0168	0.0000	.0168	0.0000	0.0000	0.0000	0.0000	0.0000	.0168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0504
STABILITY CLASS 2																	
1.5	.0671	.0349	0.0000	0.0000	.0161	.0510	.0349	.0430	.0161	.0161	0.0000	.0510	.0161	.0349	.0161	.0670	.5003
5.5	.2685	.0349	.0161	.1342	.0349	.1020	.2012	.1600	.2012	.1503	.0671	.1020	.0671	.1690	.0832	.0830	1.8386
10.0	.0349	0.0000	0.0000	0.0000	0.0003	.0161	0.0000	0.0000	0.0000	.0161	.0161	0.0000	.0349	.0349	0.0002	0.0000	.1510
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.3061	.0698	.0161	.1342	.0510	.1691	.2361	.2030	.2173	.1825	.0832	.1530	.1181	.2380	.0993	.1500	2.5179
STABILITY CLASS 3																	
1.5	.0144	.0144	0.0006	0.0000	.0144	.0646	.0502	.0860	.0646	.0359	.0359	.0144	.0502	.0359	.0359	.0646	.5380
5.5	.2153	.0144	.0359	.0144	.0861	.2153	.2656	.2519	.1148	.1651	.2369	.2656	.2656	.2512	.2656	.1148	3.1168
10.0	.5527	0.0000	0.0000	.0144	.1005	.1651	.3154	.1560	.1507	.1507	.1364	.1866	.3373	.2010	.1866	.0646	3.1118
15.5	.1651	0.0000	.0144	.0144	.0144	.0861	.0502	.0359	.0502	.0144	.0359	.1005	.0502	0.0000	.0144	0.0000	.6452
21.5	.0502	0.0000	0.0000	0.0000	0.0000	0.0000	.0646	.0144	0.0000	.0359	.0646	.0861	0.0000	0.0000	0.0000	0.0000	.3158
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0144	0.0000	0.0000	.0144	0.0000	.0359	.0502	0.0000	0.0000	0.0000	.1149
ALL	.9977	.0288	.0503	.0432	.2154	.5311	.7604	.5167	.3803	.4164	.5097	.6681	.7535	.4881	.5025	.2440	7.1280
STABILITY CLASS 4																	
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	.0758	.0758	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.1516
5.5	.2273	.1515	.0758	.1515	.1515	.3031	.3788	.2273	.3031	.3031	.1515	.3031	.3788	.5304	.3031	.1516	4.0906
10.0	.6061	.3788	.3031	.3788	.6061	.9850	1.0607	.7576	.5304	.7577	.6819	1.0604	1.7426	1.5911	1.2123	.0540	13.7125
15.5	1.1619	.6061	.3788	.5304	.5304	1.5911	1.6669	.7576	.6334	1.2880	2.3503	5.3795	3.5611	3.7126	2.7761	1.2120	28.4475
21.5	.3304	.1515	.1515	0.0000	.3031	.5304	.3788	.1516	.2273	.3794	1.4948	6.0716	1.2880	1.6669	1.5911	.7576	16.4976
28.0	.2273	.0758	0.0000	0.0000	.0758	.1515	.1515	0.0000	0.0000	.2273	1.4853	5.7563	.7577	.6334	1.5153	1.2880	14.3672
ALL	2.5760	1.3637	.9092	1.0607	1.6669	3.6364	3.7125	1.6920	1.6982	2.9550	6.7113	17.6050	7.7262	6.3144	7.3979	3.4640	79.6076
STABILITY CLASS 5																	
1.5	0.0000	0.0000	.0376	0.0000	.0470	.0470	.0657	.0188	.0376	.0376	.0188	0.0000	.0188	.0376	0.0000	.0188	.3851
5.5	.1193	.1598	.0845	.0470	.1127	.1972	.3663	.3190	.0508	.2164	.2723	.4696	.6010	.4226	.3475	.1970	4.1104
10.0	.2160	.0470	.0657	.1319	.1127	.2516	.2723	.2530	.1972	.1193	.1972	.6010	.7231	.5541	.3193	.1120	4.7750
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.5353	.2160	.1878	.1785	.2724	.4970	.7043	.5906	.6856	.5917	.4861	[illegible]	1.3429	1.0183	.6666	.3278	9.3693
STABILITY CLASS 6																	
1.5	.1193	.0986	.0345	.0345	.1331	.1020	.1676	.1670	.1331	.1161	[illegible]	.0986	.1520	.1331	.0986	.0300	1.8869
5.5	.1629	.0986	.0690	.1026	.1331	.2515	.2021	.1670	.2021	.1331	.2021	.2367	.6191	.3351	.1676	.0693	3.0311
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.3047	[illegible]	.1035	.2368	.2662	.3539	.3697	.3340	.3352	.2516	.3045	.4733	.5719	.4666	.2662	.0930	4.9180
ALL	[illegible]	[illegible]	1.2687	1.6335	2.4719	5.2[illegible]	5.7630	3.7134	3.5298	4.1[illegible]	10.17[illegible]	20.[illegible]	10.[illegible]	10.5460	8.7327	6.4880	99.8359

COMPLIANCE DETERMINATION PROCEDURES FOR ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR URANIUM RECOVERY FACILITIES

40 CFR 190

U. S. Nuclear Regulatory Commission

Division of Waste Management

Uranium Recovery Licensing Branch

December, 1980

Title: Compliance Determination Procedures for Environmental Radiation Protection Standards for Uranium Recovery Facilities - 40 CFR 190

Background

Under Title 40 Code of Federal Regulations Part 190 - Subchapter F - Radiation Protection Programs, the U.S. Environmental Protection Agency (EPA) promulgated "Environmental Radiation Protection Standards for Nuclear Power Operations" which provides limits for the radiation doses received by members of the public in the general environment as the result of operations which are part of the nuclear fuel cycle. Effective December 1, 1980, each uranium milling facility* shall conduct its operations in such a manner to assure that the annual radiation dose equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public is not exceeded. However, the dose from radon and its daughters is excluded from these doses. The following discussion briefly describes the Nuclear Regulatory Commission's (NRC) program for compliance determination for uranium recovery facilities. In April, 1980, the NRC published a proposed amendment to 10 CFR Part 20 "Environmental Radiation Protection Standards for Nuclear Power Operations" and will shortly finalize this amendment which requires that a NRC licensee shall comply with 40 CFR 190. This program is also meant to serve as guidance for the Agreement States in their implementation of 40 CFR 190.

