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SEE REPORT FILE

PATHFINDER

Pathfinder Mines Corporation
North Butte ISL Operations
935 Pendell Boulevard
P.O. Box 730
Mills, Wyoming 82644
(307) 234-5019 / (307) 234-5321 FAX

40-8981

April 1, 1992

DOCKET NO. 40-8981
License No. SUA-1540

Mr. Ramon E. Hall, Director
Uranium Recovery Field Office, Region IV
U.S. Nuclear Regulatory Commission
P.O. Box 23525
Denver, Colorado 80225

RE: Request for Amendment, North Butte and Ruth ISL Projects - License SUA-1540

Dear Mr. Hall:

Please find enclosed three (3) copies of Pathfinder Mines Corporation's request to amend Source Material License SUA-1540 and accompanying supportive information (Change Volume). Pathfinder specifically requests amendment to Conditions 10, 11, 12, 15, 24, 25, 26, 28, 31 and 32 to request the review and approval of various operational and process changes, as well as information provided as required by the conditions. The proposed changes have previously been discussed with Mr. Konwinski of your staff.

Attached to this letter is a table which specifies the license condition to be amended, our reasons for the amendment, and our requested changes to the condition language. The attached binder entitled "Changes to WDEQ Permit to Mine No. 632 and NRC License SUA-1540" contains index pages and revised replacement pages for insertion into the North Butte license application document. The change volume is in a format specified by the Wyoming Department of Environmental Quality (WDEQ), but contains all the information necessary to support our requested amendments to the NRC license. The change volume also contains other information regarding revisions to the WDEQ portions of the North Butte application; revised pages associated with these changes should be incorporated into your copies of the North Butte application documents.

Pathfinder's plans for the North Butte ISL project are to begin the drilling program, and associated road upgrading, in July of this year pending final board approval expected in May. The efforts of the NRC staff to review and approve the requested license amendment to meet this schedule will be greatly appreciated.

9206020386

92-0376

Please contact me if I may provide any assistance or additional information during the review process.

Sincerely,

Donna L. Wichers
Manager, ISL Environmental and Regulatory Services

/dw

cc: LQD District III - Sheridan

Condition No.	Explanation for Amendment	Proposed Condition Language
10	To acknowledge the approval of the proposed changes.	"For use in accordance with statements, descriptions and representations contained in the licensee's submittal*s* dated *April 1, 1992 and* September 16, 1991, and Sections 15, 16.1, . . . "
11	To increase the flow rate of the North Butte facility to 4,000 gallons per minute. Pathfinder plans to operate North Butte at flow rates ranging from 2,500 to 3,600 gpm, but wishes the flexibility to flow at 4,000 gpm if necessary. Revised MILDOS runs with the new flow rate show no impact to the nearest resident. Revised application pages and MILDOS summary are included with the attached Index sheet and change package for process changes.	"The annual throughput of the North Butte facility shall not exceed a flow rate of *4,000* gallons per minute, exclusive of restoration flow resulting in a production rate not to exceed 700,000 pounds of U_3O_8; . . . "
12	Figure 15.21 of the North Butte application has been revised to indicate Pathfinder's plans for the process building and equipment layout. Additionally, Figure 15.22 (Process Flow Sheet), has been revised to show more detail including the increase in flow rate to 4,000 gpm, the deletion of surge tanks, the addition of sand filters, and the addition of chlorine to the injection solution for bacterial control. The new Figure 15.22 fulfills the requirement of Condition 12 for submittal of detailed flow diagrams three months prior to construction. These revised drawings are contained with the Index and change package for process changes.	"Any significant changes in the process circuit as shown in Figure 15.21 of the North Butte application dated *April 1, 1992*, and Figure 15.19 of the Ruth application dated October 3, 1988, shall require approval by the NRC, Uranium Recovery Field Office in the form of a license amendment. " *(delete remainder of condition)*
15	Pathfinder has conducted site specific geotechnical studies and completed detailed engineering designs for the two evaporation ponds (prepared by Western Water Consultants, Inc.). This information is provided with the attached Index and change package for plant and ponds. Pond construction is not planned until 1993, or late fall, 1992 at the earliest.	*Recommend deletion of this condition as the requirements have now been satisfied.*
24	Pathfinder requests clarification of this condition to assure that only one (as a minimum) of the baseline samples must be analyzed for the Table 16.1 suite.	"The licensee . . . The data shall, at a minimum, *include one sample analyzed for the constituents* shown in Table 16.1 of the North Butte . . ."

Condition No.	Explanation for Amendment	Proposed Condition Language
25	Pathfinder wishes to change the density of baseline water quality establishment to be consistent with that specified in the license applications, and approved by WDEQ, which requires sampling of one production or injection well per four acres of wellfield rather than per every acre of wellfield (page 16-8 of the North Butte application). The Ruth application specifies one well per three acres of wellfield (page 16-8 of the Ruth application).	"Prior to mining at the North Butte facility, baseline groundwater quality for each mining unit shall be established at the following minimal density: all mining zone perimeter monitor wells, one upper aquifer monitor well per four acres of wellfield and one production/injection well per *four acres of wellfield*. Prior to mining at the Ruth facility, . . ., and one production/injection well per *three acres of wellfield*."
26	Pathfinder wishes to change the procedure for confirming excursions to that specified in the license applications by deleting the phrase "or if a single UCL value is exceeded by 20 percent." The method approved in the license applications requires two out of three UCLs to be exceeded for an excursion to be declared (see page 16-7 of both Ruth and North Butte applications).	"The licensee shall, . . . If two UCLs are exceeded in a well *(deletion)* the licensee shall take a confirmation sample . . . "
28	The current language of "until such time that aquifer cleanup is complete" requires clarification. It could be interpreted to mean that restoration of the aquifer must occur. Pathfinder has requested that language consistent with the last sentence of Condition No. 26 be used instead of completion of aquifer cleanup.	"A written report . . . If the wells are still on excursion at the time the report is submitted, injection of lixiviant within affected portions of the wellfield on excursion shall be terminated until such time that *the excursion is considered concluded.*"
31	Pathfinder has submitted designs for two types of ponds (see Condition 15 above): a single synthetic liner system and a double synthetic liner system. The final design chosen will be based on sand/gravel prices at the time of construction. Because of differing inside slopes, the two systems have differing operating water levels, high water levels and overtopping levels. Pathfinder would prefer to commit to a high water level restriction rather than a specific freeboard level (exact number of feet) at this time.	*Add: The solution evaporation ponds at the North Butte site shall be operated to insure that, at all times, sufficient reserve capacity is maintained in the evaporation pond system to enable the transfer of the contents of a pond to the other pond.*

REQUEST FOR AMENDMENT TO SUA-1540, DOCKET NO. 40-8981
(CONT.)

Condition No.	Explanation for Amendment	Proposed Condition Language
32	Pathfinder wishes to change the list of chemical analyses to be analyzed in the event of a potential pond leak to be consistent with that specified in the North Butte application document. The initial confirming parameters should be simple, effective and have the capability of being analyzed on-site. We therefore wish to eliminate the requirement for TDS and radium-226 analyses to verify a pond leak. Carbonate/bicarbonate will be added to the list, as specified in the application document.	"The licensee shall perform . . . Any fluid detected in the standpipes shall be analyzed for chloride, *carbonate/bicarbonate*, sodium, *and* uranium. Should analyses . . . "

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Pathfinder Mines Corporation
North Butte ISL Operations
935 Pendell Boulevard
P.O. Box 730
Mills, Wyoming 82644
(307) 234-5019 / (307) 234-5321 FAX

March 31, 1992

Mr. Bob Giurgevich, District Supervisor
Land Quality Division, District III
Department of Environmental Quality
2161 Coffeen Avenue, Suite 401
Sheridan, Wyoming 82801

RE: Request for Changes to Permit to Mine No. 632, North Butte ISL Project

Dear Mr. Giurgevich:

Please find enclosed with this letter three (3) copies of Pathfinder Mines Corporation's proposed changes to the approved application for the North Butte ISL Project, Permit to Mine No. 632. Our proposed changes are those previously discussed with you and your staff, and include the following:

- The addition of a description of the regional groundwater quality and flow characteristics as required by Condition No. 5 of Permit to Mine No. 632.
- A revision to Section 1.3, Project Owners, of the approved application to indicate Pathfinder Mines Corporation as the owner and operator of the North Butte ISL Project.
- An increase in the maximum flow rate at North Butte from 3,000 gallons per minute (gpm) to 4,000 gpm, and associated minor mining/process changes.
- The relocation of the process plant and evaporation ponds, and the submittal of detailed engineering designs and geotechnical information for the evaporation ponds. This information should satisfy Condition No. 7 of Permit to Mine No. 632.
- The redesignation of the mine access road.

For each of the above changes, an index page with associated revised replacement pages and figures are included. The changes are not numbered, as I am assuming this will be done in the order they are approved.

In your letter dated October 22, 1991, you stated that a revised surface ownership and access agreement with T-Chair Land Company must be submitted for Pathfinder's use of the oil field road as access to the permit area. I have attached copies of pages from Pathfinder's current mining agreement with T-Chair, the assignment of the agreement to Pathfinder, and a memorandum summarizing the original agreement, all of which demonstrate that Pathfinder has the right to access and construct roads associated with the pursuance of mining, and the lands on which Pathfinder has this right. Due to confidentiality reasons, I have not included the entire mining agreement, nor are the attached pages intended for insertion into the permit document.

Pathfinder's plans are to begin our drilling program, and associated road upgrading, in July of this year pending final board approval expected in May. The efforts of the Land Quality Division to review and approve the enclosed changes and meet this schedule will be greatly appreciated.

Please contact me if I may provide any assistance during your review.

Sincerely,

Donna L. Wichers
Manager, ISL Environmental and Regulatory Services

/dw

cc: R. Hall - USNRC/Denver: cover letter only - Docket 40-8981

0400 8981120E

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Mills, Wyoming 82644
(307) 234-5019 / (307) 234-5321 FAX

40-8981

April 1, 1992

DOCKET NO. 40-8981
License No. SUA-1540

DOCKETED APR 02 1992 USNRC MAIL SECTION DOCKET CLERK

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Mr. Ramon E. Hall, Director
Uranium Recovery Field Office, Region IV
U.S. Nuclear Regulatory Commission
P.O. Box 23525
Denver, Colorado 80225

RE: Request for Amendment, North Butte and Ruth ISL Projects - License SUA-1540

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Attached to this letter is a table which specifies the license condition to be amended, our reasons for the amendment, and our requested changes to the condition language. The attached binder entitled "Changes to WDEQ Permit to Mine No. 632 and NRC License SUA-1540" contains index pages and revised replacement pages for insertion into the North Butte license application document. The change volume is in a format specified by the Wyoming Department of Environmental Quality (WDEQ), but contains all the information necessary to support our requested amendments to the NRC license. The change volume also contains other information regarding revisions to the WDEQ portions of the North Butte application; revised pages associated with these changes should be incorporated into your copies of the North Butte application documents.

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Sincerely,

Donna L. Wichers
Manager, ISL Environmental and Regulatory Services

/dw

cc: LQD District III - Sheridan

PATHFINDER MINES CORPORATION
REQUEST FOR AMENDMENT TO SUA-1540, DOCKET NO. 40-8981

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REQUEST FOR AMENDMENT SUA-1540, DOCKET NO. 40-8981
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INDEX
PERMIT TO MINE NO. 632 - NORTH BUTTE ISL PROJECT

CHANGE NO. ____

Revise Description of Project Owner

Description of Change:

Section 1.3, Project Owners, of the approved permit application has been revised to indicate that Pathfinder Mines is the owner and operator of the North Butte ISL project. The page was revised to include the description of Pathfinder's access road, therefore Section 1.3 was updated at the same time. Uranerz, U.S.A. is still referenced throughout the permit document; only on pages where Pathfinder has made revisions will the new owner (Pathfinder) be reflected. Wherever Uranerz, U.S.A. appears in the permit document, the reader should understand that this is now Pathfinder Mines Corporation.

Location of Changes to Approved Permit Document:

Volume	Section	Page	Figure	Table	Explanation
I	1.3	1-4			Insert that Pathfinder Mines Corporation is the owner and operator of the North Butte ISL project

The revised page 1-4 is contained in the change package for the access road.

INDEX
PERMIT TO MINE NO. 632 - NORTH BUTTE ISL PROJECT

CHANGE NO. ____

Description of Regional Groundwater Quality and Flow Characteristics

Description of Change:

Condition No. 5 of Permit to Mine No. 632 requires Pathfinder Mines Corporation to submit a description of the regional groundwater quality and flow characteristics for the North Butte ISL Project. Accordingly, a section has been added to the permit application document which specifically addresses the hydrologic characteristics of the regional aquifer system. This section is entitled 10.1.a, Regional Groundwater Setting.

Location of Changes to Approved Permit Document:

Volume	Section	Page	Figure	Table	Explanation
I	10.1.a	10-1 10-1a 10-1b 10-2			Addition of New Section: Regional Groundwater Setting No change
I	Table of Contents	v			Addition of New Section: Regional Groundwater Setting

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

10. APPENDIX "D-6", HYDROLOGY

10.1 GROUNDWATER HYDROLOGY

10.1.a. REGIONAL GROUNDWATER SETTING

The North Butte permit area is located within the southern portion of the Powder River Basin. The Powder River Basin is part of the Great Plains physiographic province and is a structural and topographic basin of approximately 64,750 km^2 (25,000 square miles) located in eastern Wyoming and southern Montana. The basin is bounded on the east by the Black Hills and on the west by the Bighorn Mountains. The southern boundary is the Laramie Range and Hartville Uplift, and the Miles City Arch in Montana forms the basin's northern extent. The most dominant topographic features within the area are the Pumpkin Buttes. The North Butte permit area is located on the southeast flank of the North Pumpkin Butte.

The Powder River Basin incorporates a sedimentary rock sequence that approaches 15,000 feet thick along the synclinal axis. These sedimentary rocks range in age from Tertiary (3 million to 70 million years, B.P.) to Cambrian (500 million to 570 million years, B.P.). The Tertiary fluvial system had a general drainage direction from south to north. Today the drainage systems, both surface and subsurface, still generally follow the Tertiary paleodrainage trends. The Tertiary rock units outcropping within and surrounding the North Butte permit area are the Wasatch Formation (Eocene) and the White River Formation (Oligocene).

The North Butte site is located slightly west of the axis of the Powder River Basin syncline. Each of the aquifers of interest exist in the Wasatch formation. This formation is a fluvial deposit and contains alternating layers of sands and shales. The major sands can be correlated for miles, and are the basis for regional aquifers in the Powder River Basin. Regionally, combined with the underlying Fort Union Formation, the Wasatch is developed extensively by shallow domestic and stock wells. Locally, the Wasatch Formation is developed mainly as a source of groundwater for livestock use.

Recharge to the sands of the Wasatch is mainly on their outcrops, with some influx of groundwater from vertical movement through adjacent aquitards. Flow in the aquifers generally moves to the north along the paleodrainage trends, with a small portion of the groundwater discharging to streams. Aquifer properties are locally unpredictable due to large variations in local lithologies. Transmissivities within the Wasatch are known to range anywhere from 1 to 5,000 gpd/ft.

Extensive chemical data exists for the Wasatch aquifer system. Due to the discontinuous nature of the water-bearing sandstones, water quality concentrations within the system can be quite variable. Typically, total dissolved solids (TDS) content varies from less than 250 mg/l to over 6,500 mg/l, with a general decrease in TDS with increasing depth for parts of the aquifer (Feathers, et.al., 1981). Waters containing less than 500 mg/l TDS are generally enriched with bicarbonate, while higher TDS waters generally exhibit higher dissolved sulfates.

10.1.1 SUMMARY OF AQUIFER AND AQUITARD PROPERTIES

Two North Butte sites (SS2 and SSE) were tested in 1988 to define the aquifer and aquitard properties. The detailed hydrologic analyses and supporting data are contained in Volume III, Groundwater Supplement. One multi-well test was conducted at the SS2 site and is referred to in this report as HYDRO Test NB1. Two multi-well tests were performed at the SSE site. These tests are referred to as HYDRO Tests NB2 and NB3. Table A-1 of Volume III, the Groundwater Supplement, Part A, presents the basic well data for wells used to define the aquifer properties. The aquifer pump test plans for the SSE and SS2 site were approved prior to running the tests by the NRC and the LQD/DEQ in letters dated March 22, 1988, and April 24, 1988, respectively.

In addition to determining the aquifer properties at each site, HYDRO Test NB1 was designed to evaluate the Upper aquitard and HYDRO Test NB2 was designed to evaluate the Lower aquitard. The capitalized words "Upper" and "Lower" aquitards refer to the specific aquitard between the "C" and "F" sands and the aquitard between the "A" and "1" sands, respectively. Several pump tests previously conducted by Cleveland-Cliffs were analyzed and used for additional points of information.

The North Butte in situ site is located on the outcrop of the Wasatch Formation. The stratigraphy of the Wasatch at this site consists of alternating layers of sand and shale with lignite marker beds. The mineable ore exists in three sand members ("A", "B" and "C") at North Butte. These three sand members are directly connected at some locations in the North Butte area, and are essentially one sand unit referred to as the mining sand. The "B" and "C" sands are connected at the SS2 site (NB1 test) and are tested as one unit. The "BC" sand is 162 feet thick at the SS2 site. Generally, when the "B" and "C" sands are separately delineated, they are roughly 100 feet and 50

feet thick, respectively. Figure 10.1 presents a schematic of the geologic setting of the HYDRO Test No. NB1 (SS2 site). This figure also shows the relative position of the next overlying aquifer, namely the "F" sand and the overlying aquitard, "FBC", which is approximately 100 feet thick at this location.

Figure 10.2 presents a schematic of the geologic setting of the SSE site, which is the location of the NB2 and NB3 tests. This schematic shows that the tested ore sand, "A", at this site is 71 feet thick with an approximately 45 feet thick Lower aquitard ("A1"). The Lower aquitard ("A1") isolates the mining zone ("A", "B" and "C" sand members) and is between the "A" and "1" sands. The "1" sand is a marginal sand at the SSE site and is approximately 30 feet thick. Figures 10.3 and 10.4 present the locations of the cluster of wells at the SS2 (NB1 test) and SSE (tests NB2 and NB3) sites, respectively.

"BC" SAND AQUIFER

The "B" and "C" sands are discussed as a single unit in this section due to the fact that they are combined at the SS2 location. Short tests were conducted on these units separately at the SS1 site by Cleveland Cliffs. These tests will be discussed separately at the end of this section.

The "BC" sand aquifer was tested by pumping fully penetrating "BC" well SS2M. Proximal "BC" sand aquifer wells SS2BC1, SS2BC2 and SS2MP were monitored for drawdown. In addition, outlying "B" and "C" wells 11-2, 7-1 and 7-2 were also monitored.

A summary of results from HYDRO Test NB1, are presented in Table 10.1, Summary of Aquifer Properties. Table 10.1 first presents the range of aquifer properties obtained from the straight line method (Jacob), followed by the range from the Hantush type curve match and, finally, the recovery results.

The transmissivities for the observation wells obtained from Test No. NB1 from the straight line method varied from 526 to 883 gal/day/ft (7.56E-5 to 1.27E-4 sq m/sec).

INDEX
PERMIT TO MINE NO. 632 - NORTH BUTTE ISL PROJECT

CHANGE NO. ____

Revisions As a Result of Mining/Process Changes

Description of Change:

Pathfinder Mines Corporation has reviewed the Uranerz, U.S.A mine plan currently within the North Butte Permit to Mine Application and has made revisions consistent with planned Pathfinder operations. This revision pertains to the mine sequence and process changes in the plant. With regards to the mine sequence, Pathfinder has divided the North Butte orebody into ten mining units as compared with the nine units proposed by Uranerz. The overall area of the wellfields does not change from that previously proposed, however several maps have been revised to show the new mining unit boundaries.

The primary change to the application regarding the processing plant is the increase in maximum flow rate from 3,000 gallons per minute (gpm) to 4,000 gpm. Pathfinder will most likely operate the plant and wellfields in the 2,500 gpm to 3,600 gpm range of flows, but wishes to have the flexibility to expand to 4,000 gpm if necessary. The most obvious affect of the increased flow rate will be the increase in the expected wastewater stream (1% bleed) from 30 gpm to 40 gpm. The primary method for disposal of the wastewater will be via deep injection. The combined permitted capacity of the two approved disposal wells is 300 gpm, however, Pathfinder plans to install only one of the wells initially, providing a disposal capacity of 150 gpm. Pathfinder has sized the two evaporation ponds to be capable of accepting and storing the 40 gpm bleedstream for 30 days in the case maintenance is required on the deep well. Even when the wastewater from full scale restoration is added (average of 45 gpm with surface discharge, or average of 75 gpm without surface discharge and using only deep well injection for disposal), the capacity of the single deep well is not exceeded. The slight increase in bleedstream flow rate from 30 gpm to 40 gpm will, therefore, not have any impact on the planned wastewater disposal methods or designed capacities.

The increase in flow rate has also been evaluated with respect to radiological effluents using the atmospheric radiation dispersion computer model recommended by the NRC entitled MILDOS. The MILDOS analysis at the 4,000 gpm flow rate shows little change from the previous MILDOS estimate prepared by Uranerz, and there are no significant radiological impacts to the unrestricted areas or the nearest residence. The summary of the MILDOS analysis has been incorporated into the application, replacing the previous MILDOS computer runs.

Pathfinder has also incorporated a detailed process flow sheet as well as a new plant layout drawing. The changes to the previous process flow sheet are the flow rate of 4,000 gpm, the addition of sand filtration prior to ion exchange, the deletion of surge tanks (wellfield pumps are capable of sending solutions to the plant), and the addition of small amounts of chlorine gas to the injection solution to prevent bacterial invasion in the injection wells and the plant equipment. Additionally, although not indicated on the flow sheet, air vents will be located on each injection well to alleviate pressure buildup from oxygen exhalation during operations. The new plant layout provides our current estimate as to where the plant circuits will be located within the building, which has been downsized from the previous Uranerz design.

The location of changes to the approved permit document are found in the following table. All revised pages and figures for this particular permit change are attached to these Index pages.

CHANGE NO. ____

Revisions As a Result of Mining/Process Changes

Location of Changes to Approved Permit Document:

Volume	Section	Page	Figure	Table	Explanation
I	1.4.1	1-5			Change nine mining units to ten mining units; increase flow rate to maximum of 4,000 GPM
I	1.4.2	1-6			Decrease dimensions of process plant and associated office building
I	10.4.2	10-49			Increase maximum bleed rate (1%) to 40 GPM
I	14.3.1	14-11			Increase flow rate to 4,000 GPM, effects on airborne radon release
I	15.4	15-4 15-5			Increase flow rate to 4,000 GPM; change in location of process plant access road
I	15.7.1	15-22			Decrease dimensions of process building; deletion of surge tanks
		15-24	15.21		Revised process plant general arrangement
		15-25			Changes in process building arrangement, decrease in office dimensions
I	15.7.4	15-29 15-30			Increase flow range up to 4,000 GPM, and bleed range up to 40 GPM
		15-31	15.22		Revised process flow sheet
I	15.8	15-30			Increase bleed rate up to 40 GPM
I	19.8	19-30A 19-30B			Revise section with updated results from MILDOS runs at 4,000 GPM, wellhead venting and deletion of surge tanks
		19-30C			Addition of MILDOS summary by Resource Technologies Group and Enecotech

1.4 MINING OPERATIONS

1.4.1 WELLFIELD

The orebody at the commercial North Butte ISL Project will be divided into ten mining units. Each mining unit will consist of approximately 65 five spot patterns which will be used to extract the uranium from the sandstone formation. The pattern area will be comprised of approximately 15 surface acres for each mining unit. The uranium, which lies in a confined aquifer in the Wasatch Formation, will be removed by circulating leach solutions through the mineralized portions of the sandstone at a nominal flow rate of up to 4,000 gpm.

The mineralized or target sand for the solution mining operation at the North Butte site is referred to locally as the mining sand. The injection and recovery wells will be completed only in the mineralized zones of the "A", "B" and "C" sand members of the mining sand to insure as little dilution as possible. The method of well drilling and completion will involve casing the hole, cementing the annulus, and either underreaming or drilling under the casing to expose the mineralized interval.

Horizontal and vertical monitor wells will be installed in and around the wellfield to insure containment of the leaching solutions. A slight over production from the wellfield will keep groundwater moving into the operating mining unit. Additionally, information on wellfield flow rates and pressures will be collected routinely to monitor for excessive injection or recovery in any portion of the mining unit.

Following the extraction of the uranium from the orebody aquifer using solution mining techniques, the groundwater affected by the mining operation will be restored to a quality consistent with regulatory requirements. The techniques to be utilized for groundwater restoration at the North Butte site will be similar to those employed by Uranerz during the successful Ruth R & D groundwater restoration effort.

1.4.2 PROCESSING PLANT

The North Butte in-situ mining facility is designed to extract the uranium compound from the wellfield solution and produce the final yellowcake product. The elution, precipitation, and yellowcake drying facilities at this location will be capable of processing uranium loaded resin from other uranium mining facilities. Department of Transportation (DOT) approved trailers will be used to transport the resin to and from other uranium mining facilities. The leaching solution or lixiviant will consist of a diluted sodium carbonate/bicarbonate solution plus an oxidant.

The process equipment, with the exception of most of the chemical storage tanks, soda ash silo, and yellowcake storage, will be housed in an insulated metal building. The metal process building is anticipated to have dimensions of 80 feet by 150 feet with eaves 20 feet high. The office area, approximately 40 feet by 80 feet, will be adjacent to the process building. A personnel trailer may be located in the vicinity of the process and office facilities. This trailer would be used as a kitchen and as sleeping quarters for the relief operators.

The liquid effluent from the process will be treated and routed to the artificially lined solar evaporation ponds. Treated water meeting the requirements of a NPDES permit will be surface discharged to a tributary of Willow Creek. The waste solution from the precipitation and yellowcake circuits will be filtered and disposed of in the deep disposal well.

1.5 RECLAMATION AND AQUIFER RESTORATION OPERATIONS

At the appropriate stages in the life of the North Butte project, reclamation of the land surface and restoration of the affected aquifer(s) will take place. Reclamation and restoration activities will commence as soon as practicable once mining in a wellfield has terminated. The goal of reclamation will be to return all affected lands to their pre-mining use of livestock grazing and wildlife habitat, and the goal of restoration will be to return the water quality in affected aquifer(s) to acceptable

from these two wells is not suitable for drinking. The residents at the Pfister ranch haul their drinking and cooking water to their house. When mining personnel are using the man camp they bring their drinking water from town. There is no information available on the unadjudicated Pfister well. The man camp well is identified as North Butte PW-1 (permit no. P54464W) in Table 10.17.

10.3.3 NEAREST MUNICIPAL WATER SOURCE

The nearest municipal water source is located at the unincorporated community of Savageton, Wyoming some 10 air miles northeast of the North Butte ISL project. The Savageton water system consists of a well, supply tank and distribution lines. The system will serve up to 15 trailer homes. The well is 700 feet deep with 6 inch steel casing and has a 5 horsepower pump. Information on completion interval, depth to water and yield is not available. The distribution system consists of 2 inch diameter plastic pipe. The water from the well is potable according to the operator.

10.4 SOURCE, QUALITY AND QUANTITY OF WATER

The source, quality and quantity of water to be used during mining and reclamation activities at the North Butte project are described in the following two sections.

10.4.1 SURFACE WATER USAGE

There will be no diversion or use of surface water for mining or reclamation purposes at the North Butte ISL project.

10.4.2 GROUNDWATER USAGE

The mining portion of the North Butte operation will result in a wellfield bleed stream of approximately 1% of the recovery flow, or about 25 to 40 GPM being removed from the groundwater system ("A", "B" and "C" sand members of the North Butte Mining sand). This approximate 1% bleed stream will ultimately be disposed of through a combination of evaporation and deep well disposal. A portion of the 1% bleed stream

may be used in various plant processes such as eluant make-up, filter backwash, resin and yellowcake washes, and other process purposes. The portion of the bleed stream used for these purposes will also be disposed of in either the evaporation ponds or the deep disposal well. The estimated water quality of the bleed stream during mining, for the major constituents, will normally be in the ranges listed below.

Parameter	Estimated Concentrations
TDS	1,000 - 5,000 mg/l
pH	6.0 - 8.0 pH units
Chloride	50 - 2,500 mg/l
Sodium	1,000 - 2,000 mg/l
Calcium	25 - 400 mg/l
Carbonate	500 - 3,000 mg/l
Sulfate	500 - 2,000 mg/l

During aquifer restoration operations a range of flows from about 0 to 240 GPM (45 GPM average) may be withdrawn from the North Butte Mine Sand. The water quality will initially start out about the same as shown in the table above. As aquifer restoration progresses, the water quality will improve to near baseline or pre-mining conditions. If the aquifer restoration stream meets the NPDES surface discharge specifications it will be placed in a stream channel at the surface discharge point (See Figure 9.2, Volume II). If the aquifer restoration stream does not meet the NPDES surface discharge specifications it will be disposed of in either the evaporation ponds or the deep disposal well, or treated so that it meets the surface discharge criteria.

Water for plant wash down, and domestic purposes (other than drinking water) will come from a domestic well located near the plant building. The average flowrate from this well for these purposes will be about 2 GPM. The estimated daily volume of usage is about 3000 gallons. The source of this water will be a well completed in a

14.2 RADIOLOGICAL IMPACT ON BIOTA OTHER THAN MAN

The in situ mining process being proposed for the North Butte facility is similar to the operation that was conducted and monitored during the Ruth Research and Development phase. The Ruth R & D operation was monitored for any and all potential releases to the environment for over two years with no radiological impacts on any biota including man. The proposed operations for commercial mining have incorporated basically all of the same operational procedures except that the product shipped from the site will be in a dried form.

The operationally proven techniques and experience of the company will be used to insure that the potential for any accidents or spills can be eliminated or minimized.

14.3 RADIOLOGICAL IMPACT ON MAN

14.3.1 AIRBORNE RADON-222

At the North Butte facility, there are two primary sources for airborne radon. One source is from the plant building vents from any open or unpressurized process tanks, such as lixiviant makeup. The other source is from the venting of injection and production wellheads in the wellfield area. Very little radon is emanated at the evaporation ponds as most of the radon has decayed or been released prior to reaching the evaporation ponds.

While there are these potential sources, it should be noted that the amounts being released are extremely small and that simple dispersion within the atmosphere will reduce the potential emigration from the property to zero. A computer dispersion model, MILDOS, has been used by Pathfinder at the highest potential flow rate of 4,000 GPM to show that there is no radiological impact to the nearest residence from radon, assuming that <u>100%</u> of the radon present in the formation is released (see Section 19.8). The Ruth R & D facility was monitored during the two years of operation and the property boundary monitors remained within background levels the entire time. This situation has been experienced at other ISL facilities as well.

14.3.2 AIRBORNE PARTICULATES

Airborne particulates will be minimal at the North Butte facility. The only likely source of airborne particulates is in the yellowcake dryer room. Environmental controls and frequent monitoring will insure that safe working conditions are maintained at all times. Any accidents or spills will be contained and cleaned up before any potential particulates can or will be generated. Again, utilizing the data and operational experience of the Ruth R & D, no particulates will be expected. Operational monitoring for radioactive airborne particulates will take place inside the building as discussed in Section 19.1 of this document.

14.3.3 ATMOSPHERIC DISPERSION COMPUTER PROGRAM (MILDOS)

The MILDOS modeling description and results for radionuclide atmospheric dispersion at the North Butte facility is presented in Section 19.8. Background data and operational information from the proposed Ruth satellite operation have been included in the North Butte MILDOS computer run.

members are in vertical contact. A complete description of the regional and local geology is presented in Section 9.

In the North Butte ore deposit the uranium mineralization is present as amorphous uranium oxide, or sooty pitchblende, with some subordinate carnotite. The host sandstones are composed of quartz, feldspars, and rock fragments with locally occurring carbon fragments. Grain size ranges from very fine-grained sand to small granules. The sandstone is weakly to moderately cemented and friable. Occasional occurrences of pyrite and calcite as cementing materials can be observed. The uranium is deposited upon individual detrital sand grains or upon and within authigenic clays in the interstices. The interstitial clays present are primarily montmorillonite with lesser amounts of kaolinite and smectite. Hematite is a common oxidation product of pyrite within the host rock, along with minor limonite. Accessory biotite and muscovite are also present.

15.3 AMENABILITY TO IN SITU SOLUTION MINING

The amenability of the North Butte ore body to in situ mining is assured by the similarity of this ore deposit to those located in the surrounding area. Both the Ruth ore deposit to the south and the Christensen Ranch ore deposit to the west were tested using standard in situ technology and a sodium bicarbonate/carbonate, oxygen enhanced lixiviant. Both of these deposits as well as Irigary to the northwest, Reno Creek to the southeast, and Highland to the south have demonstrated excellent amenability to in situ extraction methods.

Mineralogy studies comparing North Butte cores to other ore of the Powder River Basin demonstrate that similar deposition mechanics occurred throughout the area which further supports the amenability of the ore to in situ mining technology.

As final testing of the amenability of this ore deposit to in situ leach mining technology using sodium carbonate/sodium bicarbonate oxygen enhanced lixiviant, core material was recovered at two locations on the North Butte project during the installation of hydrologic test wells. These cores were subjected to standardized leach tests

in Uranerz laboratories. The results verified that the North Butte ore is very amenable to carbonate/bicarbonate leaching.

15.4 SCOPE OF PROPOSED OPERATION

Pathfinder proposes to conduct a commercial scale in situ solution mining operation with a planned maximum flow capacity of 4,000 GPM and a production capacity of approximately 1,000,000 pounds of product throughput per year which includes processing of satellite derived resin. The total affected area including process facilities and wellfields is estimated to be approximately 343 acres. The aerial extent of the wellfields may be altered slightly depending on the economic cut-off point in relation to the fluctuating market price of the uranium product. The average depth of the orebody below the land surface is approximately 700 feet depending upon the surface relief. The host rock is sandstone of the Wasatch formation. The orebody is a typical Powder River Basin uranium roll front.

The proposed North Butte is situ mine is located in southwest Campbell County, Wyoming about 42 air miles southwest of Gillette, Wyoming in portions of Sections 18 and 19 of Township 44 North, Range 75 West and portions of Sections 13, 23, 24, and 25 of Township 44 North, Range 76 West. Access is by State Highway 50, south from Gillette to Savageton, then west and south on Campbell County and oil field roads to the mine access road in Township 44 North, Range 76 West, Section 25 (NE¼ NW¼). At that point, access to the processing facility is achieved by proceeding north and east approximately 0.9 miles.

The proposed mining operation will occur in rolling to flat terrain, generally sloping south being influenced by Willow Creek located south of the permit area. The mining will take place at surface elevations ranging from 4,900 to 5,600 feet above mean sea level. The mine property is drained by tributaries of Willow Creek which is an ephemeral stream in the project area.

The layout of the facilities and wellfields are shown on Figure 9.2 (Volume II). The process equipment, building, and wellfields will be designed specifically to meet the

North Butte in situ mine requirements. Even though specifically designed equipment will be purchased, all of it will be of a tried and proven type commonly used in the industry throughout Wyoming.

The North Butte production facility (Figure 15.1, Volume II) is designed to serve as a central processing complex. In total, the North Butte production complex will be composed of a plant capable of processing the on site wellfield solution as well as resin from satellite plants. North Butte will also have wellfields and auxiliary facilities including office accommodations, sleeping quarters, two evaporation ponds, disposal well and surface discharge area as explained in more detail below.

The processing plant is planned to be comprised of a process building, various solution holding tanks, down flow ion exchange vessels, pumps, plumbing, filter sections, precipitation section, water treatment system and a drying unit. Various office accommodations will be located in the process building as well. The process facility will be designed to accommodate resin elution and product processing from other uranium concentrating (satellite) sites.

The wellfields will have injection, recovery and monitoring wells with the appropriate equipment to transfer the solutions to and form the process facility. Aquifer restoration equipment is planned to be installed in approximately year five of the operation.

The personnel quarters will be installed outside, but near the restricted area to provide beds and living area for those operating personnel who remain on site during non regular shifts.

The chemical leach process will be the same as that previously developed by Uranerz and is very similar to that used by other ISL mining companies in Wyoming. Sodium carbonate, if needed, will be added to the recovered groundwater. The pH will be adjusted to near neutral using carbon dioxide gas. A small amount of chlorine, approximately 3 mg/l, will be added to the injection solution to prevent bacterial plugging of the injection wells. Finally, oxygen and/or hydrogen peroxide will be added to serve as the oxidant. The resulting fortified solution will be injected into the wellfield and the recovered uranium laden liquid will be passed

through the ion exchange system to extract the uranium product. Once the resin in the ion exchange vessels is loaded it will be eluted. The elution liquid will be sent to the precipitation circuit where precipitation will be accomplished. The precipitated product will then be washed and transported to the dryer. After drying, the product will be placed in drums and shipped to a converter. Alternately, the product may be transported in a slurry configuration to a converter for further processing in the nuclear fuel cycle.

The well field will generally consist of repeating five or seven spot well patterns although variations will occur to conform to the natural shape of the ore body. The distance between wells will be 50 to 120 feet and the flowrate of each recovery well will be approximately 20 - 40 GPM depending upon the permeability of the localized area.

The injection rate of each injection well is planned to be in the range of 15 - 35 GPM. The total inflow and outflow of the well field will be controlled to allow a slight hydraulic depression to form in the well field by bleeding about one percent of the total recovery flow after the uranium values have been extracted. Waste water processing methods which may include electrodialysis, reverse osmosis, barium chloride precipitation, ion exchange purification, deep disposal well injection, surface discharge, and/or evaporation will be used to dispose of unwanted liquid.

Injection pressures in the well field will be controlled at 140 psig or less. During mining, recovery wells and injection wells may be reversed in function to take advantage of the flow path reversals and improved oxidation potential.

The proposed mine plan for the North Butte ore body is to extract the economically recoverable uranium using an estimated nine unit sequence. The mining units are labeled Mining Units I through IX. Mining Unit I will be mined initially, followed by each mining unit in order. While Mining unit II is being mined Mining Unit I will be in restoration. Once Mining Unit I is restored the restoration effort moves to Mining Unit II and then continues to III and so on. Table 15.1 below summarizes the anticipated mining and restoration sequence of the North Butte operation.

and to put pressure on the casing between the packers. The interval between the packers will be pressurized to the maximum injection pressure plus 20%.

At the North Butte project the maximum injection pressure is 140 psig or 90 percent of the tested formation fracture pressure (if higher than 140 psig). Each injection and production well casing will be required to maintain pressure within 10% of the initial test pressure for a period of 10 minutes. Figure 15.20 illustrates the packer system as it will be used to integrity test the wells. At no time will Pathfinder use an injection pressure greater than ninety (90) percent of the pressure rating of the casing.

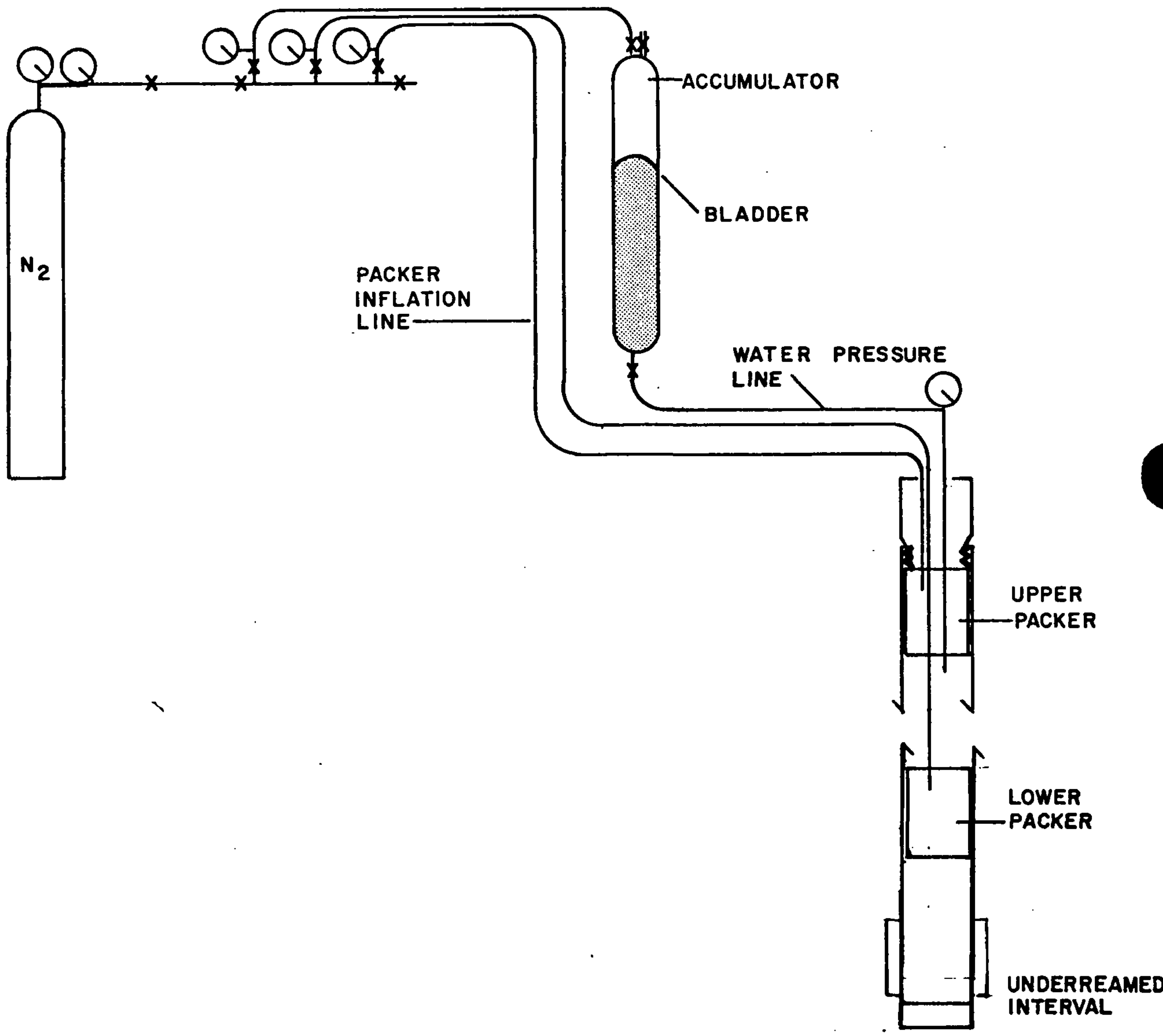
Method number two of well integrity testing will employ the casing cementing pressure/single point resistance test which has now been approved by the EPA and accepted by the NRC and DEQ.

Upon passing the integrity test, a well will be deemed acceptable for service. If a well should fail the integrity test, it will be retested. If a well continues to fail repeated tests, it will be retested. If a well continues to fail repeated tests, it will be declared unusable and will not be put into service. The problem well will be either repaired or retested, or abandoned by the proper procedure (see Section 17.3). A well must pass the integrity testing procedure before it can be used in the solution mining process. Records of integrity testing on all injection and production wells and monitor wells used in the mining process will be kept on the premises and will be available for inspection. Additionally, the integrity testing data will be submitted to the DEQ and the NRC on a calendar quarter basis.

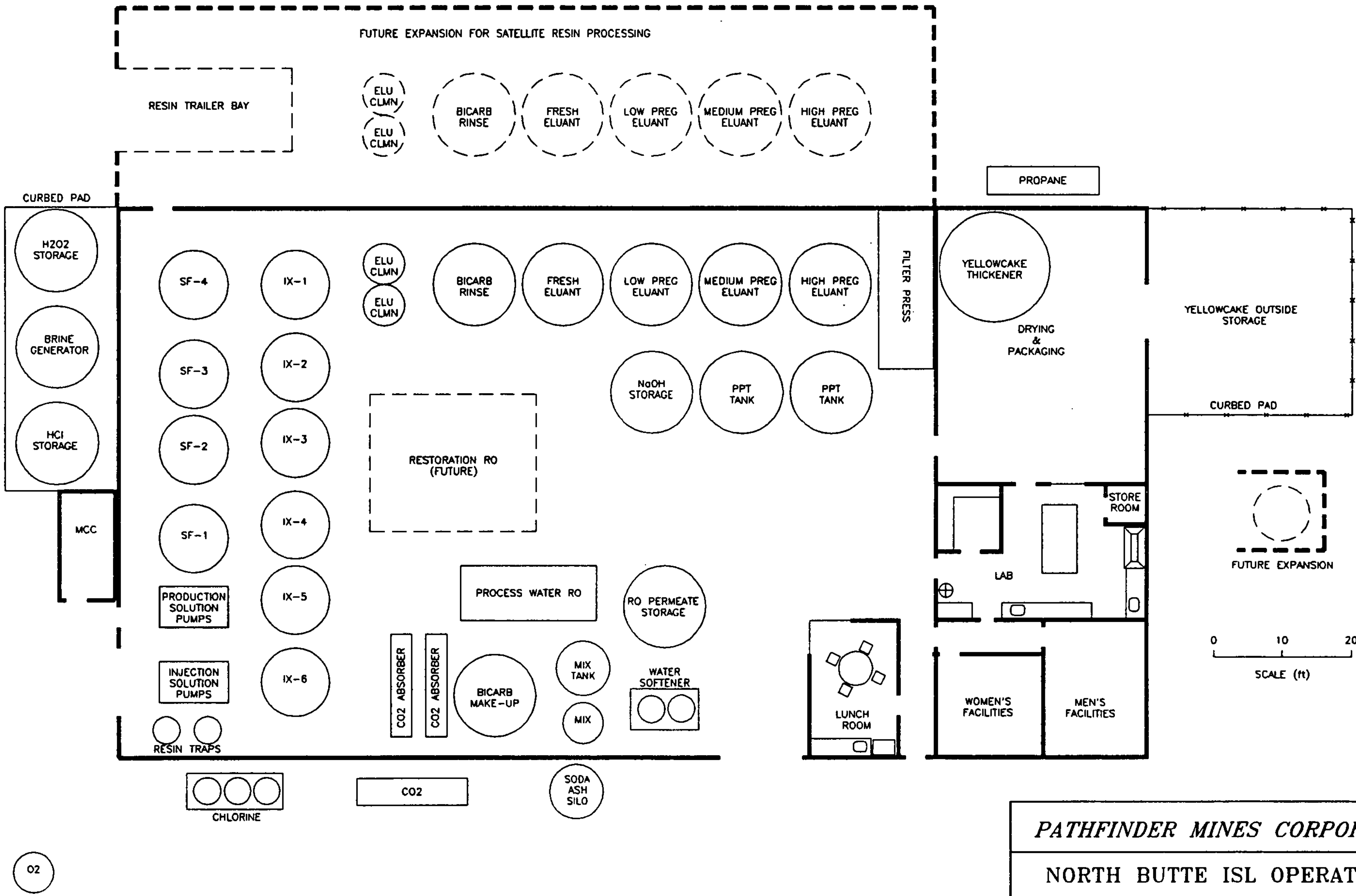
15.7 RECOVERY PROCESS

15.7.1 PLANT BUILDING AND PLANT FACILITIES LAYOUT

Most of the process equipment will be housed in an approximate 80 ft. by 150 ft. metal building with 20 ft. eaves height. As shown in Figure 15.21, the majority of the chemical storage tanks will be located outside the process building. Pathfinder has no plans to use surge tanks at this time.



URANERZ U.S.A., INC.		
NORTH BUTTE ISL PROJECT		
INTEGRITY TEST WITH DOUBLE PACKER		
GEOL: K. Mc Fall	SCALE: NONE	FIGURE: 15.20
DRAWN BY: P.S.	DATE: 4-11-86	



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PATHFINDER MINES CORPORATION

NORTH BUTTE ISL OPERATIONS

PROCESS PLANT GENERAL ARRANGEMENT

REVISED 03-01-92

Figure 15.21

The major equipment inside the process building will be the ion exchange circuit, the lixiviant make-up circuit, the elution/precipitation circuit, and the yellowcake drying facility. The water treatment system for aquifer restoration will also be located in the process building.

The office area, now planned to be approximately 40 ft. by 80 ft., will be located adjacent to the process building. The office area may be attached to the process building to allow use of a centralized lunch room and rest room facilities.

The yellowcake drying and drumming facilities will be located on one end of the process building. A yellowcake storage area will be located outside the yellowcake drying and packaging area on a curbed cement pad fenced with chain link fence.

15.7.2 PROCESS DESCRIPTION

15.7.2.1 URANIUM LEACHING

The proposed uranium in situ leaching process has been successfully tested at the Ruth R & D project and at other uranium solution mining properties in Wyoming and Texas. This process, involving the dissolution of the water soluble uranium compound from the mineralized host rock at neutral pH ranges, consists of two steps. First, the uranium must be oxidized from the tetravalent to the hexavalent state with an oxidant such as oxygen or hydrogen peroxide. Second, a chemical compound such as baking soda ($NaHCO_3$) is used to complex the uranium in the solution. The uranium enriched solution is transferred from the production wells to the processing facility nearby for uranium concentration with ion exchange resin.

15.7.2.2 LIXIVIANT COMPOSITION

The lixiviant for the in situ uranium leaching process will be a diluted sodium carbonate/bicarbonate aqueous solution. During the injection of lixiviant, oxygen or hydrogen peroxide will be added to oxidize the uranium underground. A small amount of chlorine, approximately 3 mg/l, will be added to the injection solution to prevent bacterial plugging of the injection wells. Carbon

15.7.3.2 ION EXCHANGE

A strong base resin will be used for the ion exchange of either the uranyl-dicarbonate complex, $[UO_2(CO_3)_2]^{2-}$ (UTC), or the more stable uranyl-tricarbonate complex, $[UO_2(CO_3)_3]^{4-}$ (UTC), in the process plant. The chemical reactions are:

$$[UO_2(CO_3)_3]^{4-} + 2R^{2+} = R_2[UO_2(CO_3)_3]^{4-}$$

$$[UO_2(CO_3)_2]^{2-} + R^{2+} = R[UO_2(CO_3)_2]^{2-}$$

R denotes the resin.

The barren lixiviant will be reconstituted to its proper bicarbonate strength prior to well field injection. Carbon dioxide will be used to adjust the pH to a range of 6.0 to 8.5 units. Sesqui-carbonate or soda ash will be used, if needed, to maintain proper sodium bicarbonate strength.

15.7.3.3 ELUTION PROCESS AND RESIN HANDLING

The resin is ready for elution when it is fully loaded with uranium. The elution process reverses the chemical reactions and strips the uranium off the resin. The eluant will be a salt and soda ash mixed solution. The chemical reactions are:

$$R_2[UO_2(CO_3)_3]^{4-} = 2R^{2+} + [UO_2(CO_3)_3]^{4-}$$

$$R[UO_2(CO_3)_2]^{2-} = R^{2+} + [UO_2(CO_3)_2]^{2-}$$

The elution circuit at the North Butte ISL facility will be designed to also accept and elute the uranium loaded resin from the other satellite operations. A special designed and DOT approved trailer will be used for the resin transportation. The resin elution process for the other satellite operations will take place in the trailer while at the North Butte mine. The uranium loaded solution (eluate) will be blended into the North Butte precipitation circuit where it will lose its identity.

Concentrated carbonate/bicarbonate or sulfate solution may be used to replace the chloride ion on the freshly eluted resin. The process may reduce the amount of chloride ion present in the leach solution. The anticipated chemical reactions are:

$$RCl_2 + 2HCO_3^- = R(HCO_3)_2 + 2Cl^-$$

$$RCl_2 + CO_3^{2-} = RCO_3 + 2Cl^-$$

$$RCl_2 + SO_4^{2-} = RSO_4 + 2Cl^-$$

15.7.3.4 YELLOWCAKE PRODUCTION

The yellowcake will be produced from the eluate from North Butte and possibly from other uranium mining projects.

The eluate from the elution circuit will be decarbonated with acid to below pH 3. The yellowcake product will be precipitated with hydrogen peroxide and sodium hydroxide.

Decarbonation $[UO_2(CO_3)_3]^{4-} + 6H^+ = UO_2^{2+} + CO_2 + 3H_2O$

$[UO_2(CO_3)_2]^{2-} + 4H^+ = UO_2^{2+} + 2CO_2 + 2H_2O$

Precipitation $UO_2^{2+} + H_2O_2 + 4H_2O = UO_4 \cdot 4H_2O + 2H^+$

The precipitate will be transferred to a filter where excess liquid will be separated. The product cake can then be transferred to the dryer which further reduces the amount of moisture.

15.7.4 FLOW AND MATERIAL BALANCE

The ion exchange system for the North Butte mine is designed to accomodate flowrates in the range of 2,500 GPM up to 4,000 GPM. In order to contain the lixiviant inside the leaching area, a

small portion of the barren solution is withdrawn from the ion exchange circuit. The amount of bleed is estimated to be 1% of the total flowrate or equivalent to about 25 to 40 GPM.

The bleed solution will be used to clean-up freshly eluted resin, make-up fresh eluant in the elution circuit, and wash yellowcake if necessary. The overall flow and material balances for the North Butte ISL mine, based on the maximum flow rate of 4,000 GPM, are presented in Figure 15.22.