As illustrated by radiological assessments performed in the uranium milling generic environmental impact statement (GEIS), 40 CFR 190 compliance will be achieved only by strict emission controls at the mill. The most significant sources of emissions are the tailings ponds/piles and the yellowcake dryer stacks. The NRC has made strict emission control a specific license condition in its licensing activities over the past several years; and it has been an NRC requirement that exposure limits be met by emission controls to the maximum extent reasonably achievable. Such emission control requirements are contained in the May, 1977 NRC staff position on "Tailings Management Performance Objectives" and in the final regulations on uranium milling issued in the Federal Register on October 3, 1980. A copy of the criteria in these regulations covering emission controls is attached as Appendix B. Certainly land use control, e.g., expanding the buffer zone around a mill site, cannot exclusively be used as a substitute for reducing actual emissions from the various milling processes. The primary means of meeting exposure limits must be by emission control.

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*All uranium extraction facilities; to include mills, in-situ operations and heap leach facilities. R&D facilities are not included here since initial assessments indicate that their size and potential radiological impact are insignificant; e.g., R&D in-situ operations in general have no airborne particulate releases.) However, the Edgemont mill site and the other sites selected for remedial actions for the cleanup of mill tailings (i.e., at abandoned mill sites or off-site areas where tailings have been used) have been excluded from 40 CFR 190 compliance during the remedial action work phase.

There are inherent problems in accurately determining source terms, particularly from large area sources such as the tailings impoundments. Also, there are significant uncertainties in the atmospheric transport models used to compute airborne radioactivity concentrations given a source term, particularly where there is irregular terrain. Therefore, the primary means of determining compliance must be by measurements made at the point of receptor and the procedures outlined below reflect this. On the other hand, compliance cannot reasonably be determined and corrective action taken where necessary, by inflexibly and rigidly considering point of receptor data alone. Therefore, environmental measurements at other locations near the mill and at background locations, effluent sampling, meteorologic data, and other similar information must be available to supplement point of receptor data. Such supplemental information is required most in cases where computed doses approach or exceed the limit. Other monitoring data will be necessary, for example, to screen out effects of mines that may be nearby and may be contributing to dose.

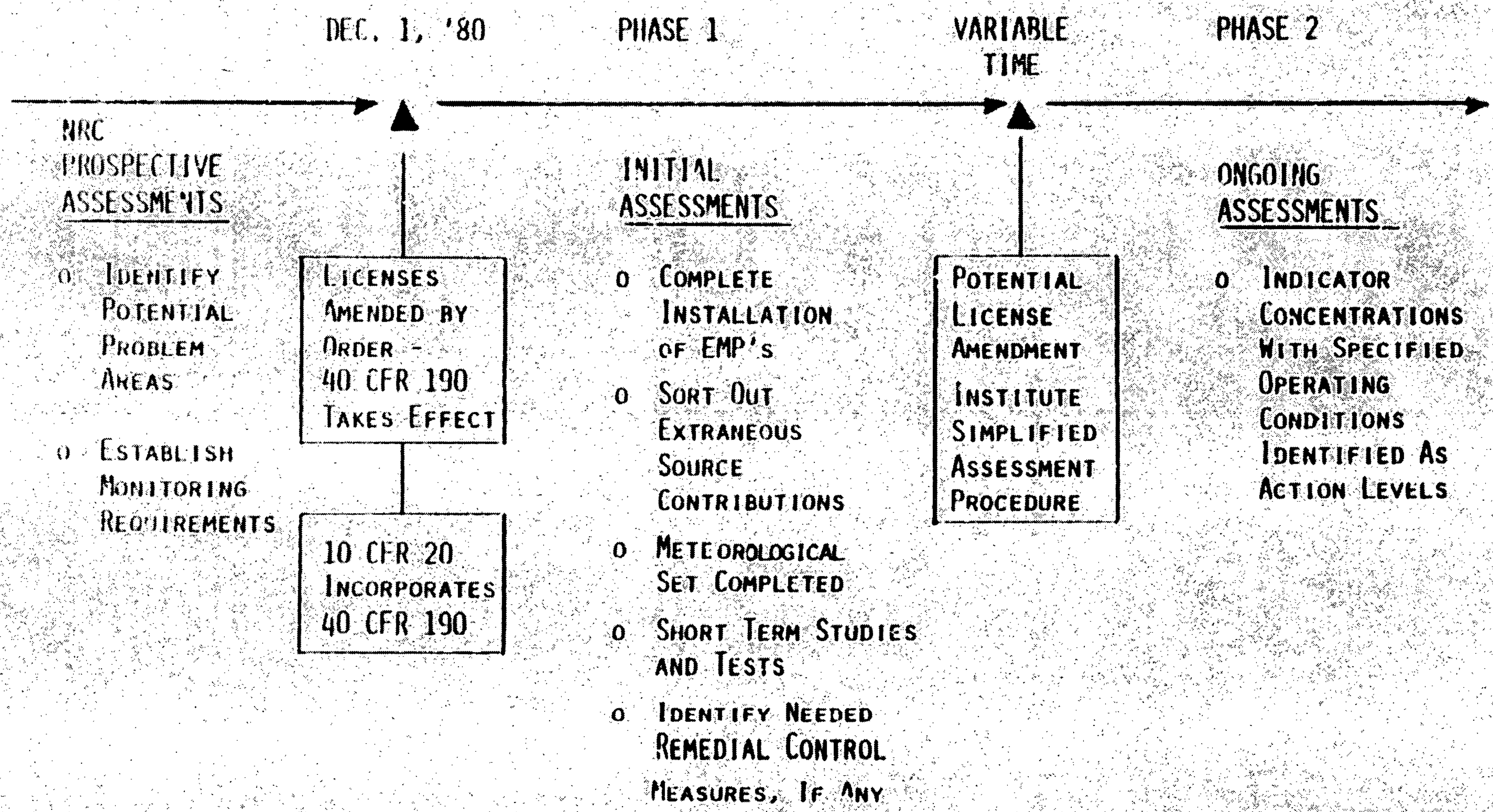
By no means will the mere assertion that the mill operations utilize emission controls suffice to show compliance to 40 CFR 190 exposure limits. The licensee must provide some supportable dose assessments based on actual environmental monitoring data which are compatible with the procedures discussed below.