15.7.5 PLANT EQUIPMENT, INSTRUMENTATION AND CONTROL

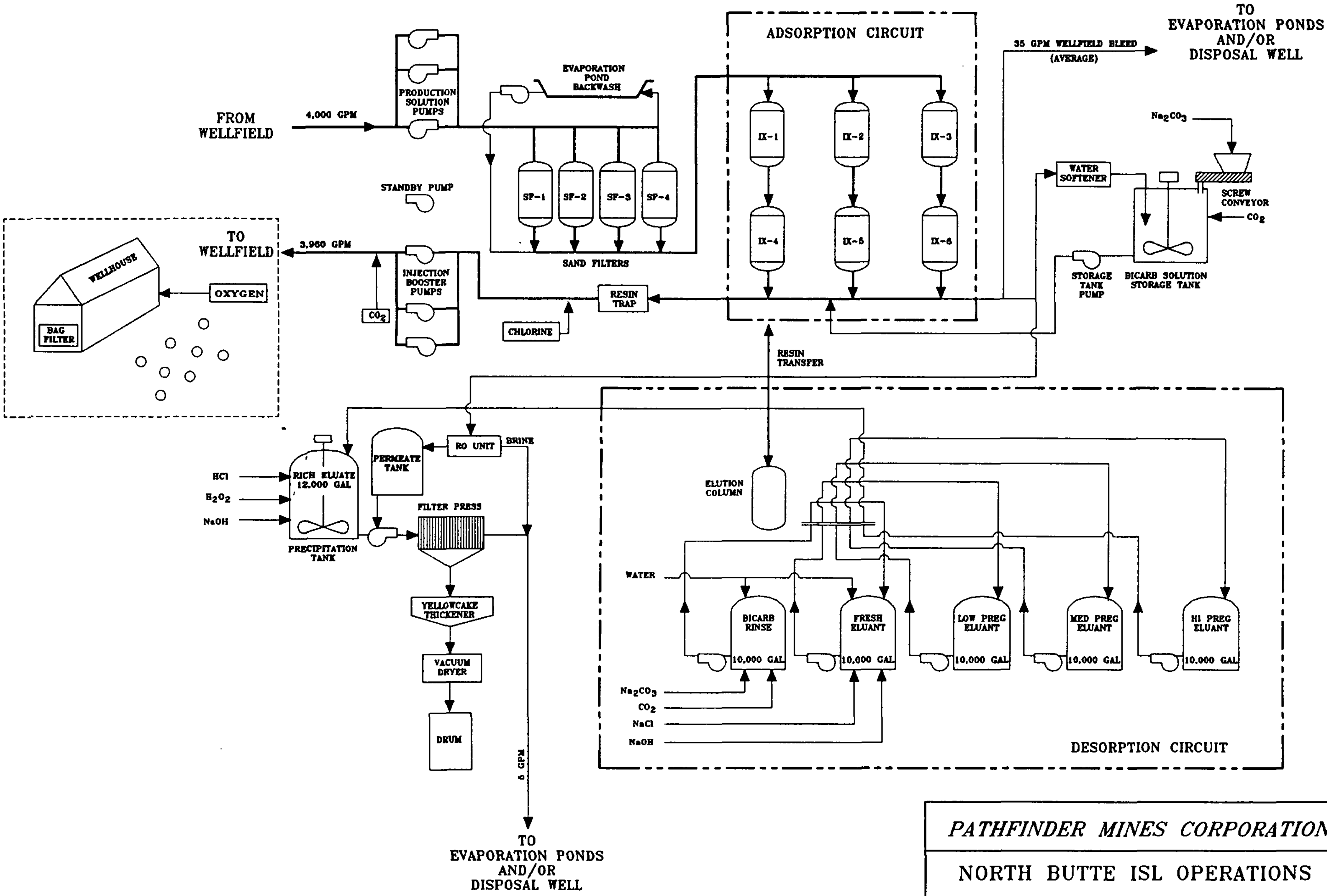
The plant equipment at the North Butte ISL project will consist of standard design, construction, and materials for uranium solution mining. Pathfinder plans to install automated devices for the plant circuits to minimize the operator coverage. Most of the operating parameters will be preprogrammed and the information will be recorded in a timely fashion. The partially automated system will include alarms and shutoffs to prevent overflows, over pressurizations, and spills.

15.8 SOURCES OF PLANT LIQUID EFFLUENTS AND DISPOSAL METHODS

For the mining operation there are three types of liquid effluent which constitute the approximate 1% bleed, or about 25 to 40 GPM from the wellfield: 1) the wellfield bleed, 2) the elution circuit bleed, and 3) the general plant waste (resin wash, filter backwash, etc.). A small quantity of water, about 1 to 2 GPM may be introduced from a domestic well for plant wash down and yellowcake wash. See Section 10.4.2.

For the restoration operation reverse osmosis or other purification technologies will be used to treat most of the leached solution from the spent mining unit. The groundwater restoration plan is discussed in detail in Section 17. For a typical restoration schedule, the anticipated liquid effluent flow rates are:

	Pore Volume	Net Water Consumption
1st month	1st	0 GPM
2nd month	2nd	300 GPM
3rd month	3rd thru 6th	60 GPM



PATHFINDER MINES CORPORATION

NORTH BUTTE ISL OPERATIONS

PROCESS FLOW SHEET

REVISED 03-01-92

Figure 15.22

19.8 ATMOSPHERIC DISPERSION COMPUTER PROGRAM RESULTS

The atmospheric radiation dispersion computer model used for the North Butte project is called MILDOS. Uranerz originally used MILDOS to estimate the radiological concentrations resulting from the planned is situ operations at the North Butte and Ruth ISL projects, but at flow rates of 3,000 GPM and 1,000 GPM respectively. Pathfinder has repeated the MILDOS runs for the North Butte and Ruth projects, but with several changes. These changes include an increase in flow rate for the North Butte up to 4,000 GPM; and increase in flow rate for the Ruth up to 2,000 GPM; the deletion of surge tanks at the processing plant as a major source of radon emissions; and the addition of radon emissions from the wellfield areas due to the venting of gases at the wellheads. The operational plan for the Ruth facility states that there will not be a dryer on-site and that uranium loaded resin will be shipped to an NRC licensed mine for final processing. Accordingly, the MILDOS modeling for the satellite Ruth facility was incorporated into the model run for the North Butte facility which will receive the uranium loaded resin. This also provides a worst-case-scenario for modeling of the North Butte site (maximum emissions with Ruth operating). Background data and operational information from the Ruth project were included in the North Butte model run after the procedure was discussed in advance and approval was received from the NRC, Uranium Recovery Field Office.

Six MILDOS computer runs were made with three addressing 10 CFR 20 requirements and three addressing 40 CFR 190 requirements. The conclusions of the assessment are as follows:

- The whole body dose to the most exposed resident in the North Butte/Ruth project area will be less than 0.5 mRem per year or approximately 0.5% of the allowable limit (100 mRem/yr.).
- The highest concentration of radon-222 gas at the permit boundary is only 0.84 pCi/l and the fraction of equilibrium is less than 10%. These values allow Pathfinder to propose a concentration higher than that specified in 10 CFR 20 for the allowable concentration at the permit boundary.
- The radon-222 emissions from the Ruth site have no impact on the total annual dose to the nearest resident at North Butte.
- The regional impact of full production operations at North Butte and Ruth combined (both radon-222 and airborne particulate) result in a whole body dose to the most exposed resident of only between 0.2 and 0.4 mRem/year.

The meteorological data which were input for the MILDOS model were the October 1978 through September 1979 data set. These data were collected by AeroVironment for Cleveland Cliffs Iron Company for a proposed uranium mining/milling operation at the North Butte site. The data set included hourly average wind speed, wind direction, and sigma theta values collected at the 10 meter exposure level. These data were processed to produce hourly stability classifications using the EPA Guideline on Air Quality Modeling, 1986, pages 9-17 through 9-22. This technique uses sigma theta data along with wind speed to estimate the Turner Stability Classes.

The following report is the MILDOS program supplement, prepared by Resource Technologies Group and Enecotech for Pathfinder Mines Corporation. The actual computer runs are not included due to the bulk of the material. These are available for inspection by any interested individual.

PATHFINDER MINES CORPORATION
ATMOSPHERIC DISPERSION COMPUTER PROGRAM RESULTS
NORTH BUTTE AND RUTH PROJECTS 3-31-92

1.0 RADIOLOGICAL EFFECTS

The proposed action is the permitting of the North Butte in-situ uranium operation with an average production flow rate of 4,000 gpm and the Ruth in-situ uranium operation (located 13 miles south-southwest of the North Butte project) with an average production flow rate of 2,000 gpm. The restoration flow at North Butte will be 150 gpm and the restoration flow at the Ruth Site will be 75 gpm. The annual Radon-222 released at North Butte will be 3,241 Ci and the annual release at Ruth will be 1,423 Ci. (See Appendix A Site Specific Information and Source Term Calculation).

The proposed production rate at the North Butte Site is 700,000 pounds of U_3O_8 per year and the proposed production rate at the Ruth Site is 300,000 pounds of U_3O_8 per year. All of the U_3O_8 produced will be dried at the North Butte Site, utilizing a rotary vacuum dryer. A vacuum dryer works of the principal that gases or particulates released during drying are collected in a liquid condenser and there is no release of air particulates. The condensate is then transferred to the precipitation circuit. The effluent collection efficiency for vacuum dryers is estimated by the manufacturers at 100% and no U_3O_8 air particulates are anticipated. This will be verified by measurement during operation of the vacuum dryer. Since the air particulate release data are not available at present, the applicant will use the default value for U_3O_8 releases from a conventional dryer for purposes of this radiological evaluation. The default value is 0.1% of the total throughput of the dryer.

1.1 Exposures for Air Pathways

The radioactive emissions from the proposed project will be radon-222 from the Ruth Site and radon-222 and potentially airborne particulates from the North Butte Site. The radiation dose from these unpressurized emissions was calculated using the computer simulation, MILDOS. The joint frequency data compiled from a site specific meteorological station were used to define the atmospheric conditions in the project area. The data from the MILDOS runs were also used to estimate the concentration of radon-222 gas at the permit boundary and to estimate the fraction of equilibrium. All radon gas will be released during operations; 75% will be released in the wellfield due to venting and the remaining 25% will be released at the process plant at unpressurized tanks. A total of 8 MILDOS simulations were run and the following conditions were evaluated.

(a) A 10 CFR 20 run was made to evaluate the fraction of MPC at the nearest resident to North Butte and to evaluate the MPC fraction at 43 positions along the North Butte Site Permit Boundary. The concentration of radon-222 gas and the fraction of equilibrium was also evaluated.

This run also assumed that the radon-222 would be released from Mine Units 7, 8 and 9. These Mine Units were chosen to represent the worst case since they are the closest to the nearest resident and these Units are also closest to the Permit Boundary. This simulation was run both with and without the contribution of radon-222 from the Ruth Site. The results were identical which indicates no increase in dose to the nearest resident at North Butte as a result of operations at the Ruth Site.

The discharge point for the U_3O_8 particulate was assumed to be a stack at the processing facility. The receptor locations are shown in Figure 1.

(b) A modified 40 CFR 190 run was made to determine the total annual dose at the nearest residences and at the 43 positions on the North Butte permit boundary. (A normal 40 CFR 190 run does not include radon-222 and this run was modified to include dose from airborne U_3O_8 and from radon-222). The conditions for this run were identical to (a), including a run with and without the contribution from the Ruth Site.

(c) A 10 CFR 20 simulation was conducted using Mine Units 1, 2, 3, 4, and 5 as the wellfield source of radon-222 and a stack at the processing facility as the source for airborne U_3O_8, and radon-222 emitted at the process facility. This simulation was run to determine the fraction of MPC at the nearest residence and to determine the radon-222 concentration and fraction of equilibrium at the Permit Boundary. The receptor locations are shown in Figure 1. As in earlier runs, it was assumed that 75% of the radon-222 was released in the wellfield and 25% was released at the process facility.

(d) A modified 40 CFR 90 simulation was conducted to determine the total annual dose at the nearest residences and at the North Butte Permit Boundary. The conditions used for this simulation are identical to those found in (c).

(e) A 10 CFR 20 simulation was conducted to determine the impact of simultaneous operation of the North Butte and Ruth Sites on all residences in the area. This simulation assumed that both sites were in full operation and that the maximum amount of radon-222 was being released and that the dryer at North Butte was processing 1,000,000 pounds of U_3O_8 per year. The data from this simulation were used to

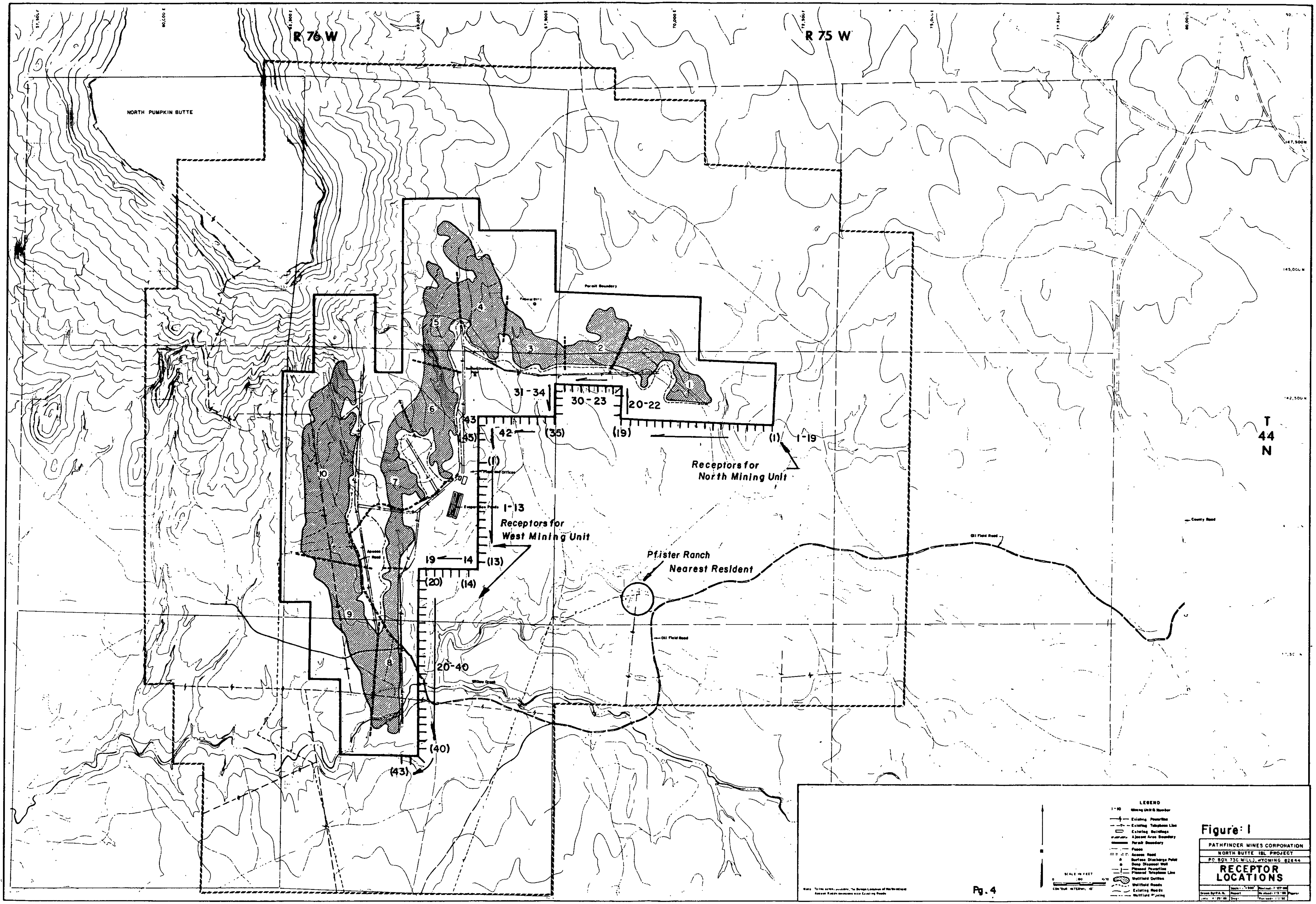


Figure: I

PATHFINDER MINES CORPORATION
NORTH BUTTE ISL PROJECT
PO BOX 730 MILLS, WYOMING 82644

RECEPTOR LOCATIONS

determine the fraction of MPC at the residences and to determine the concentration and fraction of equilibrium of radon-222 at the Permit Boundary. The coordinates for these receptor locations are listed in Table 1.

(f) A modified 40 CFR 90 simulation was conducted to determine the total annual dose to residences in the North Butte and Ruth project area. The conditions used for this simulation are identical to those found in (e).

1.2 Results of MILDOS Simulation

Table 2 shows a comparison of the MPC fraction for all isotopes in the U-238 decay chain (U-238 to Po-210) at the nearest North Butte resident obtained for mining in the West Mine Units and the North Mine Units, and also for mining concurrently at the Ruth Site. The data clearly show that the MPC fraction from the West Mine Units is approximately three times higher than the MPC fraction from the North Mine Units. It should be noted that the fraction of MPC observed was identical when a simulation was run with and without the Ruth Site.

The largest fraction MPC at a residence is only 1.45% of the allowable 10 CFR 20 limit, which would be the sum of allowable MPC for all isotopes in the U-238 decay chain.

Table 3 shows the highest concentrations of radon-222 observed at the permit boundary and the working level concentration when the Western Mine Units were simulated. Table 3 also shows the highest concentrations observed when the North Mine Units were simulated. A review of these data shows that the maximum radon-222 concentration at the site boundary was 0.84 pCi/l with a Working Level (WL) concentration of 0.0008/WL. This indicates that the fraction of equilibrium is approximately 10%. A comparison of this result to the limits specified in 10 CFR 20

TABLE 1

INDIVIDUAL RECEPTOR LOCATIONS

	LOCATION NAMES	X(KM)	Y(KM)	Z(M)	DIST(KM)
1	North 100 meters	.00	.10	.00	.10
2	East 100 meters	.10	.00	.00	.10
3	South 100 meters	.00	-.10	.00	.10
4	West 100 meters	-.10	.10	.00	.14
5	Pumpkin Butte Ranch	4.29	-4.48	1.00	6.20
6	W. Schlautmann Ranch	6.20	5.33	1.00	8.18
7	L. Gilberts Ranch	9.96	3.60	1.00	10.59
8	Earl Camblin Ranch	10.87	-1.16	1.00	10.93
9	John Groves	9.81	7.89	1.00	12.59
10	Town of Savagetown	11.48	10.03	1.00	15.24
11	Ruby Ranch	11.70	-4.60	1.00	12.57
12	Jack Christensen	-4.99	- .33	1.00	5.00
13	Bud Christensen	.51	11.25	1.00	11.26

TABLE 2

Comparison of MPC Fraction from West and North Mining Units at the Nearest Resident (Pfister Ranch)

	West M.U.	North M.U.
R-1	1.41E-02	4.27E-03
R-2	1.45E-02	4.15E-03
R-3	1.44E-02	3.94E-03

Note: MPC fraction shown is based on the fraction of allowable MPC for all isotopes in the U-238 decay chain.

West M.U. = Assumes mining in West MU; 25% of radon-222 from process plant, 75% from wellfields and all U_3O_8 from stack. Includes all radon-222 from Ruth.

North M.U. = Assumes mining in North MU; 25% of radon-222 from process plant, 75% from wellfields and all U_3O_8 from stack. Includes all radon-222 from Ruth.

TABLE 3

Rn-222 Concentration and Working Level from Western Mine Units at Permit Boundary

Receptor Coordinates X(KM)	Receptor Coordinates Y(KM)	Rn-222	WL	% Equil.
.08	-.08	0.63 pCi/l	.00031	4.9
.08	-.13	0.46	.00034	7.4
.08	-.18	0.46	.00036	7.8
.08	-.23	0.26	.00031	8.4

Rn-222 Concentration and Working Level from Northern Mine Units at Permit Boundary

X(KM)	Y(KM)	Rn-222	WL	% Equil.
.71	.58	0.81	.00084	10.4
.66	.58	0.78	.00084	10.8
.61	.58	0.74	.00086	11.6
.56	.58	0.71	.00079	11.1
.53	.58	0.84	.00081	9.6
.53	.53	0.72	.00066	9.2

(FR Vol 56, No. 98, Tuesday, May 21, 1991) indicates that the applicant should propose a concentration of approximately 2.3 pCi/l of radon-222 gas above background at the Permit Boundary. This is the concentration of radon-222 which at 10% of equilbrium will result in a dose to the general public of 100 mRem whole body dose. (Note: The radon-222 daughter dose for 10% equilibrium was calculated from a NRC document authored by Dennis Sollenberg. A copy of this document is found in Appendix B.

Table 4 and Table 5 show the whole body dose calculated by MILDOS for the nearest resident to the North Butte Site. Table 4 shows the dose during mining in the Western Mining Units and with the vacuum dryer processing 1,000,000 pounds per year of U_3O_8. Table 5 shows the dose during mining in the Northern Mine Units with the vacuum dryer processing 1,000,000 pounds per year of U_3O_8. These tables also include any contribution from the radon-222 release at the Ruth Site. A review of the data indicates that in the worst case, the most exposed resident will receive a whole body dose of less than 0.5 mRem per year, which is approximately 0.5% of the allowable limit.

Table 6 shows the Total Annual Whole Body Dose Commitment computed for the ranches and town in the vicinity of the North Butte and Ruth Sites. The locations of these receptors were given in Table 1. This Whole Body dose commitment was calculated assuming that the Northern Mine Units at North Butte were in full production; that Ruth was in full production, and that the dryer at North Butte was in full production (1,000,000 pounds/year). There should be no significant difference in regional dose based on whether the Northern or Western Mine Units are operational. The only significant difference will be at the Pfister Ranch and this is noted in Table 6.

TABLE 4

Total Annual Dose to Nearest Resident at North Butte Using Western Mining Units and Contribution from Ruth

		Whole Body Dose (mRem/yr)	Allowable Limit Whole Body Dose (mRem/yr)
R-1	Infant	4.27E-01	100
	Child	4.46E-01	
	Teenager	4.07E-01	
	Adult	3.98E-01	
R-2	Infant	4.35E-01	
	Child	4.54E-01	
	Teenager	4.15E-01	
	Adult	4.06E-01	
R-3	Infant	4.25E-01	
	Child	4.43E-01	
	Teenager	4.05E-01	
	Adult	3.97E-01	

Note: Three receptors were used to estimate the dose at the nearest resident (Pfister Ranch) to test for local variability. As can be seen from the data, no significant variability was noted.

TABLE 5

Total Annual Dose to Nearest Resident at North Butte Using Northern Mining Units and Contribution from Ruth

		Whole Body Dose (mRem/yr)	Allowable Limit Whole Body Dose (mRem/yr)
R-1	Infant	1.41E-01	100
	Child	1.49E-01	
	Teenager	1.32E-01	
	Adult	1.28E-01	
R-2	Infant	1.38E-01	
	Child	1.46E-01	
	Teenager	1.29E-01	
	Adult	1.25E-01	
R-3	Infant	1.31E-01	
	Child	1.39E-01	
	Teenager	1.22E-01	
	Adult	1.19E-01	

Note: Three receptors were used to estimate the dose at the nearest resident (Pfister Ranch) to test for local variability. As can be seen from the data, no significant variability was noted.

TABLE 6

Total Annual Dose Commitment in the Vicinity of North Butte and Ruth Sites Assuming Both Properties are in Full Production and Dryer is in Operation

	Whole Body Dose mRem/yr.[1]			
Receptor ID	Infant	Child	Teenager	Adult
# 4 - Pfister Ranch (North M.U.)	1.41E-01	1.49E-01	1.32E-01	1.28E-01
# 4 - Pfister Ranch (West M.U.)	4.27E-01	4.46E-01	4.07E-01	3.98E-01
# 5 - Pumpkin Butte	7.38E-02	7.52E-02	7.32E-02	7.28E-02
# 6 - W. Schlantmann Ranch	7.48E-02	7.61E-02	7.44E-02	7.42E-02
# 7 - L. Gilberts Ranch	6.45E-02	6.56E-02	6.46E-02	6.44E-02
# 8 - E. Camblin Ranch	7.58E-02	7.71E-02	7.59E-02	7.57E-02
# 9 - John Groves	4.77E-02	4.87E-02	4.77E-02	4.75E-02
#10 - Town of Savageton	3.88E-02	3.98E-02	3.89E-02	3.88E-02
#11 - Ruby Ranch	4.46E-02	4.55E-02	4.46E-02	4.45E-02
#12 - Jack Christensen	1.66E-01	1.68E-01	1.66E-01	1.65E-01
#13 - Bud Christensen	4.68E-02	4.76E-02	4.68E-02	4.67E-02

[1] Whole Body Dose Limit for Unrestricted Area is 100 mRem/year.

A review of the data shows that the most exposed person will receive between 0.2 and 0.4 mRem per year which is less than 0.2% to 0.4% of the allowable limit of 100 mRem/year whole body dose.

1.3 Summary

A summary of the evaluation of the radiological effects of the North Butte and Ruth Projects follows:

- The whole body dose to the most exposed resident in the North Butte/Ruth Project area will be less than 0.5 mRem per year or approximately 0.5% of the allowable limit of 100 mRem/year whole body dose.

- The highest concentration of radon-222 gas at the permit boundary is 0.84 pCi/l and the fraction of equilibrium is less than 10%. These values allow the applicant to propose an allowable concentration of 2.3 pCi/l of radon-222 at the Permit Boundary to assure that the dose at the Permit Boundary will not exceed the allowable limit of 100 mRem/year exposure to the general public.

- The radon-222 emissions from the Ruth Site have no impact on the Total Annual Dose to the nearest resident at North Butte.

- The major influence on the dose to the nearest resident at the North Butte Site (Pfister Ranch) is the location of the local area being mined. Mining in the western area results in a whole body dose of approximately 0.45 mRem/year (for a child) compared to a dose of 0.15 mRem/year (for a child) when the northern area is being mined.

- The regional impact of which area is being mined at North Butte should be minimal. This is based on the results obtained when the impact of operations at the Ruth Site was tested on the North Butte nearest resident. No measurable increase in dose was obtained.

APPENDIX A

APPENDIX A
SITE SPECIFIC INFORMATION
RUTH AND NORTH BUTTE ISL PROPERTIES

	Ruth	North Butte
Average ore quality, U_3O_8, in ore body	0.204	0.236
Ore Radon-222 activity (2820 pCi/1% U_3O_8)	575	666
Operating days per year	365	365
Average production flow rate	2,000	4,000
Formation porosity	28%	28%
Process recovery	95%	95%
Leaching efficiency	70%	70%
Rock density	1.91	1.91
Restoration flow rate	75 gpm	150 gpm
Dimensions of ore body		
Area per year to be mined	23 acres	44.9 acres
Average thickness of body	6.5 feet	6.5 feet
Average screened interval	6.5 feet	6.5 feet
Production cell parameters:		
residence time - production	4.7 days	4.6 days
residence time - restoration	63 days	41 days
type of cell pattern	nominal 5 spot	nominal 5 spot
Radius	71 feet	71 feet
Average cell flow rate - production	20 gpm	20.5 gpm
Annual Rn-222 emission from production and restoration	1423 Ci/year	3241 Ci/year
Source stack description: (Radon Vent)		
Stack height	30 inches	23 inches
Stack diameter	5 inches	4 inches
Stack exit velocity	.02 m/sec	2 m/sec
Source stack description: (Dryer)		
Stack height	N/A	40 feet
Stack diameter	N/A	4 inches

Calculation of Annual Radon Emissions
Proposed North Butte and Ruth Projects

---

1) Assume that U-238 is in equilibrium with all decay products. The radon equivalency values would be 666 pCi/g at North Butte and 575 pCi/g at Ruth.

2) **Radon Release (G)**

$G = R \quad E\,(1\text{-}p)/p \times 10^{-6}$

G = Radon release, Ci/m^3 of rock

R = Radium (Radon) content

ρ = Rock density

E = Emanating Power (0.2)

p = Formation Porosity

Ruth Site

$$G = (575\ pCi/g)(1.91\ g/cm^3)(0.2)\frac{(1-0.28)}{.28} \times 10^{-6}$$

$G = 5.65 \times 10^{-4}\ Ci/m^3$ of rock

North Butte Site

$$G = (666\ pCi/g)(1.91\ g/cm^3)(0.2)\frac{(1-0.28)}{.28} \times 10^{-6}$$

$G = 6.54 \times 10^{-4}\ Ci/m^3$ of rock

The yearly radon release from mining will then be:

3) $Y = GM\epsilon D \times 1.44$

Y = Yearly Rn Release (Ci/yr)

M = Lixiviant production rate (liters/min)

ϵ = Equilibrium factor for Rn

D = Production days per year

Ruth Site

Equilibrium Factor $= 1 - e^{-\lambda t}$

$\lambda =$ decay constant (0.181/day)

t = residence time

Production Residence Time

$$t = \frac{100 \text{ ft} \times 100 \text{ ft} \times 6.5 \text{ ft} \times .28 \times 7.48 \text{ gal/ft}^3}{20 \text{ gpm} \times 1440 \text{ min/day}} = 4.7 \text{ days}$$

Equilibrium Factor $= 1 - e^{(-0.181)(4.7)}$

$\epsilon = 1 - e^{-0.85}$

$\epsilon = 1 - 0.43$

$\epsilon = 0.57$

Y = $(5.65 \times 10^{-4}$ Ci/m^3)(7570 lpm)(0.57)(365)(1.44)

Y = 1,281 Ci/year

North Butte Site

Equilibrium Factor $= 1 - e^{-\lambda t}$

Production Residence Time

$$t = \frac{100 \text{ ft} \times 100 \text{ ft} \times 6.5 \text{ ft} \times .28 \times 7.48 \text{ g/ft}^3}{20.5 \text{ gpm} \times 1440 \text{ min/day}}$$

t = 4.6 days

Equilibrium Factor $= 1 - e^{(-0.181)(4.6)}$

$= 0.56$

Y = $(6.54 \times 10^{-4}$ Ci/m^3)(15,140)(0.56)((365)(1.44)

Y = 2,914 Ci/year

The annual radon release from restoration will be:

4) **Ruth Site**

r = GNϵ D x 1.44 where N = restoration solution rate in liters/min

$\epsilon = 1 - e^{-\ \ t}$ where t = 63 days

$\epsilon = 1 - e^{-11.4}$

$\epsilon = 1 - 1.1 \times 10^{-4}$

$\epsilon = 1$

Note: Calculation of t based on 75 gpm total flow from 50 patterns or 1.5 gpm/pattern.

r = $(5.65 \times 10^{-4}$ Ci/m^3)(284 l/min)(1)(365)(1.44)

r = 84 Ci/year

North Butte Site

Assumes 65 patterns at a flow of 150 gpm or 2.3 gpm/pattern
Residence time (t) = 41 days
$\epsilon = 1 - e^{-(.181)(41)}$
$\epsilon = 1 - 6 \times 10^{-4}$
$\epsilon = 1$
$r = GN\epsilon D \times 1.44$
$r = (6.54 \times 10^{-4}\ Ci/m^3)(568\ l/min)(1)(365)(1.44)$
$r = 195$ Ci/year

The start-up solution radon release will be:

5) $S = GATp$
A = Area of mining unit (m^2)
t = Thickness of ore (m)
p = porosity
G = Radon release (pCi/m^3)

Ruth Site

$S = GATp$
$S = (5.65 \times 10^{-4}\ pCi/m^3)(23\ acres)(4074\ m^2/acre)(1.98\ m)(.28)$
$S = 29$ Ci/year

North Butte Site

$S = GATp$
$S = (6.54 \times 10^{-4}\ pCi/m^3)(44.9\ acres)(4074\ m^2/acre)(1.98\ m)(.28)$
$S = 66$ Ci/year

The total yearly releases from all sources will be:

6)		Ruth	North Butte
	Start-up solution	29 Ci/year	66 Ci/year
	Production	1281 Ci/year	2914 Ci/year
	Restoration	84 Ci/year	195 Ci/year
*	Restoration Start-up	29 Ci/year	66 Ci/year
		1423 Ci/year	3241 Ci/year

* NUREG/CR-4088 requires that a restoration start-up be included

APPENDIX B

RADON DAUGHTER DOSE - EFFECTIVE DOSE EQUIVALENT (RDD-EDE) [1]

(REM)

FRACTIONS OF EQUILIBRIUM

Rn Conc [2] (pCi/L)	Rn-EDE [3] (mrem)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.05	0.01
10.0	50.0	4.400	3.960	3.520	3.080	2.640	2.200	1.760	1.3200	0.8800	0.4400	0.2200	0.04400
9.0	45.0	3.960	3.564	3.168	2.772	2.376	1.980	1.584	1.1880	0.7920	0.3960	0.1980	0.03960
8.0	40.0	3.520	3.168	2.816	2.464	2.112	1.760	1.408	1.0560	0.7040	0.3520	0.1760	0.03520
7.0	35.0	3.080	2.772	2.464	2.156	1.848	1.540	1.232	0.9240	0.6160	0.3080	0.1540	0.03080
6.0	30.0	2.640	2.376	2.112	1.848	1.584	1.320	1.056	0.7920	0.5280	0.2640	0.1320	0.02640
5.0	25.0	2.200	1.980	1.760	1.540	1.320	1.100	0.880	0.6600	0.4400	0.2200	0.1100	0.02200
4.0	20.0	1.760	1.584	1.408	1.232	1.056	0.880	0.704	0.5280	0.3520	0.1760	0.0880	0.01760
3.0	15.0	1.320	1.188	1.056	0.924	0.792	0.660	0.528	0.3960	0.2640	0.1320	0.0660	0.01320
2.0	10.0	0.880	0.792	0.704	0.616	0.528	0.440	0.352	0.2640	0.1760	0.0880	0.0440	0.00880
1.0	5.0	0.440	0.396	0.352	0.308	0.264	0.220	0.176	0.1320	0.0880	0.0440	0.0220	0.00440
0.9	4.5	0.396	0.356	0.317	0.277	0.238	0.198	0.158	0.1188	0.0792	0.0396	0.0198	0.00396
0.8	4.0	0.352	0.317	0.282	0.246	0.211	0.176	0.141	0.1056	0.0704	0.0352	0.0176	0.00352
0.7	3.5	0.308	0.277	0.246	0.216	0.185	0.154	0.123	0.0924	0.0616	0.0308	0.0154	0.00308
0.6	3.0	0.264	0.238	0.211	0.185	0.158	0.132	0.106	0.0792	0.0528	0.0264	0.0132	0.00264
0.5	2.5	0.220	0.198	0.176	0.154	0.132	0.110	0.088	0.0660	0.0440	0.0220	0.0110	0.00220
0.4	2.0	0.176	0.158	0.141	0.123	0.106	0.088	0.070	0.0528	0.0352	0.0176	0.0088	0.00176
0.3	1.5	0.132	0.119	0.106	0.092	0.079	0.066	0.053	0.0396	0.0264	0.0132	0.0066	0.00132
0.2	1.0	0.088	0.079	0.070	0.062	0.053	0.044	0.035	0.0264	0.0176	0.0088	0.0044	0.00088
0.1	0.5	0.044	0.040	0.035	0.031	0.026	0.022	0.018	0.0132	0.0088	0.0044	0.0022	0.00044

[1] Based on a dose conversion factor (DCF) of 0.44 rem/pCi/L of effective radon daughter concentration.
The radon daughter dose is computed as follows:

RDD-EDE (rem) = Rn Conc x fraction of equilibrium x 0.44 rem/pCi/L.

Example: 10 pCi/L (Rn Conc) x 1.0 (100% equilibrium) x 0.44 rem/pCi/L = 4.4 rem.

[2] This is Rn-222 concentration alone.

[3] This is the EDE of Rn-222 alone without daughters (mrem).

TES:
1. The above table values reflect 100 % occupancy.
2. The DCF is taken from ICRP-50, Table 4 adjusted for occupancy (8760 hours); this results in the use of the DCF mentioned in footnote 1 -- 0.44 rem/pCi/L.
3. The total dose is the sum of the Rn-EDE and the RDD-EDE. At 100 % equilibrium, 1 % of the dose is from Rn-222 alone and 99 % is from the radon daughters.

Example: At 10 pCi/L at 100% equilibrium (Fraction of equilibrium = 1.0), the total dose is computed as:

50 mrem (Rn-EDE) + 4.4 rem RDD-EDE = 4.45 rem.

INDEX
PERMIT TO MINE NO. 632 - NORTH BUTTE ISL PROJECT

CHANGE NO. ____

Relocation of Process Plant and Evaporation Ponds
Detailed Engineering and Geotechnical Analysis - Evaporation Ponds

Description of Change:

Pathfinder Mines Corporation wishes to make revisions to the North Butte Mine plan consistent with planned Pathfinder operations. One of the revisions is to relocate the processing plant and associated evaporation ponds to a site more centrally located with respect to all wellfields. Additionally, Pathfinder plans to construct only two evaporation ponds rather than the three proposed by Uranerz, U.S.A. With this change request, Pathfinder has incorporated into the mine plan detailed engineering descriptions and drawings for the two evaporation ponds, as well as revised topsoil salvage volumes for the new plant site and pond area. The site specific geotechnical studies and engineering designs for these ponds have been developed in full consideration of the criteria and requirements of the U.S. Nuclear Regulatory Commission (Regulatory Guide 3.11), as well as the WDEQ and State Engineer's Office. The design report, prepared by Western Water Consultants, is incorporated into the application document with this change request.

Pathfinder has proposed two designs for the evaporation ponds. These include an option for a single synthetic liner, with a compacted clay bottom to serve as a secondary liner, with a sand/gravel leak detection system between the two liners. The second option is a two synthetic liner system with a geonet leak detection system between the two liners. Pathfinder prefers the first option because the design is the standard uranium ISL evaporation pond used at many other operations which has a proven track record with respect to operations and environmental protection. The two synthetic liner system will be considered if the cost of delivering sand and gravel to the North Butte site is cost prohibitive. Either design will afford superior levels of environmental protection and will provide for rapid detection of a leak should a breach in the primary liner occur.

Condition No. 7 of Permit to Mine No. 632 requires all evaporation ponds to have a WQD approved monitoring plan prior to commencement of operations. Discussions with the WQD personnel in the WQD's District Office in Sheridan indicate that either of the two leak detection systems proposed by Pathfinder will meet the criteria of an approved WQD monitoring plan. Pathfinder's proposed monitoring schedule for the leak detection system has been incorporated into the application with this change request.

The location of changes to the approved permit document are found in the table, following. All revised pages and figures for this particular permit change are attached to these Index pages.

CHANGE NO. ____

Relocation of Process Plant and Evaporation Ponds
Detailed Engineering and Geotechnical Analysis - Evaporation Ponds

Location of Changes to Approved Permit Document:

Volume	Section	Page No.	Figure	Table	Explanation
I	1.1	1-2			Change three ponds to two ponds
I	15.11	15-52 15-53 15-53a 15-53b			Add new pond description
I	15.11.1	15-53c through 15-53c-22 with appendices and Sheets 1 - 5 15-33	 15.33		Incorporate Western Water Consultants, Inc. evaporation pond design and geotechnical analysis report Delete Figure 15.33
I	15.12	15-54 15-56 15-57		 15.3 15.3A	Revision of topsoil salvage quantities for new plant and pond locations
I	Table of Contents	xiii xxvi	 15.33		Add Section 15.11.1, Detailed Pond Design and Geotechnical Analysis Delete Figure 15.33
II			9.2 10.7 15.1		Indicate the new access road (existing), relocation of plant and pond sites

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1. GENERAL PROJECT DESCRIPTION

1.1 PROJECT SUMMARY

The North Butte Project is designed to mine uranium from roll front type deposits that are located approximately 600 feet below the surface using in situ leach (ISL) mining technology. The project will be a commercial scaled operation extracting some 600,000 pounds per year of uranium oxide (U_3O_8) from three sand horizons averaging approximately 50 to 100 feet thick each. All three sand members are saturated with water and are under confined aquifer conditions within the Wasatch formation. After the uranium has been extracted from the in place ore deposit it will be concentrated by loading onto solid ion exchange resin. The uranium product will then be stripped from the resin, precipitated and dried at the proposed North Butte processing facility. The salable production will next be trucked off site to enter the Nuclear fuel cycle.

A commercial scale ISL processing facility and well fields will be installed at the site to accomplish the mining and processing of the uranium product. All equipment will be purchased for the North Butte operation as there are no processing facilities or equipment on site. The equipment purchased for the North Butte ISL Project will be of a proven design.

Beginning in early 1980's and continuing through 1986 UUS conducted piloting tests at two locations in close proximity to the North Butte Site using standard uranium leaching techniques of sodium carbonate/bicarbonate and oxygen. These operations were successful which lead to the ultimate acquisition of the North Butte property from the Cleveland Cliffs Iron Company in 1987.

The North Butte production complex will be composed of processing plant, well fields and auxiliary facilities including office accommodations, sleeping quarters, evaporation ponds, disposal well and surface discharge area as explained below.

The Processing Plant will consist of process building, various solution holding tanks, ion exchange reaction vessels, pumps, plumbing, filter sections, precipitation section and a drying unit. Various office accommodations will be located in the process building. The process facility will be designed to accommodate resin elution and product processing from other uranium concentrating (satellite) sites.

The well fields will have injection, recovery and monitoring wells with the appropriate equipment to transfer the mined solution to and from the process facility. The wells will be completed in the confined mine aquifer labeled "A", "B", and/or "C" sand members depending upon the location of the economically concentrated ore. All of the sand members comprising the mine aquifer are flat lying with no known faults.

The personnel quarters will be installed near the restricted area to provide beds and eating facilities for those operating personnel who remain on site for shift work.

The two evaporation ponds will have artificial impermeable membrane liners and act primarily as a holding facility in the event the disposal well can not accommodate waste solutions during maintenance periods, etc. The disposal well will be installed near the processing facility and serve as a final elimination mechanism to solutions with high salt content.

Due to the size of the ore body and depending upon the market price of uranium, the North Butte ISL project is planned to operate a minimum of twenty-five years. The estimated mine life including reclamation, as reflected in the Mine Plan Section of this document is some 26 years.

1.2 PROJECT LOCATION

The North Butte in situ leach and processing facility is located in southwest Campbell County, Wyoming about 42 air miles south-southwest of Gillette, Wyoming. Figure 1.1 is a map that shows the general location of the North Butte project. The permit area includes portions of Sections 18 and 19 of Township 44 North, Range 75 West and

construction will keep the driving surface higher than the adjacent land providing for good drainage and preventing bogs from forming during the wet season. A two feet buffer will exist on each side of the road where topsoil will not be placed. As reflected in the land owner consent form, the rancher fully supports this method of construction of wellfield access roads at the North Butte ISL project. At the conclusion of all mining and restoration operations in a mining unit, the wellfield access roads will be reclaimed as described in Section 17.2.

Within the wellfields the wells will be installed in rows with the feeder pipelines running along the rows. Access to the wells will be provided by establishing a two track service road down every other row and connecting to the wellfield access road. Pathfinder will install minor culvert crossings, where necessary, to allow access from the wellfield access road into the wellfield.

During the life of the mine it will be necessary for the wellfield access roads to cross drainage channels at four locations within the permit area. These locations are shown on Figure 9.2 (Volume II). The crossings will consist of three gravel bottomed fords and one culvert/ford crossing placed where the flood plain geometry is suitable for fords (see Section 15.9.1).

15.11 EVAPORATION PONDS

Pathfinder plans to utilize a combination of deep well injection, evaporation ponds and surface discharge (under the NPDES system during restoration) to dispose of wastewater effluents that will be generated from the North Butte ISL process. Two evaporation ponds will be constructed for the temporary storage of process wastewater that will be injected into the deep disposal well. During normal operations, one of the evaporation ponds will receive relatively low-TDS water from the wellfield bleed stream. The wellfield bleed stored in this pond will be used for backwashing the process sand filters in the plant and will be disposed of in the deep injection well as needed. During restoration, the pond will receive the wellfield bleed stream from groundwater sweep. This water will be treated for radium removal and surface discharged under a state NPDES permit or disposed of via the deep injection well. The second evaporation pond will receive higher-TDS waters from the plant processes such as spent eluant, plant washdowns and brine from the reverse osmosis unit. This water will also be temporarily stored in the pond as necessary prior to disposal in the deep well.

The two evaporation ponds designed for the North Butte project are not intended for use as a primary disposal system, i.e. sized for active evaporation of all waste streams, although their evaporation rate at maximum operating level is 5 GPM on an annual basis. Rather, the ponds are actually holding ponds, sized to store a 40 GPM bleed stream for a 30-day time period to allow for maintenance or repair of the deep disposal well. The target operating parameter of the deep injection well is 150 GPM maximum, at 2,000 psi surface injection pressure; two deep wells are permitted for the North Butte ISL project, each with a 150 GPM capacity. Pathfinder plans to install only one deep well initially, and operate it at a rate less than the maximum 150 GPM. One well should be more than sufficient to accommodate the maximum wastewater production of 40 GPM during operations, plus the additional brine from aquifer restoration activities. Power Resources, Inc., operator of the Highland Uranium Project located 40 miles southeast of the North Butte site, has been successfully injecting wastewater into the same deep formations as Pathfinder plans for the past three years at a constant rate of 110 GPM.

The evaporation ponds will be located to the south of the process plant site, in the NW¼ SE¼ of Section 24, T.44 N., R.76 W. (see Figure 15.1, Volume II). Pathfinder has conducted extensive geotechnical studies for the evaporation pond site, and has found the site to be very suitable for pond construction. The detailed engineering for the ponds, as well as geotechnical studies, were provided to Pathfinder by Western Water Consultants, Inc. of Sheridan, Wyoming. The engineering design details for the two evaporation ponds (Ponds 1 and 2), complete with on-site geotechnical analyses, are provided in Section 15.11.1 of this document. A summary of the pond designs is provided in the following paragraphs.

In summary, Pathfinder will construct two evaporation ponds, each lined with synthetic membrane liners underlain by leak detection systems. Two lining systems have been evaluated by Pathfinder, a single synthetic liner system and a double synthetic liner system. Each system provides equivalent levels of environmental protection, and each is designed to meet the requirements of the NRC Regulatory Guideline 3.11 with regard to the use of synthetic and natural materials for ponds at uranium recovery facilities. The final selection of the lining system will be based on construction bid prices. The two liner system versus the single may be more cost effective if the sand for the single liner pond is too expensive due to availability and transportation charges. A summary of the construction details of each type of pond is provided as follows:

Single Synthetic Liner Evaporation Pond - The primary liner will consist of 36 mil, reinforced Hypalon (TM) which will be placed over a leak detection system which consists of the transport media (sand or gravel) and a collection system of 3-inch diameter slotted PVC pipes which drain to sumps. The collection pipes are placed in compacted, gravel-filled trenches at the perimeters of the pond bottoms; the bases of the ponds will be graded to slope toward the sides to facilitate the drainage of any leakage to the nearest collection pipe. The collection pipes will be sloped in approximately 70-foot long sections on each side of the ponds to drain to six sumps which will serve as collection points for the leak detection system. Taps consisting of 4-inch PVC pipe will be installed at each sump to allow inspection and sampling. The operational characteristics for the single synthetic lined pond are:

Dimensions:	Trapezoidal, 3H:1V side slopes 475 ft. long x 107 ft. wide at the maximum depth
Normal Operating Level:	5.0 ft., combined capacity (two ponds) of 2,111,370 gallons
Maximum Operating Level:	8.5 ft., combined capacity of 4,287,907 gallons
Overtopping Water Level:	9.5 ft., combined capacity of 4,691,934 gallons

(Note: the above water levels allow for the contents of either pond, when operating at or below the normal operating level, to be transferred into the other pond while still maintaining 1.0 foot of freeboard below the overtopping level. The maximum operating level is used only when a leak occurs, or if one pond is full and the other pond is empty.)

Pathfinder prefers the single synthetic liner pond system as it is the standard design used at other ISL facilities and has a proven track record with respect to operations and environmental protection. The double synthetic liner system will be considered if construction costs for the single liner system are prohibitive.

Double Synthetic Liner Evaporation Pond - Two synthetic liners are used to surround a highly permeable medium-density polyethylene netting (geonet) as the leak detection system. The top liner is 36 mil, reinforced Hypalon (TM) and serves as the primary liner. The geonet and bottom liner (secondary liner) serves as the leak detection system. The geonet will function in much the same manner as the sand in the single liner option, to convey any leakage between the two liners to the leak detection piping, which will consist of 3-inch diameter slotted PVC pipe placed in gravel-filled trenches along the sides of the pond bottoms. The floors of the ponds are also graded to slope toward the sides to facilitate

the drainage of any leakage to the nearest collection pipe. The collection system for the double liner pond is identical to the single liner pond with six collection sumps with 4-inch diameter PVC taps installed at each of the sumps to allow inspection and sampling. Operational characteristics for the double liner ponds are:

Dimensions:	Trapezoidal, 2H:1V side slopes 467 ft. long, 92 ft. wide at the maximum depth
Normal Operating Level:	5.4 ft., combined capacity (two ponds) of 2,143,953 gallons
Maximum Operating Level:	9.5 ft., combined capacity of 4,372,622 gallons
Overtopping Water Level:	10.5 ft., combined capacity of 4,993,213 gallons

(Note: The above water levels allow for the contents of either pond, when operating at or below the normal operating level, to be transferred into the other pond while still maintaining 1.0 foot of freeboard below the overtopping level.)

The operational monitoring plan and reclamation plan for the evaporation ponds are covered in Sections 16.9 and 17.2.3, respectively.

15.11.1 DETAILED POND DESIGN AND GEOTECHNICAL ANALYSES

(Western Water Consultants, Inc. report entitled "Engineering Design Report for Evaporation Ponds 1 and 2 at the Pathfinder Mines Corporation North Butte ISL Project", January, 1992.)

ENGINEERING DESIGN REPORT FOR EVAPORATION PONDS 1 AND 2 AT THE PATHFINDER MINES CORPORATION NORTH BUTTE ISL PROJECT

January 2, 1992

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FOR EVAPORATION PONDS 1 AND 2
AT THE PATHFINDER MINES CORPORATION
NORTH BUTTE ISL PROJECT

1.0 INTRODUCTION

This report presents design information for two evaporation ponds to be constructed at the Pathfinder Mines Corporation North Butte in-situ leaching uranium mine located in southwestern Campbell County, Wyoming. Engineering design information presented in the report is intended to support an application for a minor revision to Mine Permit No. 632 that is to be submitted to the Wyoming Department of Environmental Quality (WDEQ). The design information presented herein will be submitted to the Wyoming State Engineer's Office (SEO) and the United States Nuclear Regulatory Commission (NRC). The design of these facilities was developed in full consideration of the criteria and requirements of the NRC as well as the WDEQ and SEO. This report was prepared by staff engineers and geologists of Western Water Consultants, Inc. (WWC) of Sheridan, Wyoming under the direct supervision of Doyl M. Fritz, Wyoming Professional Engineer No. 1467. Soil testing and laboratory analyses were performed by Chen-Northern, Inc. of Casper, Wyoming under subcontract to WWC.

2.0 QUANTITY AND CHARACTERISTICS OF WASTEWATER

Pathfinder Mines Corporation plans to use a combination of deep well injection, evaporation ponds, and surface discharge (under the National Pollutant Discharge Elimination System) to dispose of wastewater effluents that will be generated from the North Butte uranium solution mining process. The two evaporation ponds described in this report will be utilized for temporary storage of process wastewater that will be injected into the deep disposal well, used for sand filter backwashing, or treated for radium removal prior to surface discharge (during aquifer restoration).

During normal operations, one of the evaporation ponds will receive relatively low-TDS water from the wellfield bleed stream. The wellfield bleed stored in this pond will be used for backwashing the process sand filters in the plant and will be disposed of in the deep injection well as needed. During restoration, the pond will receive the wellfield bleed stream from ground-water sweep. This water will be treated for radium removal and surface-discharged under a state discharge permit or disposed of via the deep injection well. The second evaporation pond will receive higher-TDS waters from the plant processes such as spent eluant, plant washdowns, and brine from the reverse osmosis units. This water will be temporarily stored in the pond as necessary prior to disposal in the deep well.

It is not possible to precisely predict for either pond just how much water from any given source will be in the pond at any given time. The ponds are both sized with adequate freeboard to pump the entire contents of one into the other in the event that one of the ponds develops a leak. The water in either pond could be a mixture of all the process and waste streams described above. Anticipated water quality concentration ranges for the waters stored in the ponds are as follows (all concentrations are in milligrams per liter unless otherwise noted):

bicarbonate	500 to 2,000
chloride	2,000 to 50,000
sulfate	450 to 2,000
sodium	800 to 7,500
TDS	3,000 to 75,000
pH	5.0 to 9.0
uranium	<0.1 to 15.0
radium - 226	<1.0 to 2,000 picocuries per liter

Both evaporation ponds will be lined with synthetic membrane liners underlain by leak detection systems. Liner details as well as operational monitoring of the leak detection system are described in later sections of this report.

3.0 POND DESIGN

3.1 Location and Capacity of Ponds

The proposed evaporation ponds are located in the NW¼SE¼ of Section 24, T.44 N., R.76 W. of the Sixth Principal Meridian, Campbell County, Wyoming. The location of the ponds is shown on Sheet 1 of 5 of the plans accompanying this report. The ponds will be located south of the extraction plant and approximately 3,000 feet from the channel of Willow Creek, an ephemeral tributary of the Powder River. The proposed pond site is on a bench between two minor unnamed tributaries of Willow Creek. The elevation of the bottom of the ponds is approximately 5,061 feet above mean sea level (msl). The elevation of the ground-water table is approximately 4,888 feet msl, or about 173 feet below the pond bottoms. This information is based on water level measurements from a field well (UW-53781) located approximately 500 feet to the north of the proposed construction site.

During the design of the evaporation ponds, two lining systems were investigated, termed Option A (single synthetic liner system) and Option B (double synthetic liner system). Option A will function hydraulically as a double liner system since the materials used to construct the compacted earthen bottom exhibit very small permeabilities (see Section 4.0). The two options will provide equivalent levels of environmental protection, and final selection will be based on contract bid prices. Detailed plan views and cross sections of the two options are included on Sheets 2 and 4 of 5, respectively, of the accompanying plans. The evaporation pond descriptions are as follows:

- **Option A:** The pond cross sections are trapezoidal, with 3H:1V side slopes. The pond bottoms are 418 feet long by 50 feet wide, and the pond dimensions at the maximum depth of 9.5 feet are 475 feet long by 107 feet wide. Three water levels were considered during the pond design: (1) normal operating level (NWL), (2) maximum operating level (HWL), and (3) overtopping water level. The NWL of the ponds corresponds to a depth of 5.0 feet and a combined capacity for both ponds of 6.48 acre-feet (2,111,370 gallons). The HWL is at a depth of 8.5 feet, at which the combined capacity is 13.16 acre feet (4,287,907 gallons). At the overtopping water level of 9.5 feet, the ponds have a combined capacity of 14.40 acre-feet (4,691,934 gallons). The proposed water levels allow for the contents of either pond, when operating

at or below the NWL, to be transferred into the other pond while still maintaining 1.0 foot of freeboard below the overtopping level. The capacity between the NWL and the HWL is termed auxiliary capacity (see Sheet 1 of 5 of the accompanying plans).

- **Option B:** The pond cross sections are trapezoidal, with 2H:1V side slopes. The pond bottoms are 425 feet long by 50 feet wide, and the pond dimension at the maximum depth of 10.5 feet are 467 feet long by 92 feet wide. The NWL of the ponds corresponds to a depth of 5.4 feet and a combined capacity for both ponds of 6.58 acre feet (2,143,953 gallons). The HWL is at a depth of 9.5 feet, at which the combined capacity is 13.42 acre feet (4,372,622 gallons). At the overtopping water level of 10.5 feet, the ponds have a combined capacity of 15.34 acre-feet (4,993,213 gallons). The proposed water levels again allow for the contents from either pond, when operating at or below the NWL, to be transferred into the other pond while still maintaining 1.0 foot of freeboard below the overtopping level.

3.2 Pond Liners and Leak Detection Systems

The evaporation ponds for both options presented above are designed to meet the requirements of the NRC with regard to the use of synthetic and natural materials for liners and leak detection systems in evaporation ponds at uranium recovery facilities. The liners for the two options will be installed in accordance with manufacturer's specifications utilizing the anchoring methods shown on the accompanying plans. The evaporation ponds will be equipped with leak detection systems as follows:

- **Option A:** The leak detection system for the single liner option consists of three parts - the primary Hypalon_{TM} liner, the transport media (fine sand or gravel), and the piping system. The sand will drain to collection pipes, which will in turn drain to sumps. The collection pipes will be 3-inch diameter slotted PVC pipes in gravel-filled trenches (see Sheet 3 of 5 of the accompanying plans) at the perimeters of the ponds. The bases of the ponds will be graded to slope toward the sides to facilitate the drainage of any leakage to the nearest collection pipe. The collection pipes will be sloped in approximately 70-foot long sections on each side of the ponds to drain to six sumps which will serve as collection points for the leak detection system. Taps consisting of 4-inch diameter PVC pipe will be installed at each sump to allow inspection and sampling of the sumps.