Procedure

The NRC staff will implement 40 CFR 190 in a phased fashion as shown in Figure 1. Eventually a standardized procedure which will be used to assess compliance subsequent to the establishment of each licensee's Environmental Monitoring Program (EMP) will be established. It will realistically require as much as a year's worth of effluent and environmental monitoring (Phase 1 of Figure 1), however, to firmly establish whether compliance exists at mills which are close to the limit or where there are significant nearby sources of radioactive emissions such as mines, which are not covered by the standard. Much of this time will be spent on the fine tuning of the monitoring and analysis program that is normally required in setting up such programs to assure they are operating properly and producing reliable data. It will also take some time to sort out the contributions being made by other sources. This may require some short-term, special environmental measurements. Special studies of the effectiveness of selected emission control measures may be required. These evaluations may be supplemented by computer assessments as needed and appropriate.

Eventually, under Phase 2 it is anticipated that concentration and/or dose action levels (which may even be higher than 25 millirems accounting for contributions from other sources) will be established, in combination with specific control measures and levels, as the threshold for determining compliance with the standard. This will reduce costs of implementation, eliminate uncertainty on the part of the licensee, regulatory agency and the public (particularly in cases where there are significant extraneous sources), and assure that the need for remedial action is identified most expeditiously if it exists.

FIGURE 1
PHASED IMPLEMENTATION



Before environmental monitoring data is available, which is the situation in licensing of new facilities or in authorizing significant modification to existing ones, predictive models must be utilized to evaluate the potential impacts of the prospective new operations. Use of predictive models, in addition to consideration of what limited environmental data exists, is also being used by the staff in the initial 40 CFR 190 implementation efforts in December of 1980. Predictive modeling assessments of radioactivity concentrations to which nearby individuals may be exposed, involve making numerous assumptions and simplifications about important, but frequently uncertain, factors such as mill releases and atmospheric transport; for this reason, as discussed above, actual compliance determination will be based on environmental monitoring data which indicate directly what such concentrations are. Predictive models, however, are necessary and valuable tools in evaluating what emission controls are likely necessary, in identifying potential problem areas, and in establishing environmental monitoring requirements.

The following describes the procedures which shall be followed in (A) determining compliance with 40 CFR 190 based on environmental monitoring data, and (B) assessing proposed operations in term of their ability to meet 40 CFR 190.

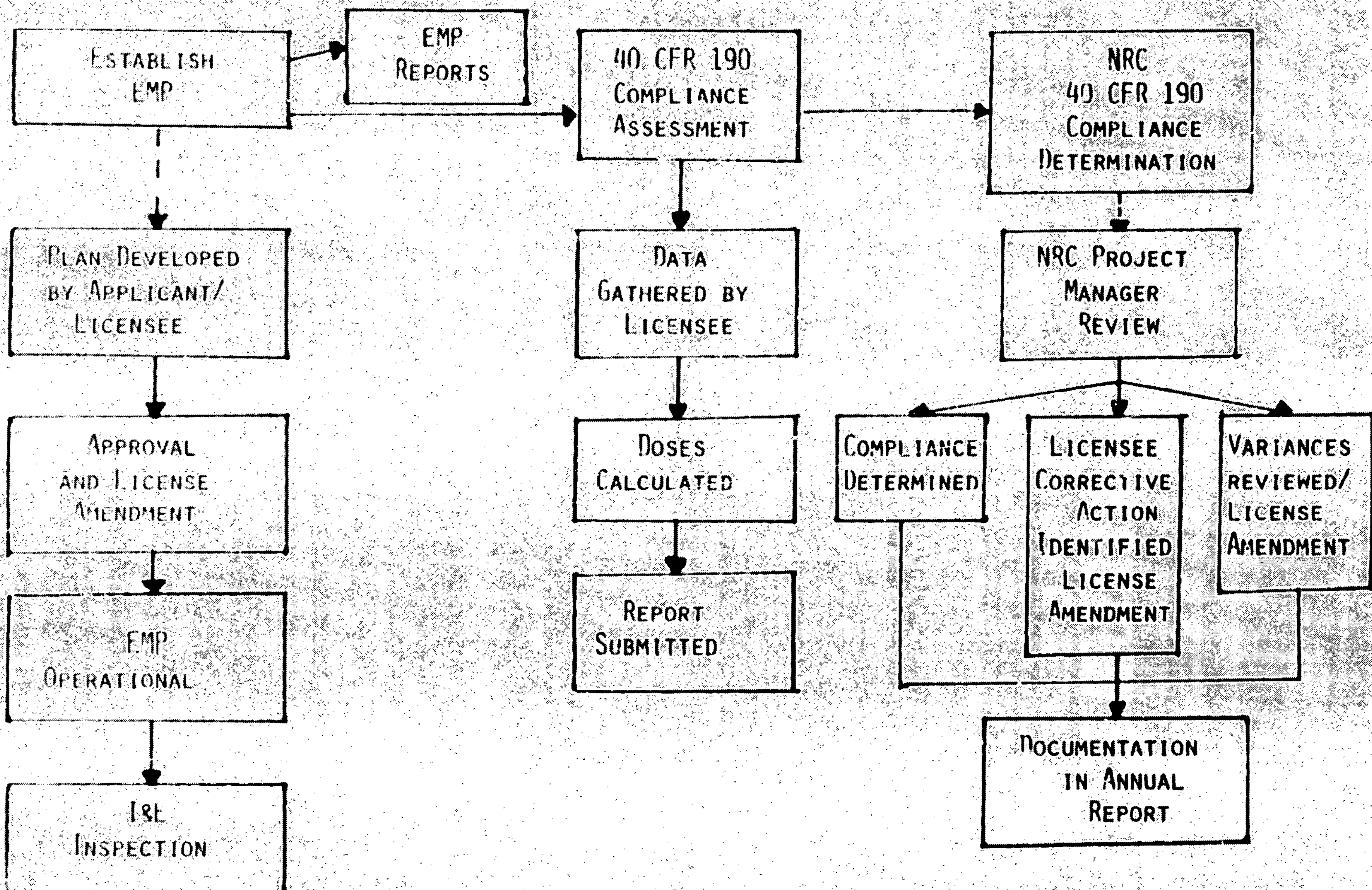
A. <u>Assessment of Actual Environmental Monitoring Data</u>