  The use of sand beneath the Hypalon_{TM} liners in Option A should reduce the need for constructing air vents beneath the liner since gases produced under the liner would be vented through the sand.

- **Option B:** The designs of the evaporation pond liner and leak detection system for the double liner option are shown on Sheet 5 of 5 of the accompanying plans. This option consists of two impermeable synthetic liners surrounding a highly permeable medium-density polyethylene netting (geonet). The top liner (primary membrane) will be $\text{Hypalon}_{\text{TM}}$ as in Option A and will provide an impermeable containment barrier. The bottom liner (secondary liner) is high density polyethylene (HDPE) and will serve as a backup containment system for the primary liner. The geonet will function in much the same manner as the sand in Option A to convey any leakage between the two liners to the leak detection piping, which will consist of 3-inch diameter slotted PVC pipe placed in gravel-filled trenches along the sides of the pond bottoms. The floors of the ponds will be graded to slope toward the sides to facilitate the drainage of any leakage to the nearest collection pipe. The collection pipes located on both sides of the ponds will be sloped to drain to six sumps consisting of 6-inch PVC pipe tees. The sumps will serve as collection points for the leak detection system. Taps consisting of 4-inch diameter PVC will be installed at each of the sumps to allow inspection and sampling of the sumps.

  To vent any gases which may form under the liner system, the pond bottoms will be constructed with a longitudinal slope from the midpoint upwards to the ends and a gravel-filled trench will be constructed along the longitudinal centerlines of the ponds. Any gas pressure under the ponds will force gases along this relief trench to the ends of the ponds, where it will be vented (see Sheet 5 of 5 of the plans accompanying this report).

3.3 Suitability of Lining Materials for North Butte Project Waste Waters

The use of a $\text{Hypalon}_{\text{TM}}$ or primary geomembrane will provide a puncture and tear resistant inner liner for the ponds. $\text{Hypalon}_{\text{TM}}$ is highly resistant to photo and chemical degradation. This material has been used extensively in this type of application and its performance in the containment of waste waters similar to those expected to occur at the North Butte project is well documented.

The geonet and the secondary liner in Option B exhibit the same resistance to degradation as the primary liner system. The physical properties for each of the components for the lining systems are included in Appendix A.

4.0 GEOTECHNICAL STUDIES

4.1 Site Investigation

A geotechnical site investigation was conducted to test foundation conditions and borrow materials for the construction of the evaporation pond. The site investigation included geotechnical drilling and soil sampling. Laboratory analyses were performed on collected soil samples for use in the engineering evaluation of slope stability described in Section 4.3 of this report.

The field investigation was conducted on November 21, 22, and 23, 1991 and included four test borings, HP-1 through HP-4, at the site of the proposed evaporation ponds. The locations of these test borings are shown on Sheet 1 of 5 of the plans. Borings HP-1 and HP-2 were completed at the northern ends of the ponds, the area from which borrow material will be excavated for use in constructing embankments around the southern ends of the ponds. All borings at the pond site were completed to a total depth approximately 20 feet below the proposed pond bottom elevations. During drilling, penetration tests were performed at frequent intervals, and the penetration effort (blows per foot) along with the classification of California tube samples were logged in the field. Field samples were obtained from drill cuttings at specified intervals and were bagged and labeled for laboratory testing. Soil boring logs for test holes HP-1 through HP-4 are presented in Appendix B of this report.

The soils encountered in the drill holes were found to be generally similar, with moderate stratigraphic variations in texture. The subsurface soils in the project area can be described as consisting of light brown, stiff to very stiff sandy or silty clay of low to medium plasticity. Variations in texture are attributable to varying sand content. Analysis according to the Unified Soil Classification System resulted in a CL classification for the bulk of these soils, with some sand found in localized strata. In general, the available borrow materials, when mixed as they will be during normal construction activities, are excellent materials for use in construction of the pond embankments. This conclusion is supported by the factors of safety calculated during the slope stability analyses described in Section 4.3 of this report.

4.2 Results of Soil Testing

Due to the similarity of the soils encountered during the borings, bagged samples from test holes HP-1 through HP-4 were composited for analysis. In addition, samples from specific depths at HP-1, HP-2, and HP-3 were tested. Testing performed by the laboratory included sieve analyses, compaction testing, direct shear tests of remolded and undisturbed samples, Atterberg limit tests, one-dimensional swell-consolidation tests, and falling head permeability tests. The laboratory tests that were conducted are summarized in Table 1. A summary of relevant test results is shown on Table 2, and copies of the laboratory test reports are included in Appendix C.

Table 1. Summary of Completed Laboratory Soil Tests

Test Hole	Depth (ft)	Tests
HP-1	4	Atterberg limits and -200 analysis One-dimensional, swell-consolidation test
	9	Atterberg limits and -200 analysis One-dimensional, swell-consolidation test
HP-2	0-20	Atterberg limits and -200 analysis Gradation-hydrometer analysis Falling head (liner) permeability test Laboratory compaction test Direct shear test - remolded sample
	9	Direct shear test - undisturbed sample
HP-3	4	Atterberg limits and -200 analysis Direct shear test - undisturbed sample
	19	Atterberg limits and -200 analysis
HP-4	0-14	Atterberg limits and -200 analysis Gradation-hydrometer analysis Falling head (liner) permeability test Laboratory compaction test Direct shear test - remolded sample

Table 2. Summary of Relevant Laboratory Soil Test Results

Test boring:	HP-1		HP-2		HP-3		HP-4
Depth (ft):	4	9	0-20	9	4	19	0-14.5
Natural moisture (%)	8	7	5	2	8	9	6
Natural dry density (pcf):	93	103	—	103	93	113	—
Atterberg limits:							
LL (%):	36	29	28	18	35	42	36
PI (%):	10	13	14	—	16	25	20
-#200 (%)	59	60	54	23	82	93	82
Permeability (cm/sec):	—	—	4.8×10^{-8}	—	—	—	3.8×10^{-8}
Maximum dry density (pcf):	—	—	116.5	—	—	—	109.9
Opt. moisture content (%)	—	—	12.9	—	—	—	14.3
Direct shear tests:							
Sample (1)	—	—	Remld.	Undis.	Undis.	—	Remld.
Cohesion (psf):	—	—	300	0	250	—	200
Friction angle (degrees)	—	—	34	35	24	—	38
Soil classification (2):	CL	CL	CL	SM	CL	CL	CL

(1) Remld. -- remolded sample, Undis. -- undisturbed sample.
(2) Classification by WWC Inc. according to the Unified Soil Classification System.

Compaction testing of composite samples from HP-2 and HP-4 was conducted according to ASTM D-698 to determine the optimum moisture contents and corresponding maximum dry densities of these soils. The values of maximum dry density for these samples were 116.5 and 109.9 pounds per cubic foot (pcf), respectively. Optimum moisture content was 12.9 percent for the HP-2 sample and 14.3 percent for the HP-4 sample.

Direct shear tests (ASTM D-3080) were conducted on remolded composite samples from test holes HP-2 and HP-4 and on undisturbed samples from test holes HP-2 and HP-3. The two sets of tests were used to provide data for use in the slope stability analyses discussed in Section 4.3 of this report. Test results from the two remolded samples were used to derive soil strength characteristics for typical compacted embankment fill material, while test data from the two undisturbed samples provided soil strength characteristics for typical pond foundation soil. The WWC geologist on site during the boring operations indicated that the undisturbed sample from a 9-foot depth in test hole HP-2 was from a sand lens. The resultant

soil parameters derived from direct shear test data for this sample are therefore not typical of the soils in the area of the evaporation ponds.

Falling head permeability tests (ASTM D-5084) were conducted on the two composite samples from test holes HP-2 and HP-4. The sample specimens were remolded to approximately 95 percent of the maximum dry density in accordance with ASTM D-698 prior to testing. The compacted permeabilities of the samples are shown on Table 2.

4.3 Slope Stability Evaluation

A computer evaluation of slope stability was conducted for the proposed evaporation ponds at the Pathfinder ISL Mine. The computer program SB-SLOPE (Von Gunten Engineering Software, 1984 and 1991) was used to perform the evaluation. The program is based on the simplified Bishop method and employs an interactive search procedure to find the critical failure surface.

For the purpose of this study, the "worst case" condition was determined to occur for Option B at a cross section through the outer embankment on the southeast side of the evaporation ponds at station 9 + 58, near test hole HP-4. The location and geometry of this section are shown on Sheet 4 of 5 of the drawings that accompany this report. This section was chosen for evaluation because it exhibits the highest effective embankment height and the steepest interior embankment slope (2H:1V).

Engineering soil properties that are required for an analysis of slope stability include cohesion, friction angle, and in-situ density (unit weight). For this study, engineering properties for typical foundation and embankment soils were derived from soil testing completed by Chen-Northern, Inc. as described in part 4.2 of this report.

Engineering properties of soil to be used for compacted embankment fill were based on data from direct shear tests of remolded composite samples from test holes HP-2 and HP-4. Soil excavated from the area around bore holes HP-1 and HP-2 will comprise most of the compacted fill material used for construction of the embankments. The test values for maximum dry density, cohesion, and friction angle

from the HP-2 sample are more conservative (have smaller strength) than those from the HP-4 sample. Soil parameters used for typical embankment material were therefore those derived from the HP-2 sample. Density of compacted embankment material was assumed to be 110.6 pounds per cubic foot (pcf), which is 95% of the reported maximum dry density of 116.5 pcf for the HP-2 sample. The soil friction angle used for these stability analyses was 34 degrees, and a cohesion value of 300 pounds per square foot (psf) was also used. These values are all within the range of typical values for a CL soil (USBR, 1987).

Soil properties used for the pond foundation soil were based on data from direct shear tests of an undisturbed sample from test hole HP-3. As noted in Section 4.2 of this report, the undisturbed sample from test hole HP-2 was considered to be unrepresentative of the soils in the area of the proposed evaporation ponds. Based on the test results for the HP-3 sample, an average wet density of 100.4 pcf was used, as were a friction angle of 24 degrees and cohesion of 250 psf. A summary of soil strength parameters used in the slope stability analyses are included in Table 3.

In addition to soil strength parameters, data required for the computer modeling study includes coordinate data for the ground surface and the proposed evaporation pond embankment. Ground surface elevations used in the study were based on the assumption that three feet of topsoil and subsoil will be removed before the placement of compacted fill. Since the ponds will be lined and all construction will occur above the local water table, no phreatic surfaces are considered in the stability analyses of the pond embankment and foundation.

Four embankment conditions were considered, two each for both the interior and exterior embankment slopes. Both embankment slopes were analyzed with and without seismic loading conditions. The interior slope was analyzed assuming no water in the pond while the exterior slope was analyzed using a technique of applied distributed loads on the pond floor and interior embankment to simulate the maximum storage pool in the pond. This technique is used to analyze lined reservoir embankments in which there is no phreatic surface. A seismic coefficient of 0.05 was used in the calculation of the dynamic safety factors as recommended for this region

by the Mine Safety and Health Administration (MSHA, 1979). The minimum factors of safety generated by the computer slope stability analyses are graphically illustrated by Figures 1 through 4 and summarized in Table 4.

Table 3. Summary of Soil Strength Parameters Used in Slope Stability Analyses

EMBANKMENT SOIL	
Sample from which parameters were derived	HP-2, 0-20 ft.
Maximum dry density, pcf	116.5
95% maximum dry density, pcf	110.6
Cohesion, psf	300
Friction angle, degrees	34
FOUNDATION SOIL	
Sample from which parameters were derived	HP-3 @ 4 ft.
Soil unit weight, pcf	100.4
Cohesion, psf	250
Friction angle, degrees	24

5.0 GENERAL CONSTRUCTION AND MATERIAL SPECIFICATIONS

5.1 Earthwork Specifications

The soil types discussed in this report are suitable for the construction of the proposed evaporation ponds. The silty to sandy clay soils which will be used to construct the evaporation ponds exhibit permeabilities which are sufficiently low to reduce or inhibit infiltration if a leak should occur. A professional engineer licensed to practice in the State of Wyoming will be available during construction to assure that suitable foundation and borrow materials are used.

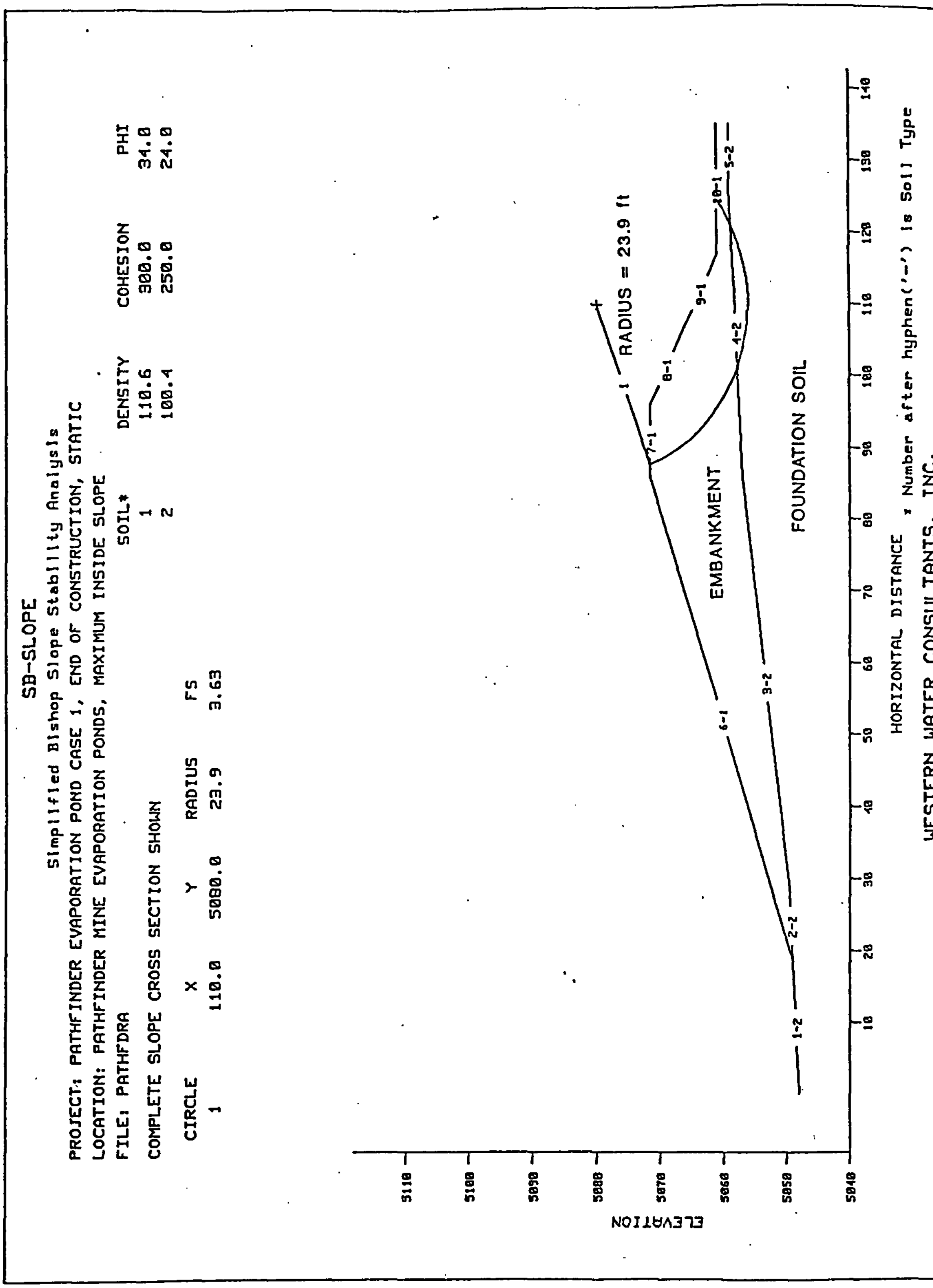


Figure 1. Critical Failure Surface for Case 1 - Interior Slope, Pond Empty, Static Conditions

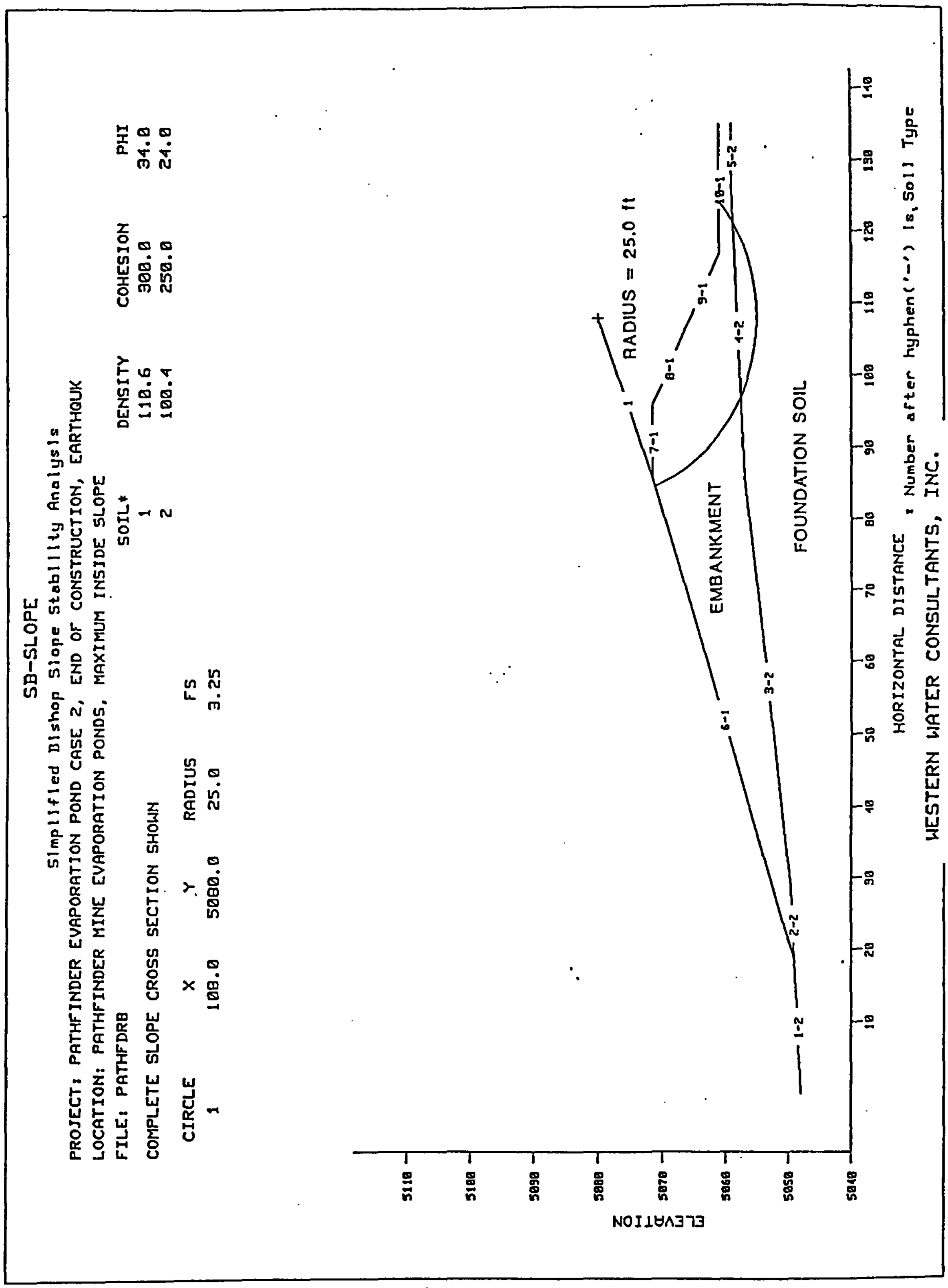


Figure 2. Critical Failure Surface for Case 2 - Interior Slope, Pond Empty, Earthquake Conditions

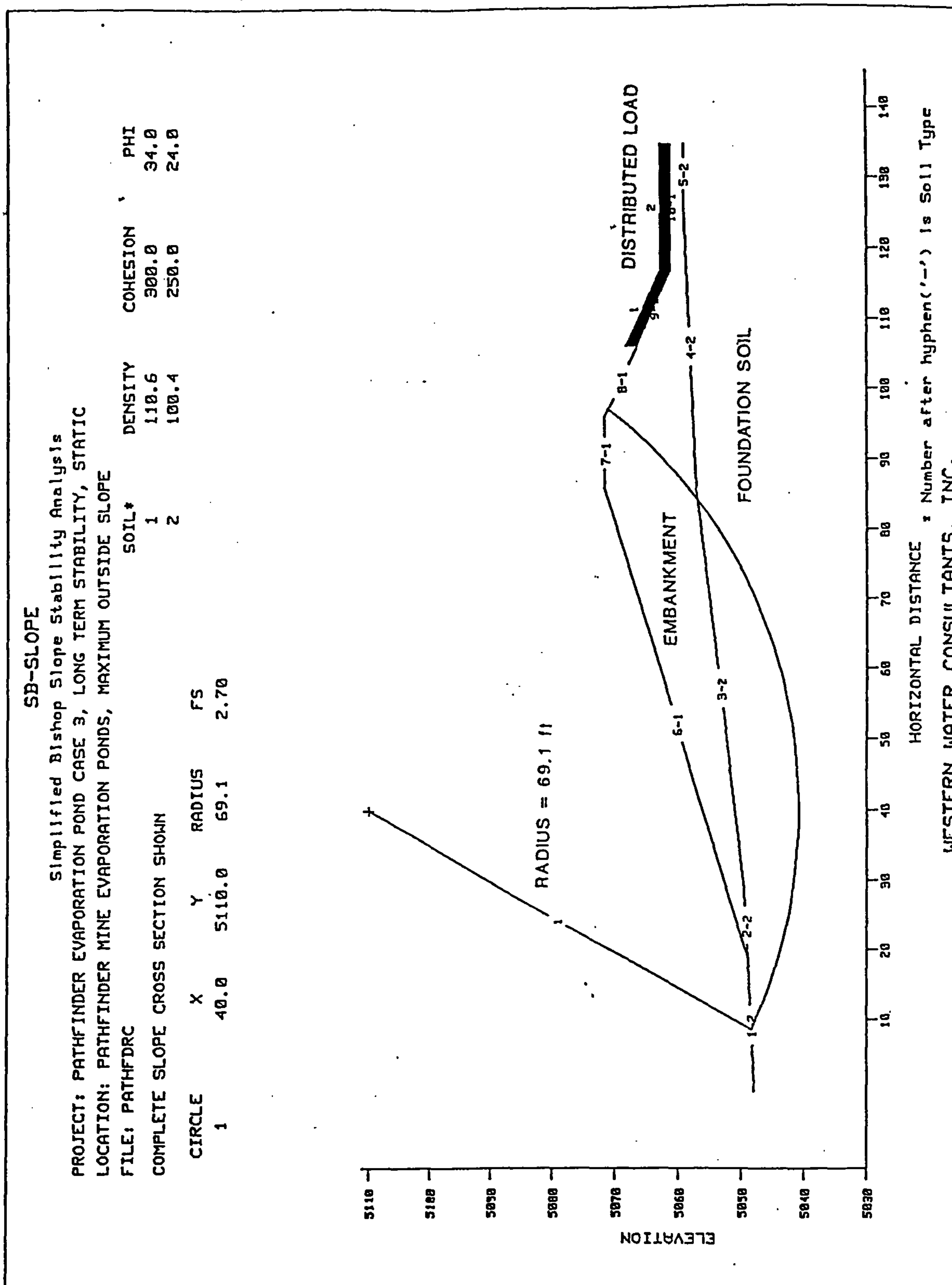


Figure 3. Critical Failure Surface for Case 3 - Exterior Slope, Pond Full, Static Conditions

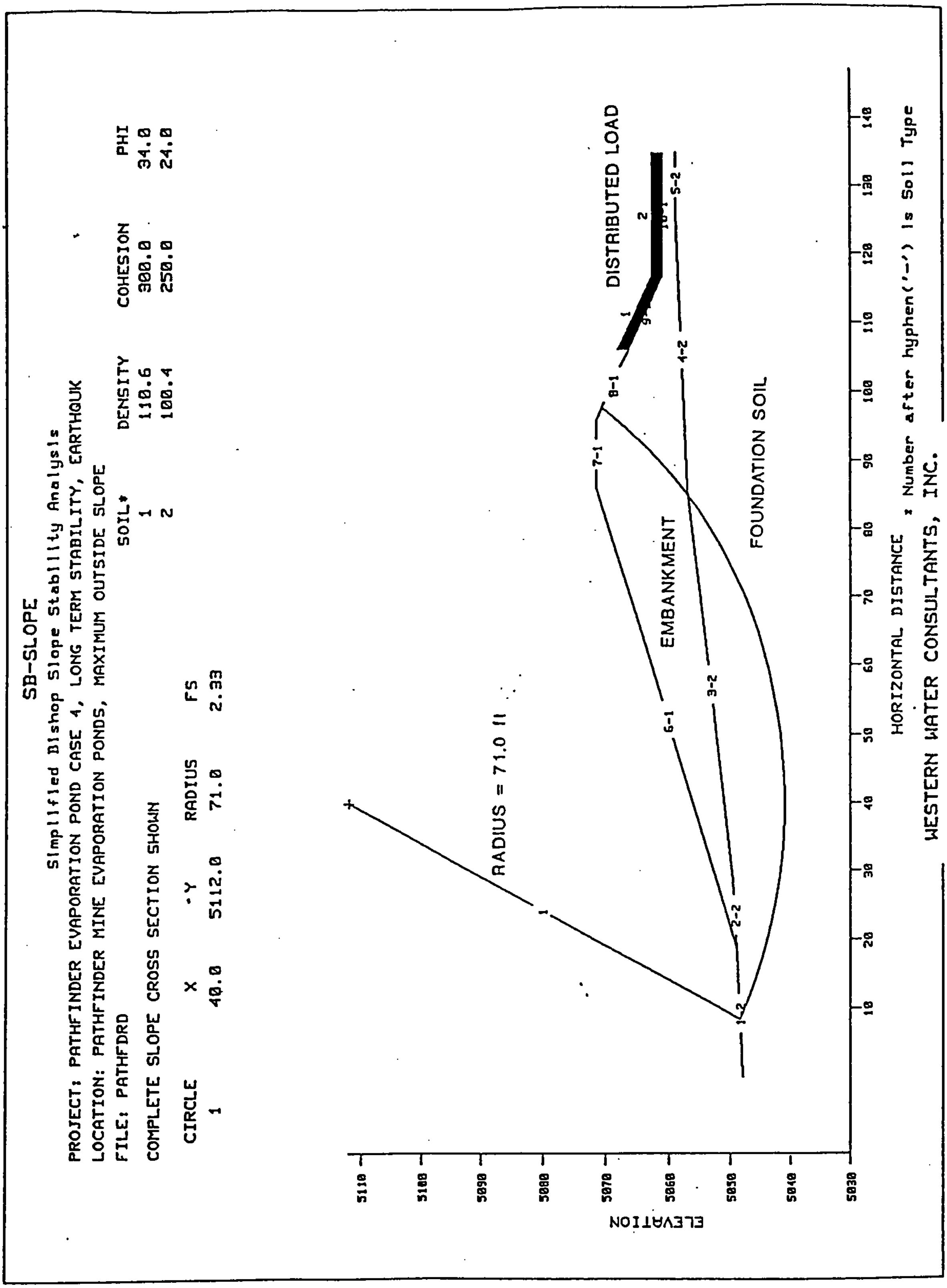


Figure 4. Critical Failure Surface for Case 4 - Exterior Slope, Pond Full, Earthquake Conditions

Table 4. Summary of Embankment Slope Stability Analyses

Case	Condition	X	Y	Radius	Minimum FS
Earthquake (seismic) coefficients used: Vertical -- 0.05 Horizontal -- 0.05					
		Center Point Coordinates			
INTERIOR SLOPE WITH POND EMPTY					
1	Static	110.0	5080.0	23.9	3.63
2	Earthquake	108.0	5080.0	25.0	3.25
EXTERIOR SLOPE WITH POND FULL					
3	Static	40.0	5110.0	69.1	2.70
4	Earthquake	40.0	5112.0	71.0	2.33

To maintain low permeabilities under the impoundments and to minimize settlement, the following specifications shall be adhered to during construction:

- Prior to the placement of fill, the work area will be cleared of all suitable topsoil, timber, brush, trash and other organic material. Suitable topsoil will be removed from the work area to an approximate depth of 36 inches, with final topsoil salvage depths being determined in the field at the time of construction. Salvaged topsoil will be placed in a stockpile and seeded with a temporary (interim) seed mix to protect the stockpile from erosion.

- Fill to be placed in embankments will be clean and free of organic matter, frozen material, and rocks greater than 4 inches in the maximum dimension.

- All fill placed for embankment construction will be compacted to a minimum of 95 percent of the Standard Proctor maximum dry density as determined by ASTM D-698. The fill shall be placed in uniform, successive six-inch (compacted) horizontal layers at a uniform moisture content within plus 2 or minus 4 percent of the optimum moisture content as determined by ASTM D-698.

- The foundation soils at the bottom of the ponds will be scarified or ripped to a depth of a least two feet and watered or aerated as necessary to bring the moisture content within plus 2 or minus 4 percent of the optimum moisture content and compacted to a density of not less than 95 percent of the maximum dry density as determined by ASTM D-698.

- Following trenching operations, all ditches or trenches in the bottoms of the ponds will be brought to within plus 2 or minus 4 percent of optimum moisture content and compacted to within 95 percent of the maximum dry density as determined by ASTM D-698.

- Sand used for leak detection purposes will contain no more than five (5) percent material by weight capable of passing #200 mesh, will contain no particles larger than one-half inch, and will exhibit a hydraulic conductivity greater than 1×10^{-5} cm/s.

5.2 Leak Detection Systems

- **Option A:** The leak detection system will be installed at the grades and slopes shown on the plans and covered with clean, washed gravel. Any trenching or regrading required during installation of the leak detection system will be followed by scarification, wetting, and compaction to within 95 percent of Standard Proctor maximum dry density as described in Section 5.1 above.

  After the leak detection piping and gravel have been installed, the pond bottoms and sides will be covered with clean washed sand which will be smoothed to the grades and slopes shown on the plans. Sand used in the leak detection system will conform to the specifications included in Section 5.1 above.

- **Option B:** The leak detection system for this option will be installed to the liners, and grades shown on the accompanying plans. Gas relief trenches and leak detection piping ditches will be constructed and the bottoms compacted as specified in Section 5.1. Prior to the placement of the secondary liner all surface irregularities will be removed to assure a smooth contact surface.

  The secondary liner will be installed in accordance with the manufacturer's recommended installation methods. After the secondary liner is installed the leak detection piping will be installed with gravel covering to the designed lines and grades.

  Geonet leak detection media will be placed above the secondary liner in accordance with the manufacturer's recommended installation procedures prior to the installation of the primary liner.

5.3 Pond Lining Systems

After the leak detection system has been constructed and inspected, the liner will be installed in accordance with the manufacturer's specifications. The reinforced

liner will be anchored in backfilled trenches located three feet from the interior embankment crest and extending at least two feet into the crest of the berm as shown on the plans. All pipes extending through the liner will be booted and sealed according to the liner manufacturer's specifications. All seams will be inspected and air tested in accordance with the liner manufacturer's recommended testing procedure for the material involved.

6.0 REFERENCES

Mine Safety and Health Administration, 1979, Design Guidelines for Coal Refuse Piles and Water, Sediment, or Slurry Impoundments and Impounding Structures.

U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 3rd Edition, 1987.

Von Gunten Engineering Software, Inc., 1984 and 1991, GEOSYSTEM (TM) Software for Slope Stability Analysis.

Wagner, A.A., 1957, The Use of the Unified Soil Classification System by the Bureau of Reclamation, Proceedings of the 4th International Conference of Soil Mechanics and Foundation Engineering, London, Vol. 1.

APPENDIX A

Synthetic Pond Liner Physical Properties

Table A-1. Physical Properties of Hypalon$_{(TM)}$ Membrane Liner

PROPERTY	TEST METHOD	SPECIFIED VALUES
Gauge, nominal (mils)´		36
Plies, reinforcing 10 x 10 1000d polyester		1
Thickness, minimum (mils)	ASTM D-751	
Overall	Optical Method	34
Over scrim		11
Breaking strength (pounds, minimum (lbs))	ASTM D-751, Method A	200
Tear strength (pounds, minimum)		
1. Initial	ASTM D-751	80
2. After aging	Modified	35
Low temperature flexibility (°F)	ASTM D-2136, 1/8 in. mandrel, 4 hrs - Pass	-40
Dimensional stability (each direction percent change maximum)	ASTM D-1204, 212°F, 1 hr.	2
Volatile loss, maximum, for 30 mil unsupported sheet (percent)	ASTM D-1203, Method A	0.5
Resistance to soil burial (maximum percent change from original values)		
a. 30-mil unsupported sheet	ASTM D-3084 (per ASTM paragraph 9.5)	
1. Breaking strength		5
2. Elongation at break		20
3. Modulus at 100% elongation		20
b. Membrane fabric breaking strength	ASTM D-751, Method A	25
Hydrostatic resistance, minimum (psi)	ASTM D-751, Method A Procedure 1	250
Ply adhesion, each direction, minimum (lbs/in)	ASTM D-413, Machine Method	8
	ASTM D-413, Modified Method	10
Water absorption, maximum, 30 mil unsupported sheet (percent weight gain)	ASTM D-471	
	14 days @ 70°F	1.5
	30 days @ 70°F	2.0
	120 days @ 70°F	2.0
	14 days @ 158°F	30.0
	30 days @ 158°F	30.0
	120 days @ 158°F	30.0

Table A-2. Physical Properties of 30 Mil High Density Polyethylene (HDPE) Membrane Secondary Liner

PROPERTY	TEST METHOD	SPECIFIED VALUES
PHYSICAL PROPERTIES		
Gauge of Material (mils)	ASTM D-1593	30 (±5%)
Specific Gravity (g/cc)	ASTM D-792 A	0.945
Minimum Tensile Properties	ASTM D-638	
Tensile @ Yield (psi)		2,000
Tensile @ Break (psi)		3,800
Elongation @ Yield (%)		13
Elongation @ Break (%)		600
Modulas of Elasticity (psi)		80,000
Tear Resistance, Minimum (psi)	ASTM D-1004 Die C	700
Low Tem. Brittleness (°C)	ASTM D-746 B	-75
Resistance to Soil Burial (%)	ASTM D-3083 (NSF SPEC 54)	
Tensile @ Yield		± 10
Tensile @ Break		± 10
Elongation @ Yield		± 10
Elongation @ Break		± 10
Modulas of Elasticity		± 10
Environmental Stress Crack Res. (hrs)	ASTM D-1693 (NSF SPEC 54)	2,000
Carbon Content (%)	ASTM D-1603	2-3
Carbon Dispersion (score)	ASTM D-3015	A-2
Melt Index (g/10m)	ASTM D-1238	< 1.0
Puncture Resistance (lbs)	FTMS 101 C	30
Water Vapor Transmission (GM-MIL/24 HR/100 in^2/90°/RH)		0.5
Hydrostatic Resistance (psi)	ASTM D-751 A	450
SEAL SEAMING PROPERTIES		
Bonded Seam Strength, Shear (ppi)	ASTM D-3083	130 (min.)
Bonded Seam Strength, Peel (ppi)	ASTM D-413	90 (min.)
Peel Adhesion, Minimum (ppi)	ASTM D-413	Film Tear Bond
Resistance to Soil Burial	ASTM D-3083	
Bonded Seam Strength Change (%)		-20
Peel Adhesion		Film Tear Bond

Table A-3. Physical Properties of Medium Density Polyethylene Geonet

Property	
Raw Material (All Domestic and Virgin Material)	Polyethylene
Manufacturing	Extruded
Color	Black
Carbon Black (%)	2
Density & Polymer (g/cm^3)	0.936
Melt Index (g/10 min.)	1.10
Tensile Strength (Mach. Direction) (lbs/in)	53
Tensile Strength (Trans. Direction) (lbs/in)	31
Elongation to Break (Mach. Direction) (%)	925
Elongation to Break (Trans. Direction) (%)	425
Porosity	0.81 - 0.84
U.V. Resistance	Stable

APPENDIX B

Soil Boring Logs

WWC ENGINEERING INC.

ENGINEERING AND HYDROLOGY AND HYDROGEOLOGY

LOG OF BOREHOLE	BOREHOLE HP-1	PAGE 1 OF 2
PROJECT: North Butte ISL LOCATION: N 140613.1 E 65803.5 GROUND ELEVATION: 5074.91 SURVEYED: YES X NO	DRILLER: Joe Highsmith, Chen-Northern Inc. LOGGED BY: M. Wolf, WWC RIG: CME 55 auger BIT(S): Hollow stem FLUID: Occasional water	DATE: TIME: START: 11/22/91 START: 12:40 FINISH: 11/22/91 FINISH: 3:25 GEOPHYS LOG: NO TOTAL DEPTH: 40 ft. HOLE DIA: 4 in.

ELEV	DEPTH	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS (ASTM D2488)	BPF	WL	TESTS OR NOTES
	0-4		More sandy clay than in liner			
	4-5	CL	Sandy clay, light buff, very stiff, friable, sands are poorly sorted, fine to coarse grained, dry, $CaCO_3$	29		(CAL)
	9-10	CL	Clay, sandy, buff, hard, poorly sorted, abundant $CaCO_3$ veinlets, slightly moist.	50		(CAL)
	14-15		SM, sand, buff, silty, non-plastic, hard, $CaCO_3$ less than above, sand poorly sorted.	50		(CAL)
	19-20		Top of liner is CL, light grey brown and very small coal chips, very plastic bottom of liner is SC, very fine sand, slight moisture.	38		(CAL)
	24-25		Clay, sandy, buff, very stiff, friable, granular, slight moisture, sands are very fine grained.	28		(CAL)
			At 26 feet driller says material stiffened up, cuttings suggest claystone or clay with minor sand.			
	29-30		Top liner is as above, clay, sandy, buff; shoe and bottom liner is clayey sand with large 3/4" pink sandstone clasts	26		(CAL)
	30-34		Fast penetration of auger, seems fairly soft. Cuttings collected from auger flights are very clayey, slight moisture as bit was pulled, cutting on the last ~2 ft. are brick red sandy clay.			Apparent contact: Tertiary Wasatch at approximately 33 feet.
	34-35		Slow penetration, sandstone, salmon pink/red, hematite staining, moist, very hard, friable, moderately well sorted, fairly uniform, fine grained, must have penetrated pink sandstone at approximately 33 ft.	50/6"		(CAL)
	39-40		As above, little less pink	50/4"		(CAL)

NOTES:

Ring samples were obtained using a 2-in. inside diameter/ 3-in. outside diameter ring-lined barrel sampling assembly. See ASTM D-3550.

Composite Samples (DBS): Bag 1: 0 ft. - 20 ft.
Bag 2: 20 ft. - 34 ft.

Water Check:
11/23/91, 8:08 AM, boring was checked for water with an electronic well probe, was dry at 40 ft.

ABBREVIATIONS:

SWL - Static Water Level
SPT - Standard Penetration Test with Split Barrel Sample (ASTM D-1586)
CAL - California Tube Sample
ST - Shelby Tube Sample
DBS - Disturbed Bulk Sample

WWC ENGINEERING INC.

ENGINEERING AND HYDROLOGY AND HYDROGEOLOGY

LOG OF BOREHOLE JOB #1097	BOREHOLE HP-2	PAGE 1 OF 2
PROJECT: North Butte ISL LOCATION: N 140582.6 E 65929.7 GROUND ELEVATION: 5075.21 SURVEYED: YES XX NO	DRILLER: Joe Highsmith, Chen-Northern Inc. LOGGED BY: M. Wolf, WWC RIG: CME 55 auger BIT(S): Hollow stem FLUID: None	DATE: TIME: START: 11/22/91 START: 9:40 FINISH: 11/22/91 FINISH: 12:25 GEOPHYS LOG: NO TOTAL DEPTH: 40 ft. HOLE DIA: 4 in.

ELEV	DEPTH	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS (ASTM D2488)	BPF	WL	TESTS OR NOTES
	4-5		Top two rings - clay, sandy, $CaCO_3$; bottom rings - clayey, sandy, silty, less clay; only bottom ring saved, slight moisture.	32		(CAL)
	9-10	SC	Top rings, CL, sandy (not saved), contact with sand in ring 2; bottom ring (saved) SM, medium to coarse-grained, buff, loose, slight moisture.	32		(CAL)
	14-15		Top 1-1/2 rings - CL -SC, buff; bottom 1-1/2 rings - GP, fine gravel with coarse sand, light grey brown, some red pebbles, $CaCO_3$, mottled. Only bottom ring (gravel) saved-dense, granular, friable.	40		(CAL) Apparent Contact: Tertiary Wasatch at Approximately 18 feet.
	19-20		Top ring - CL, buff, medium plasticity; bottom 2 rings - sand, SP, poorly consolidated, $CaCO_3$, Fe-stained, fine to medium grained, dense, granular, friable, only slight moisture.	50		(CAL)
	24-25		Top rings - CL, sandy, one may be slough in top ring; bottom ring - SW, fine sand, buff, medium stiff, friable, probably bedrock, slight moisture. Note: Also saving bags of auger cuttings, are much more clayey than brass liners indicated.			(CAL)
	29-30		Sand - SP, buff, fine to medium-grained, very stiff, friable, poorly consolidated, non-plastic poorly graded sands, very fine to medium grained. Top 1-1/2 liners -hole slough - clay, sandy. Bottom liner - sand, few coal particles.	50		(CAL)
	34-35		Sand - SP, buff, fine to medium grained, as above (more moist) but not yet wet.	29		(CAL)
	39-40		Note: From 35 ft. to 39 ft., material got significantly more soft; sand, SP, drilling rate became faster, sand as above, moist, non-plastic. Top 1-1/2 liners is clay, sandy, wet from introduction of water to get cuttings out.	29		(CAL)
	0-20	CL	(DBS) Composite bag sample from auger cuttings, clay, with sand, buff, slight moisture.			

LOG OF BOREHOLE JOB #1097			BOREHOLE HP-2	PAGE 2 OF 2		
ELEV	DEPTH	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS (ASTM D2488)	BPF	WL	TESTS OR NOTES

NOTES:

Ring samples were obtained using a 2-in. inside diameter/3-in. outside diameter ring-lined barrel sampling assembly. See ASTM D-3550.

Composite samples (DBS): Bag 1: 0 ft. - 20 ft.
Bag 2: 20 ft. - 30 ft.

Water Checks:
11/22/91 at 12:24: probed hole for water, no water, depth 39.8 ft.
11/23/91 at 8:11: boring checked for water, hole was still dry at 39.5 ft.

ABBREVIATIONS:

SWL - Static Water Level
SPT - Standard Penetration Test with Split Barrel Sample (ASTM D-1586)
CAL - California Tube Sample
ST - Shelby Tube Sample
DBS - Disturbed Bulk Sample

WWC ENGINEERING INC.

ENGINEERING AND HYDROLOGY AND HYDROGEOLOGY

LOG OF BOREHOLE Job #1097	BOREHOLE HP-3	PAGE 1 OF 1
PROJECT: North Butte ISL LOCATION: N 140288.2 E 65716.9 GROUND ELEVATION: 5064.21 SURVEYED: YES XX NO	DRILLER: Joe Highsmith, Chen-Northern Inc. LOGGED BY: M. Wolf RIG: CME-55 auger BIT(S): Hollow stem FLUID: Occasional water	DATE: START: 11/22/91 FINISH: 11/22/91 TIME: START: 3:34 FINISH: 4:30 GEOPHYS LOG: NO TOTAL DEPTH: 20 ft. HOLE DIA: 4 in.

ELEV	DEPTH	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS (ASTM D2488)	BPF	WL	TESTS OR NOTES
	4-5	CL	Top 8 in. has dark organics, clay, slightly sandy, very light brown, $CaCO_3$ granular, friable, very stiff, dry to slightly moist	20		(CAL)
	9-10		Clay, slightly sandy, same as above, abundant clay, moist, friable, very stiff, abundant $CaCO_3$	22		(CAL)
	14-15		Thin fine gravel lens at 13 ft., maybe 6 in. thick, sand, silty, buff grey, friable, slight moisture, very stiff, poorly sorted; sand ranges from very fine to medium-grained, slight coarse fraction, maybe few small pebbles from gravel lens.	33		(CAL)
	19-20		Clay, sandy, buff, very stiff.	32		(CAL)

NOTES:

Ring Samples were obtained using a 2-in. inside diameter/3-in. outside diameter ring-lined barrel sampling assembly. See ASTM D-3550.

Composite sample (DBS): 0 ft. - 19 ft., boring remained dry.

ABBREVIATIONS:

SW - Static Water Level
SPT - Standard Penetration Test with Split Barrel Sample (ASTM D-1586)
CAL - California Tube Sample
ST - Shelby Tube Sample
DBS - Disturbed Bulk Sample

WWC ENGINEERING INC.

ENGINEERING AND HYDROLOGY AND HYDROGEOLOGY

LOG OF BOREHOLE	BOREHOLE HP-4	PAGE 1 OF 1
PROJECT: Job #1097 LOCATION: N 140251.8 E 65828.7 GROUND ELEVATION: 5064.01 SURVEYED: YES XX NO	DRILLER: Joe Highsmith, Chen-Northern Inc. LOGGED BY: M. Wolf RIG: CME-55 auger BIT(S): Hollow stem FLUID: None	DATE: TIME: START: 11/23/91 START: 8:35 FINISH: 11/23/91 FINISH: 9:28 GEOPHYS LOG: NO TOTAL DEPTH: 20 ft. HOLE DIA: 4 in.

ELEV	DEPTH	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS (ASTM D2488)	BPF	WL	TESTS OR NOTES
	4-5		Clay, buff, slight sand, very stiff, granular, friable, slight moisture, very plastic	20		
	9-10		Sand, clayey, buff, very stiff, very granular and friable, slight moisture.	18		
	14-15		Top ring - CL, buff as above; bottom ring-sand, buff, very fine. Sand at ≈14 1/2 ft., very friable, moderately well sorted, may be Wasatch Formation, non-plastic.	18		
	19-20		Sand, buff, moderate clay, slight plastic, friable, slight moisture.	24		
	0-14 1/2	CL	(DBS) Composite sample auger cuttings: clay with sand, buff, medium to low plasticity, slight moisture.			

NOTES:

Ring samples were obtained using a 2-in. inside diameter/3-in. outside diameter ring-lined barrel sampling assembly. See ASTM D-3550.

Composite sample (DBS): 0 ft. - 14.5 ft.

ABBREVIATIONS:

SWL - Static Water Level
SPT - Standard Penetration Test with Split Barrel Sample (ASTM D-1586)
CAL - California Tube Sample
ST - Shelby Tube Sample
DBS - Disturbed Bulk Sample

APPENDIX C

Laboratory Test Reports

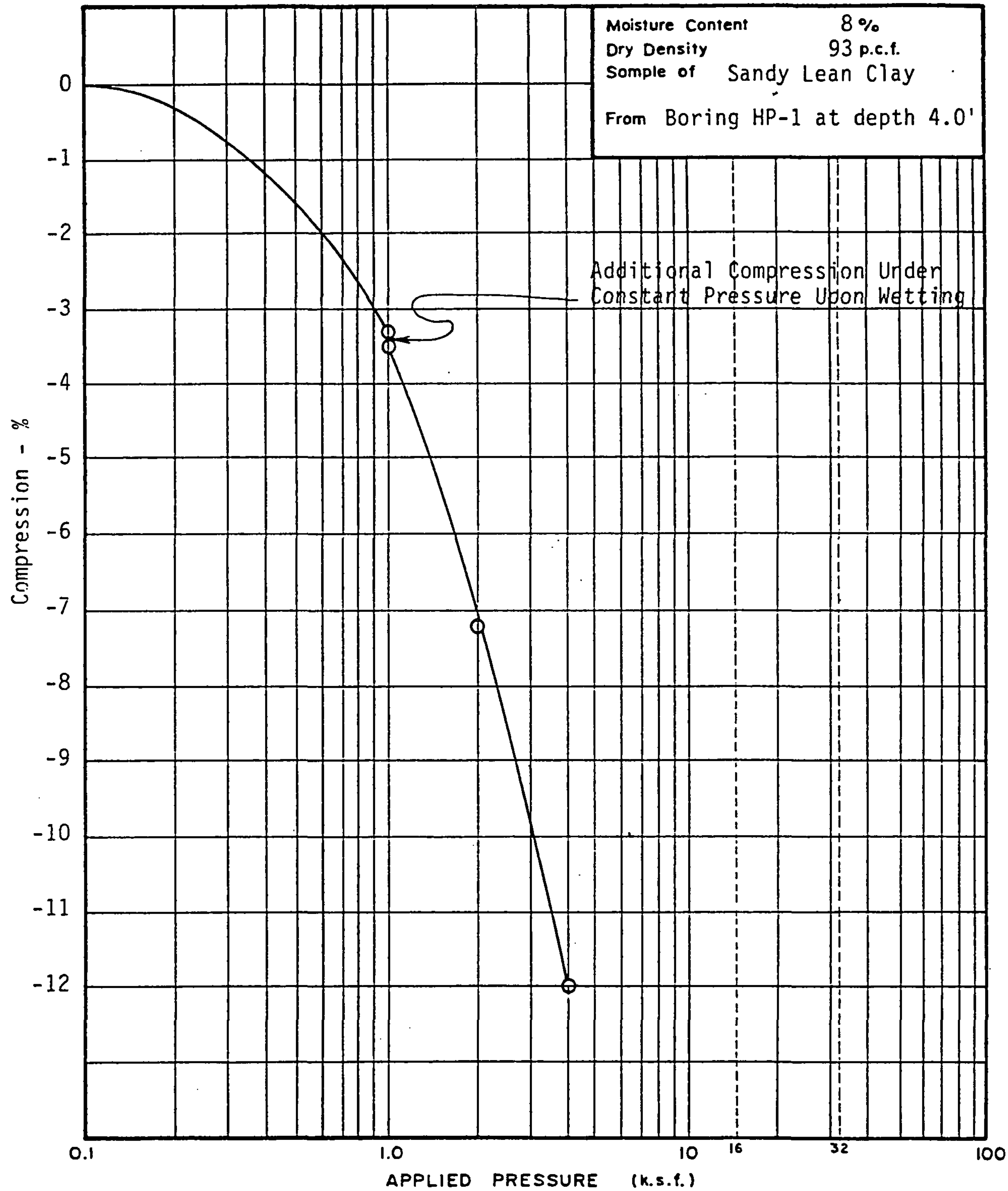
TABLE I
SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (feet)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (p.c.f.)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (p.s.f.)	WATER SOLUBLE SULFATE (%)	GRADATION ANALYSIS			SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)			+#4 (%)	-#4 +#200 (%)	-#200 (%)	
HP-1	4.0	8	93	36	10					59	Sandy Lean Clay
	9.0	7	103	29	13					60	Sandy Lean Clay
HP-2	0.0-20.0	5		28	14			1	45	54	Sandy Lean Clay
	9.0	2	103	18	NP					23	Silty Sand
HP-3	4.0	8	93	35	16					82	Sandy Lean Clay
	19.0	9	113	42	25					93	Lean Clay
HP-4	0.0-14.5	6		36	20			0	18	82	Sandy Lean Clay
P-1	7.5	6		28	10					78	Sandy Lean Clay
P-2	2.5	7		35	19					70	Sandy Lean Clay
O-1	5.0	6		26	13					46	Sandy Lean Clay