Figure 2 - "40 CFR 190 Compliance Determination Procedure" shows a diagram of the various steps to be followed to ultimately assure compliance to 40 CFR 190 for all licensing applications.

1. Each licensee shall establish an Environmental Monitoring Program (EMP) consistent with NRC's Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (April 1980). This document provides specific details for both a pre-operational and the operational monitoring programs which are considered adequate by the staff to obtain the necessary information to be used by the licensee to estimate the maximum potential annual radiation dose to any member of the general public as a result of actually measured mill effluent releases. In order to establish such an acceptable EMP, each applicant/licensee shall be required to:

   a. Develop an EMP and submit a plan to the NRC for review and approval. Such a plan shall include specific details of the number, location, collection method (i.e., equipment), sampling frequency and analysis information for all sample types (e.g., air particulate, radon/WL, stack samples, surface and ground waters, vegetation, food, fish, soil, and direct radiation). For each site (including existing mills), at least one year of site specific meteorological data; e.g., wind speed and direction, stability class, etc., shall be collected, summarized, and reported. A site map, including all affected off-site areas, showing each point of sample collection shall

Figure 2
40 CFR 190
Compliance Determination Procedure
(Based on actual environmental monitoring data)



also be provided. Participation in a Quality Assurance Program (QAP) as described in NRC's Regulatory Guide 4.15, "Quality Assurance Programs for Radiological Monitoring Programs (Normal Operations) -Effluent Streams and the Environment" (February 1979) shall also be discussed in the EMP plan.

b. Upon NRC's review and approval, the EMP shall be added to the license and any subsequent change or modification of the approved EMP shall require that a specific license amendment be initiated by the licensee.

c. The EMP plan shall provide a time schedule providing the date when each phase of the EMP will become operational. For new license applicants, at least one year of pre-operational monitoring shall be required. For existing facilities, a realistic time schedule shall be implemented; however, all phases of the EMP shall be operational within 120 days of NRC's approval of the EMP plan.

d. The NRC's Office of Inspection and Enforcement shall conduct periodic on-site inspections of both the actual environmental monitoring systems/locations, as well as all reports and records of such an EMP to ensure that the actual operations of the EMP are within the approved EMP license condition.

2. Each licensee shall provide an EMP report every six months, as required in 10 CFR 40.65, "Effluent Monitoring Reporting Requirements." The report should contain the specific information as outlined in Section 7 "Recording and Reporting Results" of NRC's Regulatory Guide 4.14, supra.

3. As a license condition, each license shall be required to submit, in conjunction with its every six months EMP report (EMPR), its own 40 CFR 190 compliance assessment for NRC review and action, as described below.

a. Such an assessment shall be based on data gathered by the licensee from the approved EMP as discussed above. Such data gathering shall include a semiannual survey of land use (i.e., residences, grazing, water wells, etc.) in the area within 8 km (5 miles) of the mill. Any difference in land use from that previously reported shall be discussed and evaluated with respect to 40 CFR 190 compliance. In order to minimize records keeping and formal reporting requirements, while still maintaining a reasonable and timely review of the EMP, annual averages based on the immediate past two consecutive six month reporting periods shall be used for the compliance assessment and reporting requirements.

b. Dose evaluation using site specific input parameters shall be completed using the standardized procedures delineated in Attachment A - "Dose Calculational Guidance", which are based on NRC's draft Regulatory Guide RH#802-4, "Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations". These attached tables are provided to allow the rapid dose calculational assessment of environmental monitoring data. Variations in specific assumptions made in Attachment A will be considered by the staff upon request. Also, it is permissible to subtract out the contribution from background and extraneous sources as determined from measured concentrations at background locations.

c. As necessary, a licensee shall indicate in the report what corrective action is being taken if non-compliance is determined. Each licensee shall complete its initial 40 CFR 190 compliance assessment and shall submit its EMP report for NRC review and approval prior to July 1, 1981; and subsequently within 60 days after January 1 and July 1 of each year thereafter, so long as the license is active.

4. Once each year, the NRC shall review and complete its own independent determination of each licensee's EMPR and 40 CFR 190 compliance assessment. Such a review shall consider the influence of extraneous sources (e.g., mining and transportation ac vities) and any anomalous data (e.g., the indication of e neous data generated during sample collection or sample analysis).

a. The NRC Project Manager (PM) shall review all submittals, and shall primarily be responsible for all approvals, license amendments and verification of 40 CFR 190 compliance.

i. Upon determination of compliance to 40 CFR 190, the PM will document such findings via a brief Memorandum to File (standardized form memo) for the subject license within 30 days of receipt of reports submitted under 3(c).

ii. Upon determination of non-compliance to 40 CFR 190, the PM shall assure that the licensee take any necessary corrective actions and shall issue specific license amendments as required to accomplish this. This may require differentiating extraneous sources such as background, mining and transportation activities, obtaining site specific meteorological data, conducting short-term studies, etc. as shown in Phase 1 of Figure 1 above.

iii. The PM shall review any variance request per 40 CFR 190.11, and shall initiate appropriate licensing action as required. The EPA shall be notified whenever a variance is granted.

iv. The WMUR PM for 40 CFR 190 Compliance assessment shall issue a brief annual report summarizing the results of the individual license compliance reviews. This report shall also consider the cumulative dose to any member of the population due to exposure from releases from multiple mill facilities in the general area. The EPA shall be provided with a copy of this summary report for their review and comment.