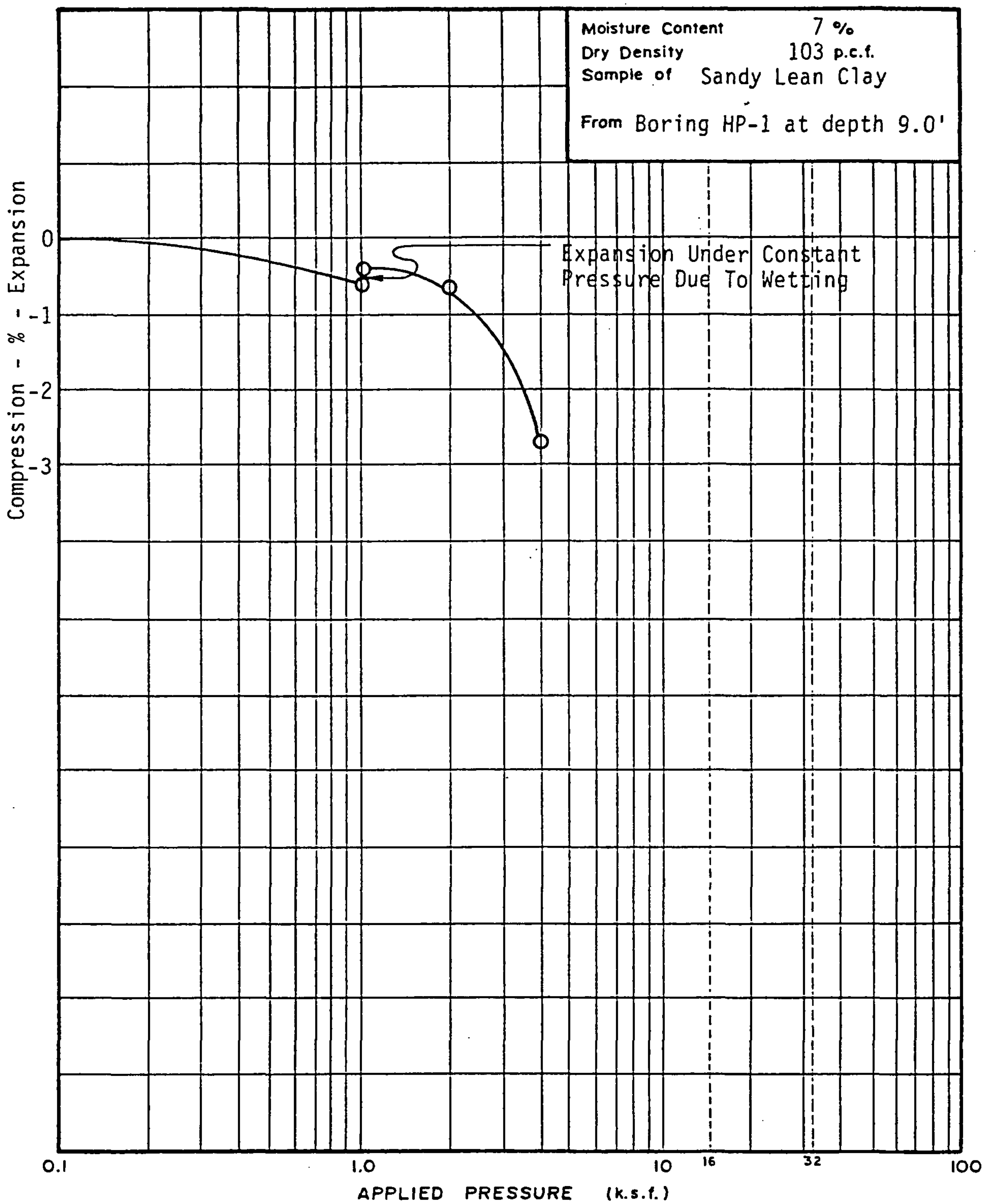
TABLE II

FALLING HEAD PERMEABILITY TESTS

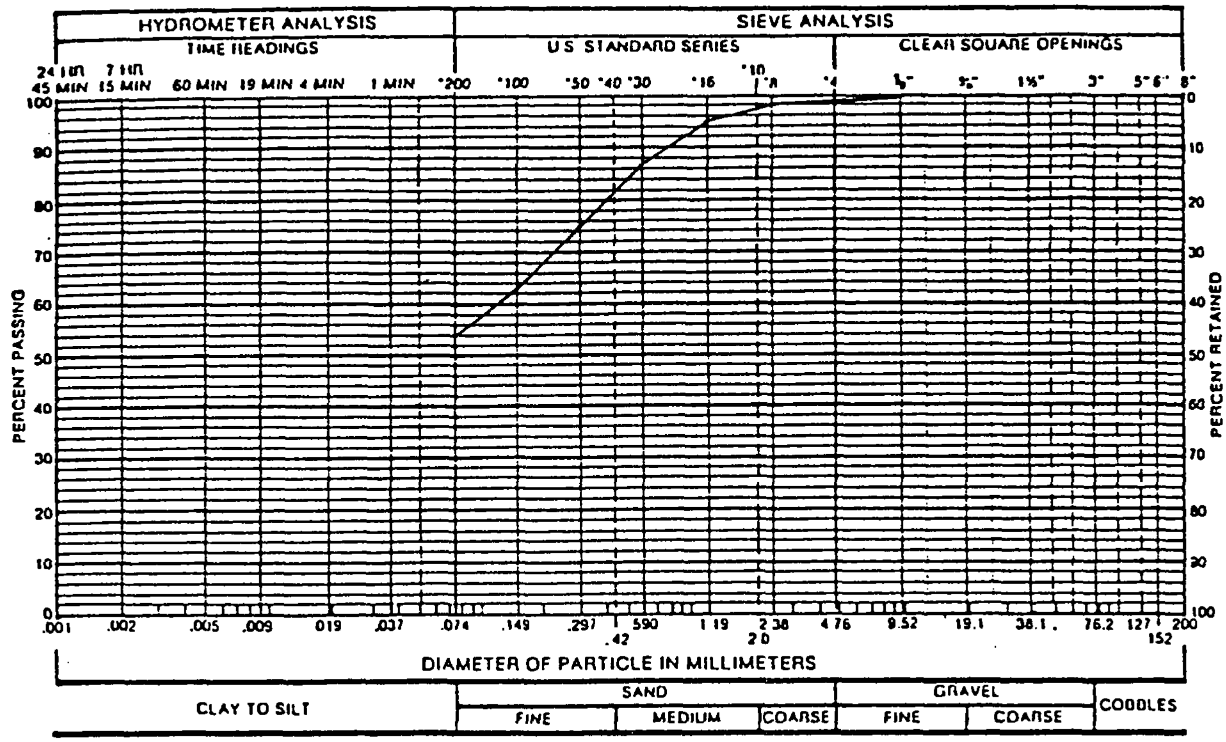
Boring	Depth (ft)	Remolded Moisture Content (%)	Remolded Dry Density (pcf)	Permeability (cm/sec)
HP-2	0-20	12.2	111	$4.8X10^{-8}$
HP-4	0-14	14.3	104.6	$3.8X10^{-8}$



92-4333	Chen-Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig. A-1

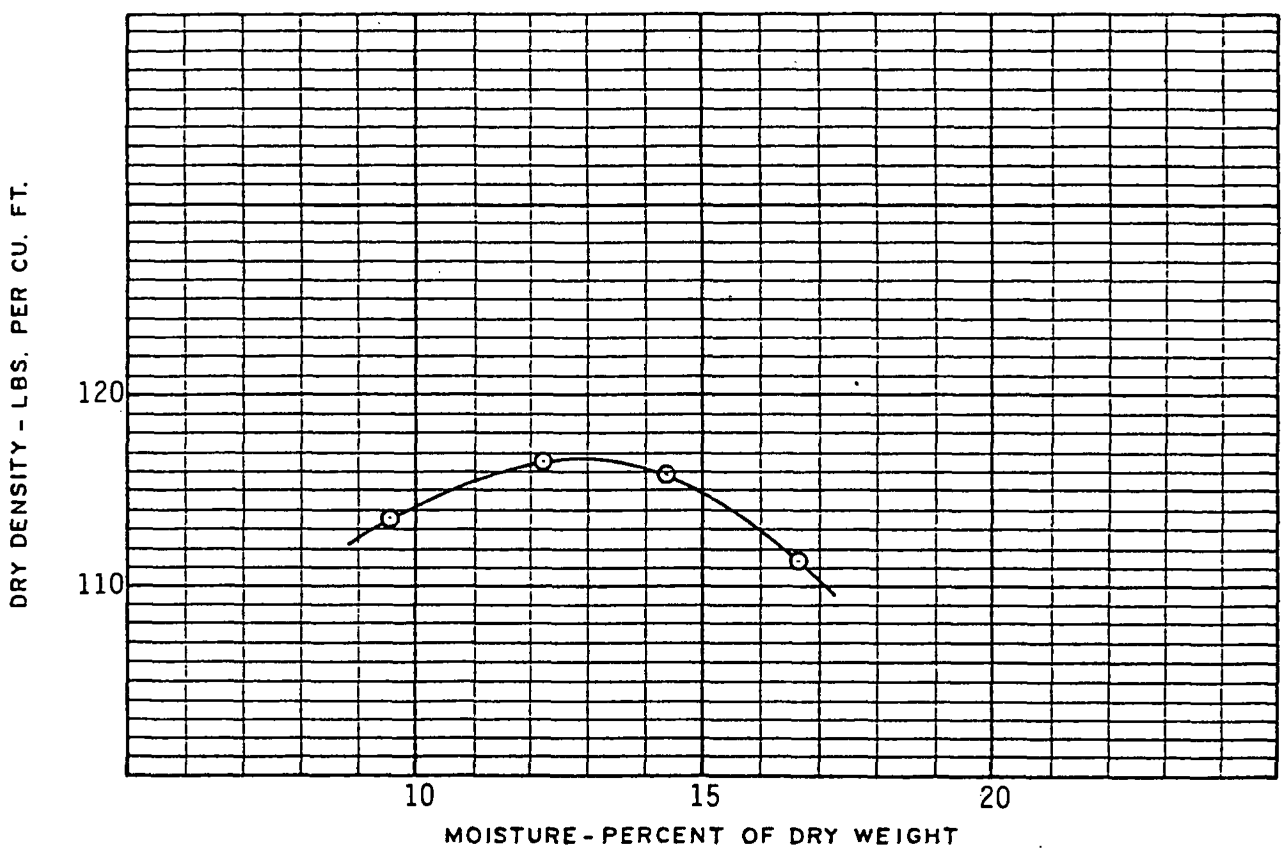


92-4333	Chen Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig. A-2



GRAVEL 1 % SAND 45 % SILT AND CLAY 54%

LIQUID LIMIT 28 % PLASTICITY INDEX 14%



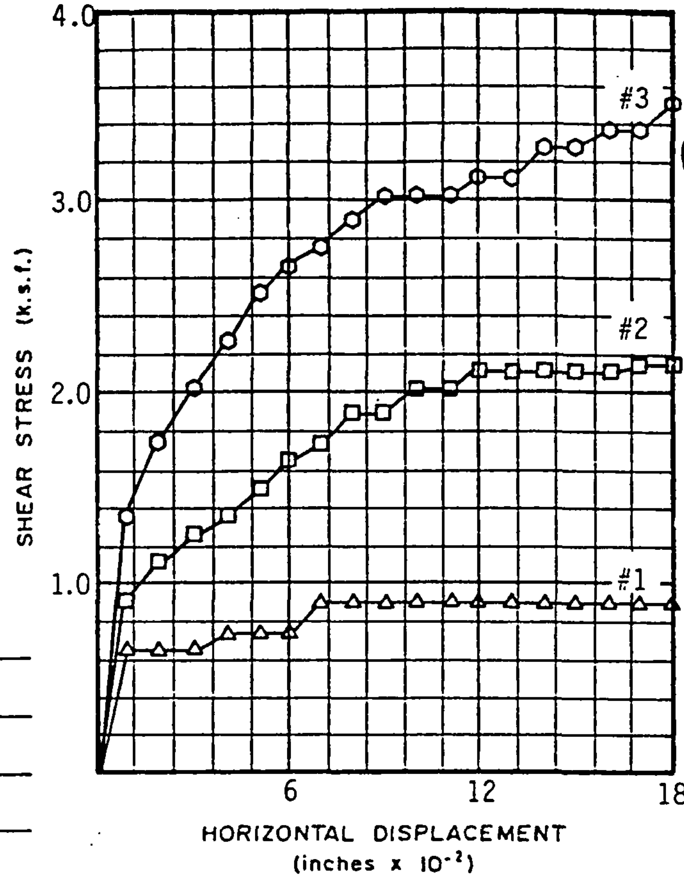
COMPACTION TEST PROCEDURE ASTM D698, Method "A"

MAX. DRY DENSITY (p.c.f.) 116.5 OPTIMUM MOIST. CONT. (%) 12.9

SAMPLE OF Sandy Lean Clay FROM Boring HP-2 at depth 0.0' to 20.0'

92-4333	Chen-Northern, Inc.	GRADATION AND COMPACTION TEST RESULTS	Fig. A-3

TEST NUMBER	1	2	3
FROM	Boring HP-2 at Depth 0.0' to 20.0'		
HEIGHT (inch)	1.00	1.00	1.00
DIAMETER (inch)	1.94	1.94	1.94
MOISTURE CONTENT (%)	12.2	12.2	12.2
DRY DENSITY (p.c.f.)	110.9	111.1	111.1
CONSOL. LOAD (k.s.f.)	1.0	3.0	5.0
NORMAL LOAD (k.s.f.)	1.0	3.0	5.0
SHEAR STRESS (k.s.f.)	0.9	2.3	3.5

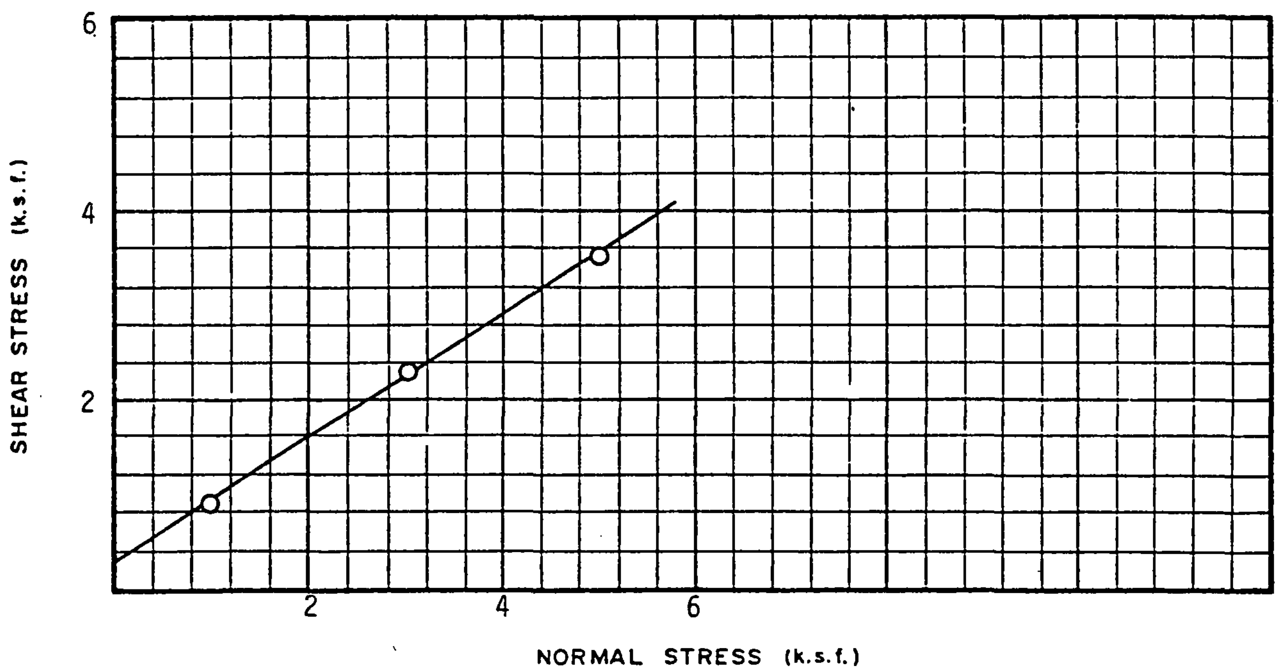


TYPE OF SPECIMEN Remolded

SAMPLE OF Sandy Lean Clay

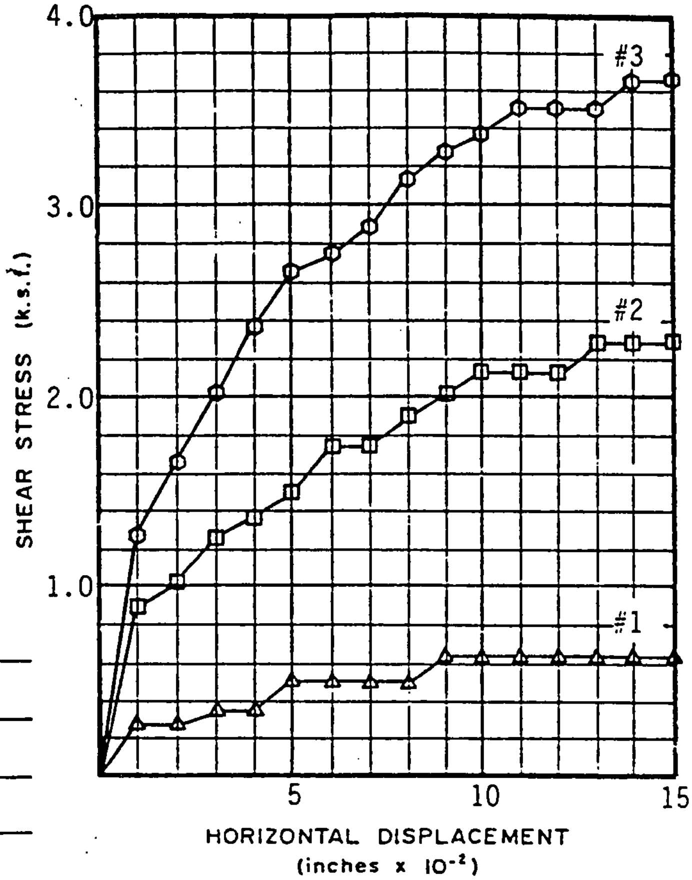
TYPE OF TEST Consolidated, Drained

TAN Ø 0.675 Ø 34° COHESION (k.s.f.) 0.3



92-4333	Chen-Northern, Inc.	DIRECT SHEAR TEST RESULTS	Fig. A-4

TEST NUMBER	1	2	3
FROM	Boring HP-2 at Depth 9.0'		
HEIGHT (inch)	1.00	1.00	1.00
DIAMETER (inch)	1.94	1.94	1.94
MOISTURE CONTENT (%)	1.3	2.4	1.3
DRY DENSITY (p.c.f.)	106.5	98.7	103.4
CONSOL. LOAD (k.s.f.)	1.0	3.0	5.0
NORMAL LOAD (k.s.f.)	1.0	3.0	5.0
SHEAR STRESS (k.s.f.)	0.6	2.2	3.6

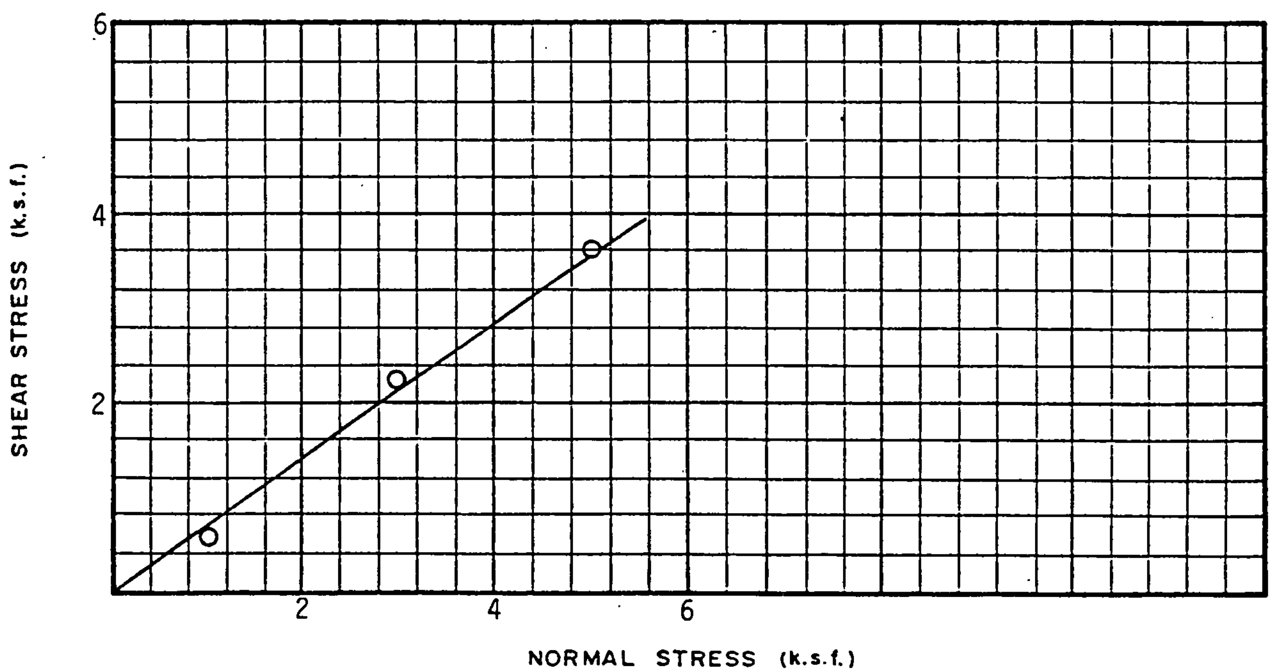


TYPE OF SPECIMEN Undisturbed

SAMPLE OF Silty Sand

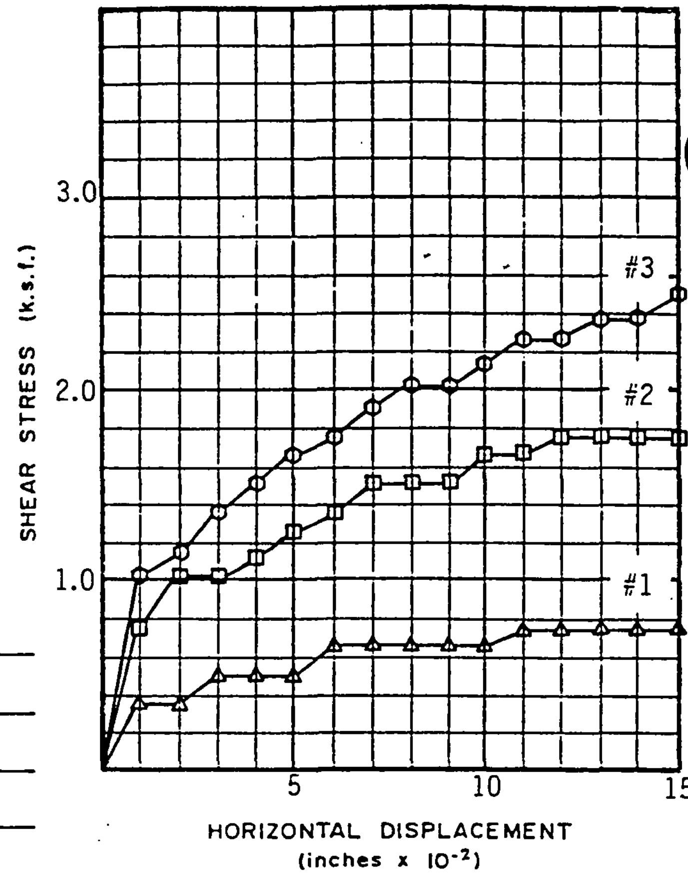
TYPE OF TEST Consolidated, Drained

TAN Ø 0.700 Ø 35° COHESION (k.s.f.) 0.0



92-4333	Chen-Northern, Inc.	DIRECT SHEAR TEST RESULTS	Fig. A-5

TEST NUMBER	1	2	3
FROM	Boring HP-3 at Depth 4.0'		
HEIGHT (inch)	1.00	1.00	1.00
DIAMETER (inch)	1.94	1.94	1.94
MOISTURE CONTENT (%)	6.4	7.8	10.1
DRY DENSITY (p.c.f.)	94.1	94.2	90.1
CONSOL. LOAD (k.s.f.)	1.0	3.0	5.0
NORMAL LOAD (k.s.f.)	1.0	3.0	5.0
SHEAR STRESS (k.s.f.)	0.7	1.8	2.5