5. The PM shall periodically review and evaluate the EMP, EMP reports, and 40 CFR 190 compliance assessments, and shall eliminate any requirements that experience shows to be nonessential or shall require specific actions necessary to show compliance. For example, if the airborne concentration measurements show that there is no need to continue radium-226, or thorium-230 analyses, then such requirements shall be eliminated from the EMP. As shown in Phase 2 of Figure 1, efforts will be made to streamline the periodic compliance assessment effort by prescribing specific concentration levels which, based on experience and in combination with other readily observable parameters related to mill operations and local land use, could be relied upon to determine compliance.

B. Predictive Modeling

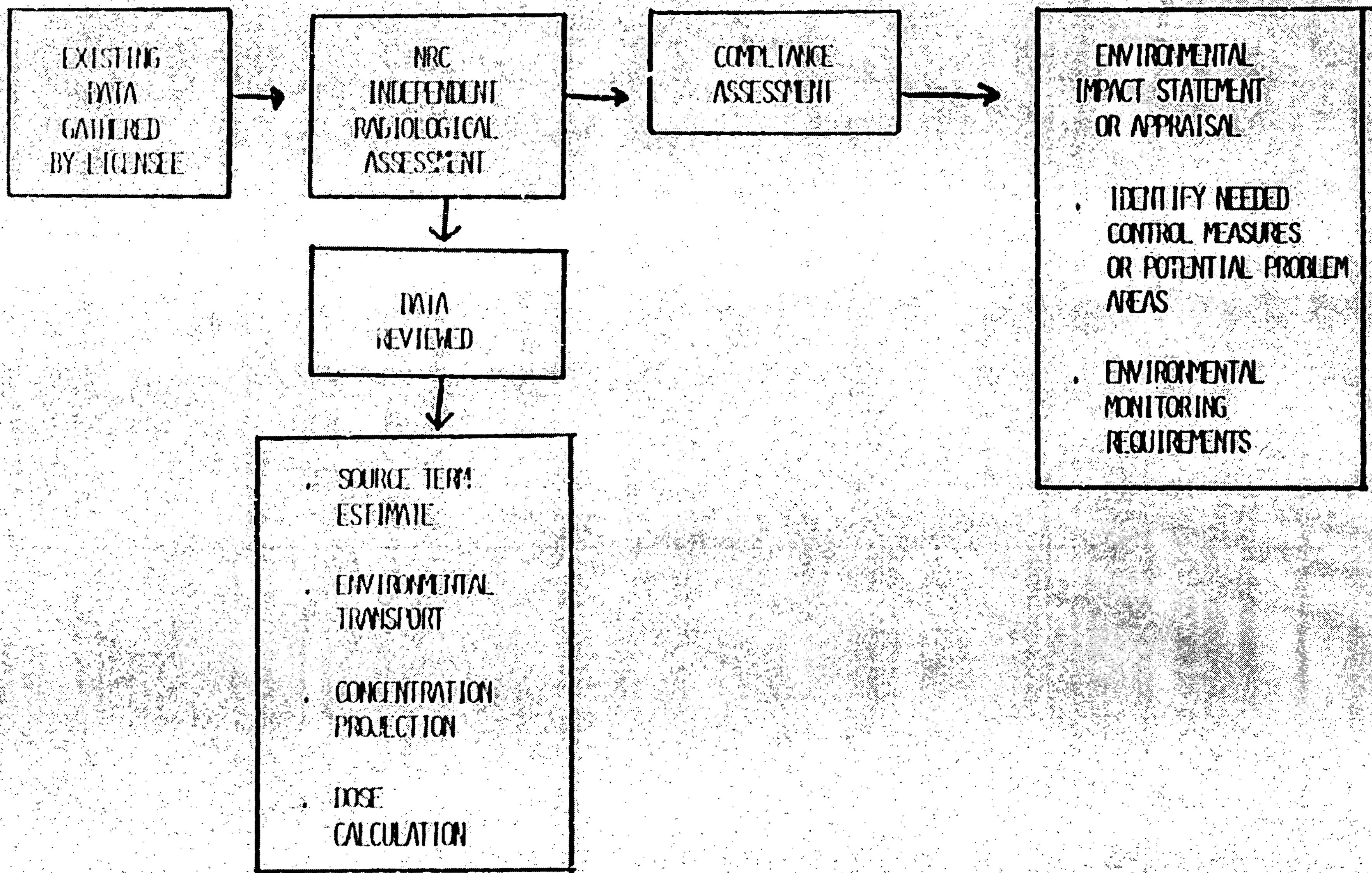
Figure 3 - "NRC 40 CFR 190 Assessment of Prospective Milling Operations" shows a diagram of the various steps to be followed by the NRC Project Manager in licensing reviews.

1. All existing data, e.g., source term, environmental monitoring data, land use, population distribution, meteorology etc., shall be gathered and reviewed by the NRC Project Manager (PM).

2. The NRC PM shall complete an independent radiological assessment to 40 CFR 190 compliance based on predictive modeling using methodology as described in Regulatory Guide RH#802-4.

3. These assessments shall be documented in the Environmental Impact Statement (EIS) or environmental appraisal conducted in support of the licensing action. These assessments shall consider the cumulative dose to any member of the population due to exposure from releases from multiple mill facilities in the general area.

FIGURE 3
NRC 40 CFR 190 ASSESSMENT OF PROSPECTIVE MILLING OPERATIONS (BASED ON PREDICTIVE MODELING)



APPENDIX A

Attachment A
Dose Calculational Guidance

The estimated dose received by any member of the general population shall be calculated based on the applicable potential exposure of the nearest resident in the off-site area surrounding the mill site. The total dose shall be the sum of the external exposure (i.e., due to radiation sources outside the body) and of the internal exposure (i.e., radioactive materials within the body). Doses which are due to background and extraneous sources should be subtracted from those measured at the nearest receptor. The contribution from non-mill sources (e.g., mining and trsnsportation activities) should also be determined based upon actual measurements at representative background locations.

1. External Radiation Exposure -

   The direct radiation exposure may be assumed to be equal to the actual personal or environmental dosimetric data less the appropriate background contribution.

2. Internal Radiation Exposure -

   The total dose to organs (e.g., lung, bone, whole body, etc.) shall be evaluated based on summing all applicable human pathways, such as:

   a. Inhalation of Airborne Particulates -

      The measured airborne concentration multiplied by the dose conversion factors as given in Table A-1.

   b. Ingestion of Contaminated Food and Milk -

      The measured concentration in the food product multipled by the dose conversion factor as given in Table A-2(a) through (c).

   c. Ingestion of Meat or Milk from Livestock Grazing on Contaminated Vegetation -

      The measured concentration in vegetation (e.g., grasses in grazing areas) multiplied by the dose conversion factor as given in Table A-3(a) and (b).

   d. Ingestion of Contaminated Water -

      The measured concentration in potable water multiplied by the dose conversion factor as given in Table A-4.

e. Ingestion of Meat or Milk from Livestock Watered on Contaminated Water -

The measured concentration in water used by livestock for watering purposes multiplied by the dose conversion factor as given in Table A-5(a) and (b).

If any of the human exposure pathways as given above are not in evidence at a mill site, then that dose contribution obviously does not need to be considered here. The total dose for each critical organ shall be obtained by summing the dose due to each radionuclide of the uranium decay chain series (i.e., uranium, radium-226 and thorium-230) and through each pathway, i.e., inhalation plus external exposure plus any applicable ingestion pathways. Since 40 CFR 190 excludes the dose due to radon and its daughters, the dose contribution from lead-210 and polonium-210 have been excluded from these assessments of actual environmental monitoring data. However, the dose due to the inhalation pathway shall be of primary concern, with the other pathways providing supplemental information regarding possible exposure. Additionally, a thorough evaluation of background conditions must be completed so that any contribution due to the mill operations (i.e., value measured at point of receptor less applicable background level) may be adequately assessed.

The point of receptor data must be reviewed in connection with other environmental and effluent monitoring data, and other appropriate information or assessment tools (such as computer modeling where this may be helpful), in cases where extraneous sources may cause calculated doses to exceed the 40 CFR 190 limits or where anomalous data may be encountered.

Table A-1
Dose Conversion Factors for the Inhalation of Airborne Particulates
(MilliRem per pCi/m^3)*

Radionuclide	Whole Body	Bone	Lung
U-238	4.32	79.2	158
U-234	4.92	79.5	180
Th-230	166	5950	3220
Ra-226	30.9	309	6610

*The 50-year dose commitment for each year of exposure to 1 pCi/m^3 of each radionuclide for an adult breathing rate of 20 m^3/day. Particle size of 1.55 μm AMAD (i.e., mean diameter of 1 μm and density of 2.4 g/cm^3) being representative of uranium ore. The Quality Factor for alpha radiations is 10. The total dose per organ is the summation of doses due to each radionuclide. (Final GEIS, NUREG-0706).

Table A-2(a)
Dose Converson Factors for Ingestion of Contaminated Meat

(MilliRem per $\frac{pCi}{kg}$)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	3.55 E-03	6.01 E-02	0.0	1.37 E-02
U-234	4.05 E-03	6.55 E-02	0.0	1.56 E-02
Th-230	4.46 E-03	1.61 E-01	9.16 E-03	4.42 E-02
Ra-226	3.60 E-01	3.60 E+00	4.49 E-04	1.28 E-02

*The 50-year dose commitment for each year of ingestion of contaminated meat. The above factors correspond to an adult ingestion rate of 78.3 kg/yr of meat (beef, poultry, pork, mutton). (Regulatory Guide RH#802-4).

Table A-3 (a)
Dose Conversion Factors for Ingestion of Meat from Cattle
Grazing on Contaminated Vegetation
(MilliRem per $\frac{pCi}{kg}$)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	6.04 E-05	1.02 E-03	0.0	2.33 E-04
U-234	6.88 E-05	1.11 E-03	0.0	2.65 E-04
Th-230	4.46 E-05	1.61 E-03	9.16 E-05	4.42 E-04
Ra-226	9.18 E-03	9.18 E-02	1.15 E-05	3.25 E-04

*The 50-year dose commitment for each year of ingestion of meat. The above values are based on the following.

i) Animal uptake of vegetation: 50 kg/day

ii) Environmental transfer coefficients: $\left(\frac{pCi/kg}{pCi/day}\right)$

U - 3.4×10^{-4}

Th - 2.0×10^{-4}

Ra - 5.1×10^{-4}

iii) Adult meat ingestion rate: 78.3 kg/year

iv) Adult ingestion dose conversion factors (see Regulatory Guide RH#802-4)

Table A-3(b)
Dose Conversion Factors for Human Consumption of Milk from Dairy Cows Ingesting Contaminated Vegetation

(MilliRem per $\frac{pCi}{kg}$)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	1.80 E-04	3.03 E-03	0.0	6.94 E-04
U-234	2.05 E-04	3.31 E-03	0.0	7.89 E-04
Th-230	1.85 E-06	6.70 E-05	3.80 E-06	1.84 E-05
Ra-226	1.76 E-02	1.76 E-01	2.20 E-05	6.25 E-04

*The 50-year dose commitment for each year of ingestion of milk. The above values are based on the following:

i) Animal uptake of vegetation: 50 kg/day

ii) Environmental transfer coefficients: $\left(\frac{pCi/kg}{pCi/day}\right)$

U - 6.1×10^{-4}

Th - 5.0×10^{-6}

Ra - 5.9×10^{-4}

iii) Adult consumption of milk: 130 liters/year

iv) Adult ingestion dose conversion factors (see Regulatory Guide RH#802-4)

Table A-4
Dose Conversion Factors for Human Consumption of Contaminated Water

(MilliRem per $\frac{pCi}{l}$)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	1.68 E-02	2.84 E-01	0.0	6.48 E-02
U-234	1.91 E-02	3.09 E-01	0.0	7.36 E-02
Th-230	2.11 E-02	7.62 E-01	4.33 E-02	2.09 E-01
Ra-226	1.70 E+00	1.70 E+01	2.12 E-03	6.03 E-02

*The 50-year dose commitment for each year of ingestion of contaminated water. The above values are based on an average adult consumption rate of 370 liters/year (Regulatory Guide 1.109) and adult ingestion dose conversion factors (Regulatory Guide RH#802-4).

Table A-2(b)
Dose Conversion Factors for Ingestion of Contaminated Edible Vegetation
(MilliRem per $\frac{pCi}{kg}$)

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	2.38 E-03	4.03 E-02	0.0	9.19 E-03
U-234	2.71 E-03	4.39 E-02	0.0	1.04 E-02
Th-230	2.99 E-03	1.08 E-01	6.14 E-03	2.97 E-02
Ra-226	2.42 E-01	2.42 E+00	3.01 E-04	8.56 E-03

*The 50-year dose commitment for each year of ingestion of contaminated edible vegetation.

A factor of 50% activity reduction through food preparation was assumed, and an adult ingestion rate of 105 kg/yr total vegetable ingestion rate, as well as uniform concentration throughout all vegetable types. Should data be presented as concentration of edible above ground vegetables, C_1; potatoes, C_2; and other below ground vegetables, C_3; then the following weighted concentration C_v should be used when multiplying the above dose factors:

$$C_v = 0.38\ C_1 + 0.58\ C_2 + 0.05\ C_3$$

Table 5 of Regulatory Guide RH#802-4 details the breakdown of vegetable consumption.

Table A-2(c)
Dose Conversion Factors for Ingestion of Contaminated Milk
(Mill:Rem per pCi/l)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	5.90 E-03	9.97 E-02	0.0	2.28 E-02
U-234	6.72 E-03	1.09 E-01	0.0	2.59 E-02
Th-230	7.41 E-03	2.68 E-01	1.52 E-02	7.35 E-02
Ra-226	5.98 E-01	5.98 E+00	7.46 E-04	2.12 E-02

*The 50-year commitment for each year of ingestion of contaminated milk. These values are based on an adult consumption rate of 130 liters/year. Since children drink greater quantities, the resultant dose is much higher for younger people. Dose conversion factors, as before, are for adults. Proper dose conversion factors and milk consumption rates for other age groups are presented in Regulatory Guide RH-802-4.

Table A-5
Dose Conversion Factors for Ingestion
of Meat from Cattle Watered on Contaminated Water

(MilliRem per $\frac{pCi}{l}$)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	6.04 E-05	1.02 E-03	0.0	2.33 E-04
U-234	6.88 E-05	1.11 E-03	0.0	2.55 E-04
Th-230	4.46 E-05	1.61 E-03	9.16 E-05	4.42 E-04
Ra-226	9.18 E-03	9.18 E-02	1.15 E-05	3.25 E-04

*The 50-year dose commitment for each year of ingestion of meat.
The above values are based on the following:

i) Animal uptake of water: 50 liters/day

ii) Environmental transfer coefficients: $\left(\frac{pCi/kg}{pCi/day}\right)$

U - 3.4×10^{-4}

Th - 2.0×10^{-4}

Ra - 5.1×10^{-4}

iii) Adult meat ingestion rate of 78.3 kg/year

iv) Adult ingestion dose conversion factors (see Regulatory Guide RH#802-4)

Table A-5(b)
Dose Conversion Factors for Human Consumption
of Milk from Dairy Cows Watered on Contaminated Water

(MilliRem per $\frac{pCi}{1}$)*

Radionuclide	Whole Body	Bone	Liver	Kidney
U-238	2.16 E-04	3.65 E-03	0.0	8.33 E-04
U-234	2.46 E-04	3.98 E-03	0.0	9.47 E-04
Th-230	2.22 E-06	8.03 E-05	4.56 E-06	2.20 E-05
Ra-226	2.12 E-02	2.12 E-01	2.64 E-05	7.50 E-04

*The 50-year dose commitment for each year of ingestion of milk. The above values are based on the following:

i) Dairy animal intake rate: 60 liters/day

ii) Adult ingestion milk rate: 130 liters/year

iii) Environmental transfer coefficients: $\left(\frac{pCi/liter}{pCi/day}\right)$

U - 6.1×10^{-4}

Th - 5.0×10^{-6}

Ra - 5.9×10^{-4}

iv) Adult ingestion dose conversion factors (see Regulatory Guide RH#802-4)

impacts of operation and to detect potential long term effects.

Criterion 8—Milling operations shall be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable. The primary means of accomplishing this shall be by means of emission controls. Institutional controls, such as extending the site boundary and exclusion area, may be employed to ensure that offsite exposure limits are met, but only after all practicable measures have been taken to control emissions at the source. Notwithstanding the existence of individual dose standards, strict control of emissions is necessary to assure that population exposures are reduced to the maximum extent reasonably achievable and to avoid site contamination. The greatest potential sources of offsite radiation exposure (aside from radon exposure) are dusting from dry surfaces of the tailings disposal area not covered by tailings solution and emissions from yellowcake drying and packaging operations.

Checks shall be made and logged hourly of all parameters (e.g., differential pressures and scrubber water flow rates) which determine the efficiency of yellowcake stack emission control equipment operation. It shall be determined whether or not conditions are within a range prescribed to ensure that the equipment is operating consistently near peak efficiency; corrective action shall be taken when performance is outside of prescribed ranges. Effluent control devices shall be operative at all times during drying and packaging operations and whenever air is exhausting from the yellowcake stack. Drying and packaging operations shall terminate when controls are inoperative. When checks indicate the equipment is not operating within the range prescribed for peak efficiency, actions shall be taken to restore parameters to the prescribed range. When this cannot be done without shutdown and repairs, drying and packaging operations shall cease as soon as practicable. Operations may not be re-started after cessation due to off-normal performance until needed corrective actions have been identified and implemented. All such cessations, corrective actions, and re-starts shall be reported to the appropriate NRC regional office as indicated in Criterion 8A, in writing, within 10 days of the subsequent restart.

To control dusting from tailings, that portion not covered by standing liquids shall be wetted or chemically stabilized to prevent or minimize blowing and dusting to the maximum extent reasonably achievable. This requirement may be relaxed if tailings are effectively sheltered from wind, such as may be the case where they are disposed of below grade and the tailings surface is not exposed to wind. Consideration shall be given in planning tailings disposal programs to methods which would allow phased covering and reclamation of tailings impoundments since this will help in controlling particulate and radon emissions during operation. To control dusting from diffuse sources, such as tailings and ore pads where automatic controls do not apply, operators shall develop written operating procedures specifying the methods of control which will be utilized.

Criterion 8A—Daily inspections of tailings or waste retention systems shall be conducted by a qualified engineer or scientist and documented. The appropriate NRC regional office as indicated in Appendix D of 10 CFR Part 20, or the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, shall be immediately notified of any failure in a tailings or waste retention system which results in a release of tailings or waste into unrestricted areas, and/or of any unusual conditions (conditions not contemplated in the design of the retention system) which if not corrected could indicate the potential or lead to failure of the system and result in a release of tailings or waste into unrestricted areas.

II. Financial Criteria

Criterion 9—Financial surety arrangements shall be established by each mill operator prior to the commencement of operations to assure that sufficient funds will be available to carry out the decontamination and decommissioning of the mill and site and for the reclamation of any tailings or waste disposal areas. The amount of funds to be ensured by such surety arrangements shall be based on Commission-approved cost estimates in a Commission-approved plan for (1) decontamination and decommissioning of mill buildings and the milling site to levels which would allow unrestricted use of these areas upon decommissioning, and (2) the reclamation of tailings and/or waste disposal areas in accordance with technical criteria delineated in Section I of this Appendix. The licensee shall submit this plan in conjunction with an environmental report that addresses the expected environmental impacts of the milling operation, decommissioning and tailings reclamation, and evaluates alternatives for mitigating these impacts. The surety shall also cover the payment of the charge for long term surveillance and control required by Criterion 10. In establishing specific surety arrangements, the licensee's cost estimates shall take into account total costs that would be incurred if an independent contractor were hired to perform the decommissioning and reclamation work. In order to avoid unnecessary duplication and expense, the Commission may accept financial sureties that have been consolidated with financial or surety arrangements established to meet requirements of other Federal or state agencies and/or local governing bodies for such decommissioning, decontamination, reclamation, and long term site surveillance and control, provided such arrangements are considered adequate to satisfy these requirements and that the portion of the surety which covers the decommissioning and reclamation of the mill, mill tailings site and associated areas, and the long term funding charge is clearly identified and committed for use in accomplishing these activities. The licensee's surety mechanism will be reviewed annually by the Commission to assure that sufficient funds would be available for completion of the reclamation plan if the work had to be performed by an independent contractor. The amount of surety liability should be adjusted to recognize any increases or decreases resulting from inflation, changes in engineering plans, activities performed, and any other conditions affecting costs. Regardless of whether reclamation is phased through the life of the operation or takes place at the end of operations, an appropriate portion of surety liability shall be retained until final compliance with the reclamation plan is determined. This will yield a surety that is at least sufficient at all times to cover the costs of decommissioning and reclamation of the areas that are expected to be disturbed before the next license renewal. The term of the surety mechanism must be open ended, unless it can be demonstrated that another arrangement would provide an equivalent level of assurance. This assurance could be provided with a surety instrument which is written for a specified period of time (e.g., five years) yet which must be automatically renewed unless the surety notifies the beneficiary (the Commission or the State regulatory agency) and the principal (the licensee) some reasonable time (e.g., 90 days) prior to the renewal date of their intention not to renew. In such a situation the surety requirement still exists and the licensee would be required to submit an acceptable replacement surety within a brief period of time to allow at least 60 days for the regulatory agency to collect.

Proof of forfeiture must not be necessary to collect the surety so that in the event that the licensee could not provide an acceptable replacement surety within the required time, the surety shall be automatically collected prior to its expiration. The conditions described above would have to be clearly stated on any surety instrument which is not open-ended, and must be agreed to by all parties. Financial surety arrangements generally acceptable to the Commission are:

(a) Surety bonds;
(b) Cash deposits;
(c) Certificates of deposit;
(d) Deposits of government securities;
(e) Irrevocable letters or lines of credit; and
(f) Combinations of the above or such other types of arrangements as may be approved by the Commission. However, self insurance, or any arrangement which essentially constitutes self insurance (e.g., a contract with a state or federal agency), will not satisfy the surety requirement since this provides no additional assurance other than that which already exists through license requirements.

Criterion 10—A minimum charge of $250,000 (1978 dollars) to cover the costs of long term surveillance shall be paid by each mill operator to the general treasury of the United States or to an appropriate State agency prior to the termination of a uranium or thorium mill license.

If site surveillance or control requirements at a particular site are determined, on the basis of a site-specific evaluation, to be significantly greater than those specified in Criterion 12 (e.g., if fencing is determined to be necessary) variance in funding requirements may be specified by the Commission. In any case, the total charge to cover the costs of long term surveillance shall be such that, with and assumed 1 percent annual real interest rate, the collected funds

References

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- U.S. Nuclear Regulatory Commission - Regulatory Guide 4.15, "Quality Assurance Programs for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment" (February 1979).
- U.S. Nuclear Regulatory Commission - Regulatory Guide RH#802-4, "Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations" (draft, May 1979).
- U.S. Nuclear Regulatory Commission - Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I" (Revision 1, October 1957).
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