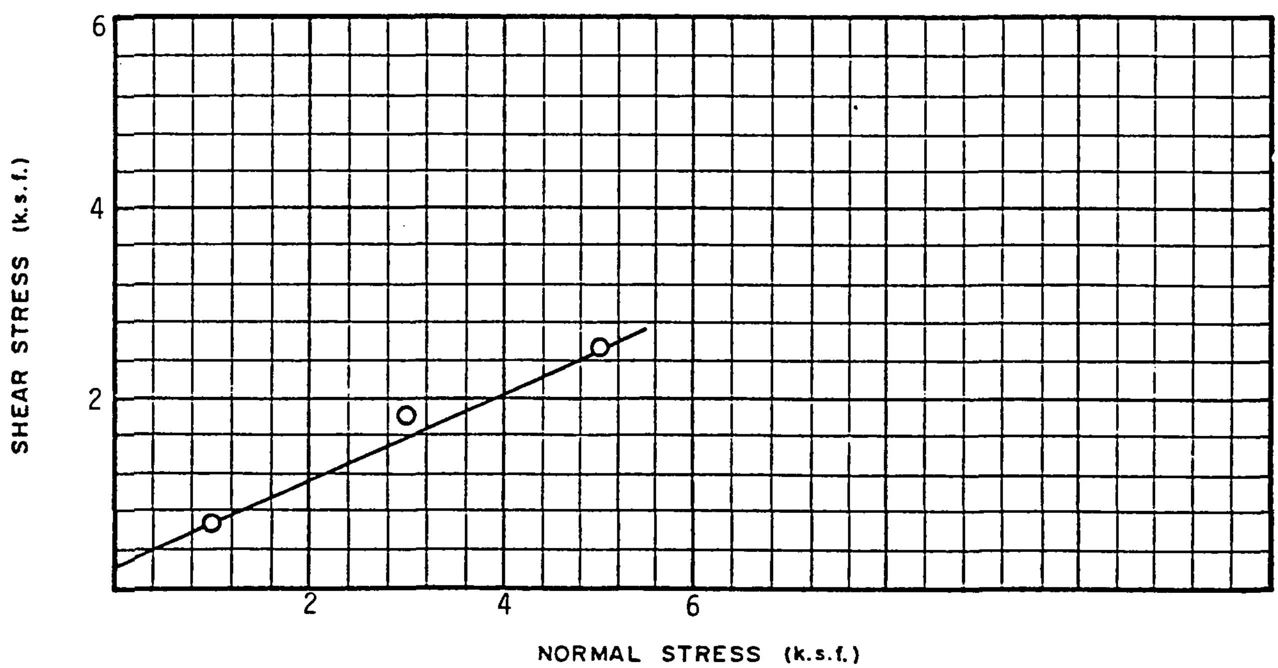


TYPE OF SPECIMEN Undisturbed

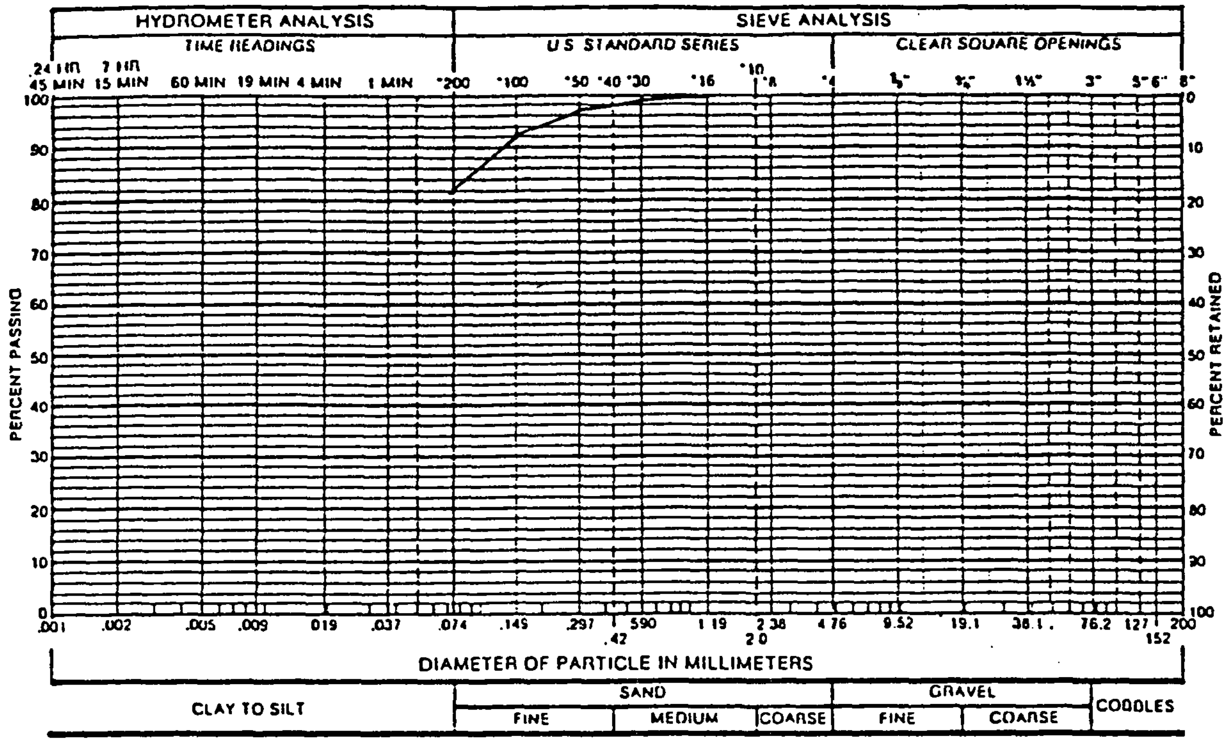
SAMPLE OF Sandy Lean Clay

TYPE OF TEST Consolidated, Drained

TAN Ø 0.445 Ø 24° COHESION (k.s.f.) 0.25

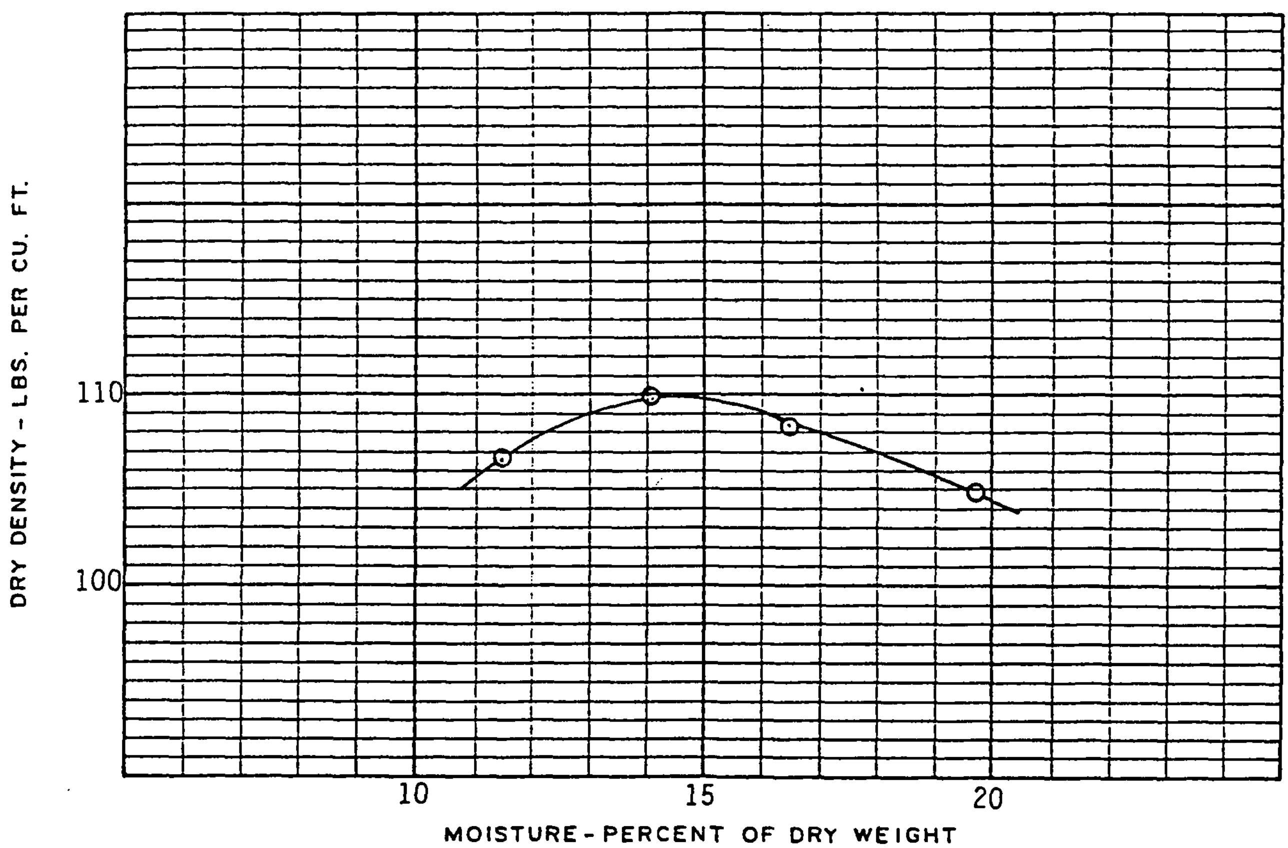


92-4333	Chen-Northern, Inc.	DIRECT SHEAR TEST RESULTS	Fig. A-6



GRAVEL 0% SAND 18 % SILT AND CLAY 82 %

LIQUID LIMIT 36 % PLASTICITY INDEX 20 %



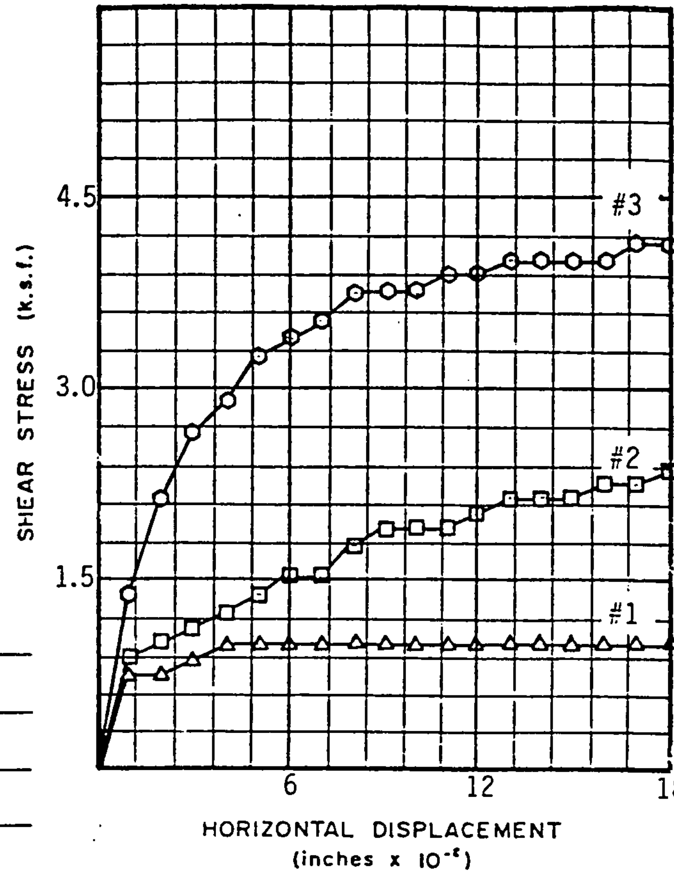
COMPACTION TEST PROCEDURE ASTM D698, Method "A"

MAX. DRY DENSITY (p.c.f.) 109.9 OPTIMUM MOIST. CONT. (%) 14.3

SAMPLE OF Sandy Lean Clay FROM Boring HP-4 at depth 0.0' to 14.5'

92-4333	Chen-Northern, Inc.	GRADATION AND COMPACTION TEST RESULTS	Fig. A-7

TEST NUMBER	1	2	3
FROM	Boring HP-4 at Depth 0.0' to 14.5'		
HEIGHT (inch)	1.00	1.00	1.00
DIAMETER (inch)	1.94	1.94	1.94
MOISTURE CONTENT (%)	14.1	14.1	14.1
DRY DENSITY (p.c.f.)	104.8	104.5	104.7
CONSOL. LOAD (k.s.f.)	1.0	3.0	5.0
NORMAL LOAD (k.s.f.)	1.0	3.0	5.0
SHEAR STRESS (k.s.f.)	1.0	2.4	4.1

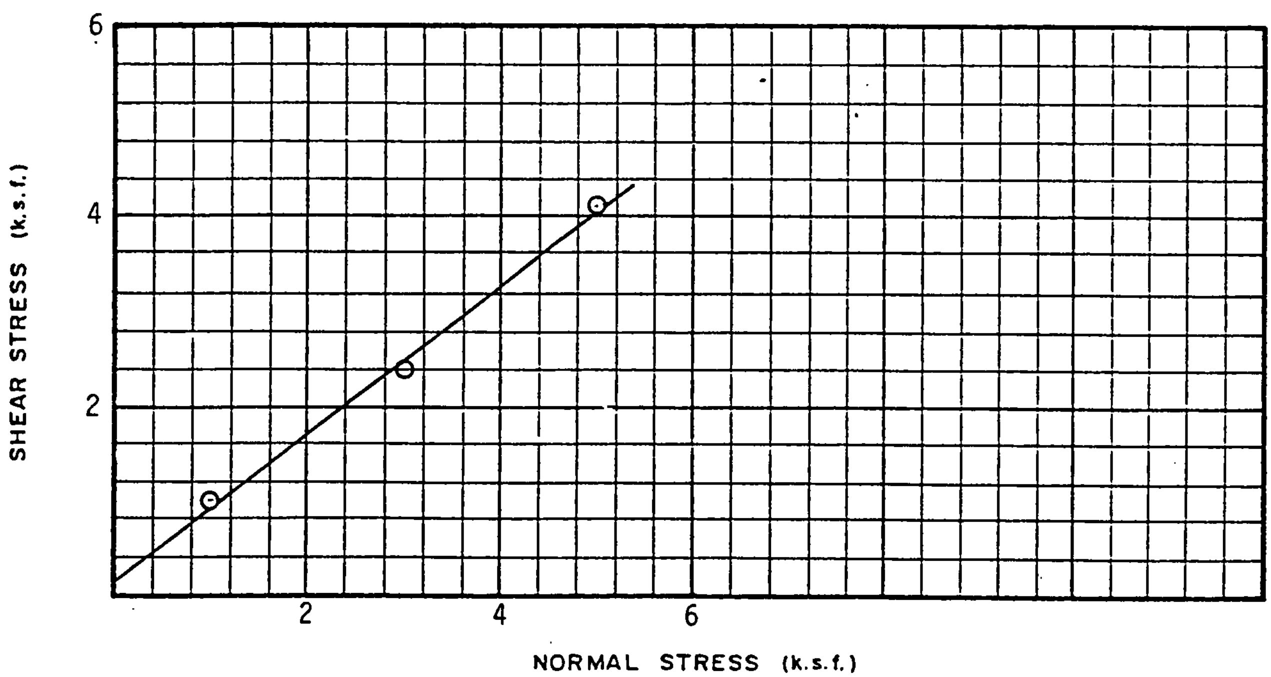


TYPE OF SPECIMEN: Remolded

SAMPLE OF: Sandy Lean Clay

TYPE OF TEST: Consolidated, Drained

TAN Ø 0.781 Ø 38° COHESION (k.s.f.) 0.2



92-4333	Chen Northern, Inc.	DIRECT SHEAR TEST RESULTS	Fig. A-8

15.12 TOPSOIL REMOVAL AND STORAGE

All areas that will be disturbed by mining related activities at the North Butte ISL project will be reclaimed to the historic land use of livestock grazing and wildlife habitat. In order to achieve this goal, Pathfinder will salvage topsoil to the extent necessary to achieve successful land reclamation. The areas of major disturbance, the plant site and evaporation ponds site, will have the topsoil stripped and stockpiled. The locations of the plant site, evaporation ponds, and tentative topsoil storage piles are shown on Figure 15.1 (Volume II). Pathfinder does not plan to do any stripping of topsoil in the wellfields. Topsoil will be segregated during construction of mud pits and pipeline trenches so that it can be placed on top of the pit or trench when it is back filled. The method of salvaging topsoil for the construction of the auxiliary access road (if built) and the wellfield access roads are presented in Section 15.9, and Section 15.10, respectively. As the access road to the processing plant is an existing road, topsoil salvage will be limited. All topsoil encountered will be treated in the same manner as that specified for the wellfield access roads. The methods of constructing all roads are based on the desires of the landowner.

At the processing plant compound area all available topsoil, 13,713 cubic yards, will be stripped and stockpiled. Some subsoil may be used as fill to level the compound area, in which case only the "C" horizon subsoil will be used. At the evaporation ponds area, 29,443 cubic yards of topsoil will be stripped and stockpiled. The remaining subsoil will be used to construct the pond embankments. Pathfinder will use only subsoil in the construction of the pond embankments.

The construction of the auxiliary access road (if built) will disturb about 5.4 acres. Stripping and stockpiling the top three inches of land surface will produce about 2,178 cubic yards of material to be stockpiled along side the road as discussed in Section 15.9.

The ten mining units occupy approximately 322 acres of which about 26 acres or eight percent will be directly disturbed by the mining related activities. The type of land impact associated with the 26 acres of disturbance (roads, mud pits, pipelines, etc.) does not significantly impact the soil and does not necessitate the removal and stockpiling of topsoil to achieve reclamation goals. It has been demonstrated at another commercial uranium ISL mining operation in Wyoming that surface reclamation of the

wellfields can be achieved without stripping and stockpiling topsoil. A listing of the topsoil volumes, depths and soils types are presented in Tables 15.3 and 15.3A.

TABLE 15.3

DISTURBED AREAS AND TOPSOIL SALVAGE VOLUMES

LOCATION	DISTURBED AREA (acres)	SALVAGE DEPTH (feet)	TOPSOIL SALVAGED (cu. yds)
Plant Site Compound	2.7	See Table 15.3A	13,713
Evaporation Ponds	6.5	See Table 15.3A	29,443
Well Fields	26	0.0	0.0
Auxiliary Access Road		See Table 15.1A	
Well Field Access Roads		See Table 15.2A	

TABLE 15.3A

PLANT SITE COMPOUND AND EVAPORATION PONDS TOPSOIL SALVAGE VOLUMES

Plant Site

Soil Type	Acres	Salvage Depth (feet)	Salvage Volume (cu. yds.)
Cushman Loam	2.5	3	12,100
Forkwood Loam	0.2	5	1,613
Totals	2.7		13,713
Evaporation Ponds			
Cushman Loam	4.9	3	23,716
Cushman Bowbac	1.0	3	4,840
Shingle Gullied	0.6	0.5	887
Totals	6.5		29,443

16.1.3 EVAPORATION PONDS LEAK DETECTION SYSTEM

The North Butte ISL project will utilize two evaporation ponds located south of the plant building. Each pond will have a useable capacity of approximately 1.05 million gallons. The location and design of the ponds are presented in Figures 9.2 and 15.1 in Volume II, and Section 15.11.1 of this document.

The leak detection system for the ponds will consist the transport media between the liners (sand/gravel or geonet) and a collection system of 3-inch diameter slotted PVC pipes which drain to sumps. The collection pipes are placed in compacted, gravel-filled trenches at the perimeters of the pond bottoms; the bases of the ponds will be graded to slope toward the sides to facilitate the drainage of any leakage to the nearest collection pipe. The collection pipes will be sloped in approximately 70-foot sections on each side of the ponds to drain to six sumps which will serve as collection points for the leak detection system. Taps consisting of 4-inch PVC pipe will be installed at each sump to allow inspection and sampling.

The inspection tubes from each pond will be inspected once a week to check for the presence of liquid. If a level of liquid is present that is equal to the level of fluid in the pond, it will be chemically analyzed to verify from its composition that liner failure has occurred. If the failure is confirmed, an attempt will be made to repair the leak while the liquid remains in the pond. If this procedure is not successful, the liquid in the pond with the failure will be evacuated to the required level and the leak will be repaired.

The weekly check of the sumps for liquid will also include an inspection of the condition of the pond embankments and liners by an appropriately trained employee.

16.2 SURFACE WATER MONITORING

As described in Section 10.2, Willow Creek flows from east to west through the southern tip of the North Butte permit area. Willow Creek is an ephemeral stream that occasionally flows in the wet spring and early wet summer, and in response to severe thunderstorm activity. Surface water sampling stations have been established on Willow Creek upstream and down stream of the permit area. The location of these two stations are shown in Figure 10.7 (Volume II) and baseline water quality and sediment data are presented in Sections 10.2.2 and 14.1.3, respectively. A third surface water sampling site is the stock pond located in the southwest corner of the permit area (see Figure 10.7, Volume II). The water quality and sediment data from this third site are also presented in Sections 10.2 and 14.1.3, respectively.

Operationally, the water quality at the three surface water stations will be sampled and analyzed once each year during spring or early summer if liquid is present. The parameter list for operational water quality sampling will be the same as the baseline list which is based on LQD/DEQ Guideline No. 8. Sediment samples will not be collected annually, but will be collected at the end of decommissioning. The sediment samples will be analyzed for the same parameters used for baselining which consisted of uranium, radium-226, thorium-230, and lead-210. The operational water quality data collected from Willow Creek will be submitted in the LQD/DEQ Annual Report and the NRC Semi Annual Report. The operational surface water monitoring program will commence with the start of construction, and end when surface reclamation and aquifer restoration have been completed.

16.3 SOILS AND SEDIMENTS

16.3.1 RADIOLOGICAL

extended to the restoration phase for the reverse osmosis brine solution. All liquid effluents will be either surface discharged subject to the provisions of the Federal Water Pollution Control Act (NPDES permit), routed to evaporation ponds or injected into a deep disposal well.

16.11 EVAPORATION PONDS MONITORING

As stated in Section 16.1.3, the leak detection system for each evaporation pond will have collection pipes that will drain to six sumps which will serve as collection points for any fluid from a pond leak. Taps will be installed in each sump to allow inspection for fluids and sampling of the fluids if detected. Each tap of the leak detection system will be checked once a week for the presence of liquid. If liquid is present in an inspection tube a sample will be collected and analyzed to determine if the source of the liquid is an evaporation pond. The anticipated water quality concentration ranges for the waters stored in the ponds are as follows (all concentrations are in mg/l unless otherwise noted):

bicarbonate	500 to 2,000
chloride	2,000 to 50,000
sulfate	450 to 2,000
sodium	800 to 7,500
TDS	3,000 to 75,000
pH	5.0 to 9.0
uranium	$<$0.1 to 15.0
radium-226	$<$1.0 to 2,000 pCi/l

Based on the above concentrations, any fluid detected in the leak detection system shall be analyzed for chloride, carbonate/bicarbonate, sodium and uranium to verify whether the fluid is from an evaporation pond. These are relatively simple analyses which can be performed at the North Butte on-site laboratory, thereby allowing a rapid response time to a pond leak, if verified.

If the analysis confirms that a leak exists in a pond the appropriate regulatory agencies will be notified by telephone no later than the next business day and a written report will follow within seven days. A description of the leak detection system and the evaporation ponds is presented in Section 15.11.

Remedial action in the event of a leak in one of the ponds is to attempt to repair the leak with the water in the pond if the failure is near the water line. If such action is not possible, the liquid in the problem pond will be transferred into the adjacent pond so that repair work can take place. Each pond is designed with a normal operating level, a maximum operating level and the overtopping level. These levels allow for the contents of either pond, when operating at or below the normal operating level, to be transferred into the other pond while still maintaining 1.0 feet of freeboard below the overtopping level. The maximum operating level is used only when a leak occurs, or if one pond is full and the other pond is empty. The filling of a pond after repair work is completed will be carefully monitored on a daily basis to ensure that the leak has been fixed.

INDEX
PERMIT TO MINE NO. 632 - NORTH BUTTE ISL PROJECT

CHANGE NO. ____

Redesignation of Mine Access Road

Description of Change:

Pathfinder Mines Corporation has reviewed the Uranerz, U.S.A mine plan currently within the North Butte Permit to Mine Application and has made revisions consistent with planned Pathfinder operations. One of the revisions is to relocate the processing plant and associated evaporation ponds to a site more centrally located with respect to the wellfields. This will also allow Pathfinder to use an existing road for access to the processing plant rather than construct a new access road as planned by Uranerz, U.S.A.

Pathfinder's proposed access road is an existing road built by Cleveland Cliffs Iron Company for use in developing the North Butte orebody. The road takes off from an oil field road at a point within the permit area located in the NE¼ NW¼ of Section 25, T.44 N., R.76 W. At that point, the road is used exclusively for access to the ISL wellfields and processing facilities. The majority of the road is located on patented surface owned by Pathfinder. Pathfinder plans to upgrade the road by widening to a top width of 20 feet with the addition of six inches of gravel. All upgrading will comply with the landowner's desires for road construction as outlined in the permit application, and applicable performance standards as stated in Land Quality Rules and Regulations Chapter IV, Section 2.(i). The primary advantage of using the existing road is that the additional environmental damage associated with the new road construction as previously proposed by Uranerz will be maintained within the permit boundary, but Pathfinder has no plans at this time to utilize the area. The Uranerz access road has been redesignated the "auxiliary access road" for this change request.

The existing oil field road which provides access to the permit area will also be upgraded by some widening in certain areas, as well as the addition of six inches of gravel. The surface ownership maps in the application have been revised to show ownership of the oil field road outside the area adjacent to the permit boundary (T-Chair Land Company). A copy of pertinent portions of Pathfinder's access agreement with the landowners is enclosed for WDEQ review, but is not intended for insertion into the permit document for confidentiality reasons.

The location of changes to the approved permit document are found in the following table. All revised pages and figures for this particular permit change are attached to these Index pages.

CHANGE NO. ____

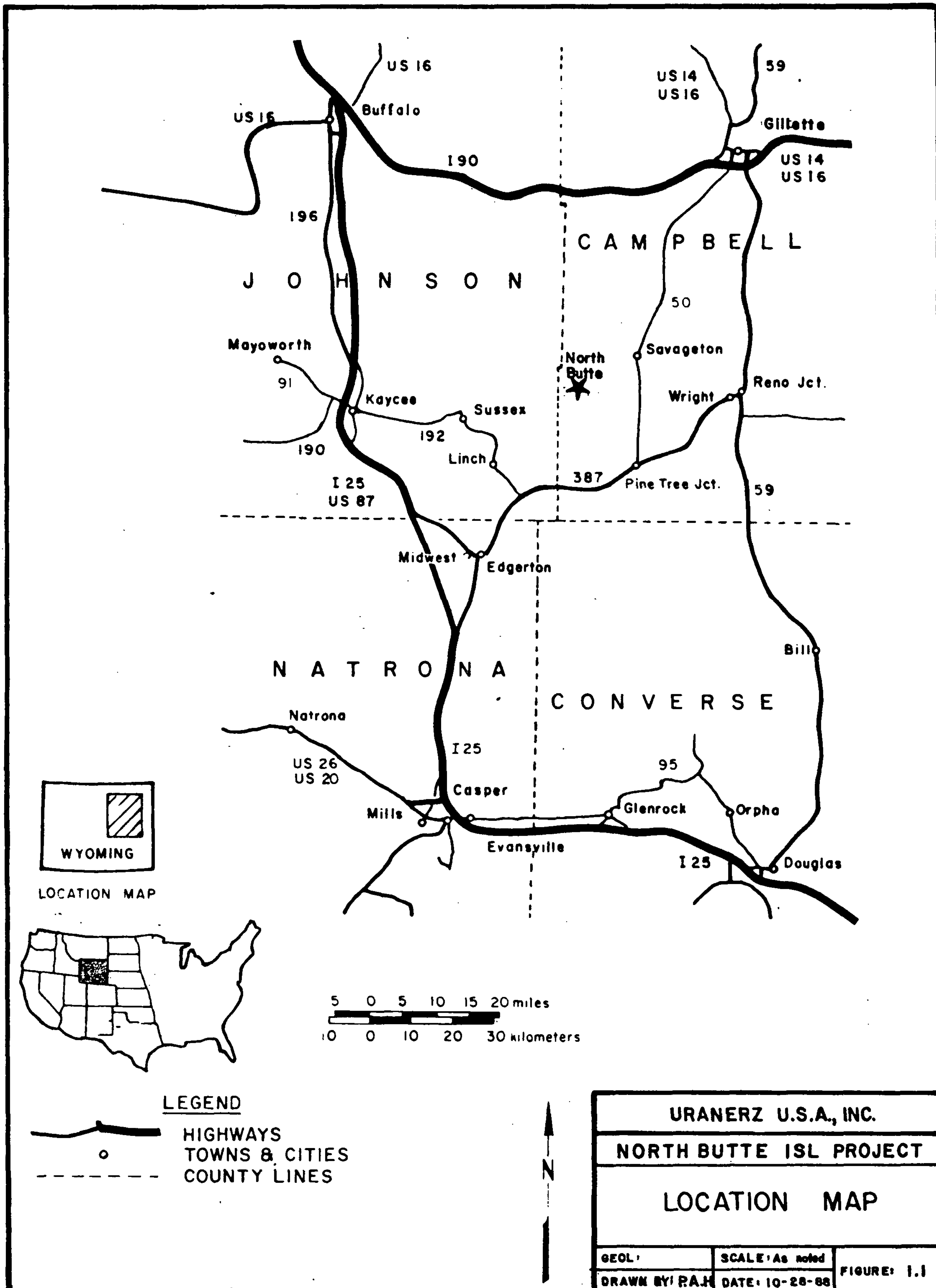
Redesignation of Mine Access Road

Location of Changes to Approved Permit Document:

Volume	Section	Page	Figure	Table	Explanation
I	1.2	1-4			Change legal description of access road
I	15.1	15-1 15-9	 15.12		Change description of access road; note changes on map
I	15.9	15-32 15-32a 15-32b 15-33a 15-33b 15-34	 15.23	 15.1a 15.1a	Insert description of Pathfinder access road; redesignation of Uranerz mine access road to auxiliary access road
I	17.2.8	17-12			Insert description of Pathfinder access road; redesignation of Uranerz mine access road to auxiliary access road
I	Table of Contents	xxvi	15.23		Change mine access road to auxiliary access road
II			2.1		Revise surface ownership map to show ownership of oil field access road outside of adjacent area boundary
II			10.5 10.9		Designation of Pathfinder access road

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)


US 16
Buffalo
US 16
190
196
JOHNSON
US 14
US 16
59
Gillette
US 14
US 16
CAMPBELL
50
Savageton
Mayoworth
91
North Butte
Kaycee
Sussex
Wright
Reno Jct.
192
Linch
190
I 25
US 87
387
Pine Tree Jct.
59
Midwest
Edgerton
NATRONA
Bill
CONVERSE
Natrona
I 25
US 26
US 20
95
Casper
Mills
Glenrock
Orpha
Evansville
I 25
Douglas
WYOMING
LOCATION MAP
5 0 5 10 15 20 miles
10 0 10 20 30 kilometers
LEGEND
HIGHWAYS
TOWNS & CITIES
COUNTY LINES
N
URANERZ U.S.A., INC.
NORTH BUTTE ISL PROJECT
LOCATION MAP
GEOL:
SCALE: As noted
DRAWN BY: P.A.H
DATE: 10-28-88
FIGURE: 1.1

portions of Sections 13, 23, 24, and 25 of Township 44 North, Range 76 West. Part of the project site is located on the Franklin Brown ranch with the remainder of the surface ownership belonging to Pathfinder Mines Corporation. Access is by state highway 50, south from Gillette to Savageton, then west and south on Campbell county and an existing oil field road to the existing plant site access road located in Section 25 of T.44 N., R.76 W. At that point, the road is used exclusively for North Butte mining activities, and progresses approximately 0.9 miles to the process facility.

1.3 PROJECT OWNERS

Pathfinder Mines Corporation purchased the North Butte property from Uranerz, U.S.A. in February, 1991. Effective March 5, 1991, the Wyoming Department of Environmental Quality (WDEQ) transferred Permit to Mine No. 632 to Pathfinder. Permit to Mine No. 632 authorizes the commercial uranium ISL operations addressed by this permit application document. This permit application still refers to Uranerz, U.S.A. as the owner and operator. Wherever Uranerz, U.S.A. appears in this document, one should understand that this is now Pathfinder Mines Corporation.

The corporate offices for Pathfinder Mines Corporation are located in Bethesda Maryland. The President and CEO of Pathfinder reports directly to the President of Cogema, Inc. whose offices are also located in Bethesda, Maryland. The current offices for the North Butte operation are located in Mills, Wyoming. Pathfinder owns and operates two other uranium mines in Wyoming, notably the Shirley Basin Mine in Shirley Basin and the Lucky Mc Mine located in the Gas Hills.

15. MINE PLAN

15.1 SITE LOCATION AND LAYOUT

The North Butte ISL Project is located in southwest Campbell County, Wyoming about 42 air miles southwest of the city of Gillette. Figure 1.1 in Section 1 is a map that shows the general location of the North Butte ISL Project. The permit area includes portions of Sections 18 & 19, Township 44 North, Range 75 West, and Sections 13, 23, 24 and 25, Township 44 North, Range 76 West. Access to the North Butte ISL Project is via State Highway 50 south of Gillette to Savageton, thence west and south on the Vanbuggenum/Christensen County road to the Oxy-USA oil field access road. The oil field access road is a good quality gravel road currently used for access to oil field and ranching operations, and is owned and maintained by the T Chair Land Company. The oil field road will be used by Pathfinder to reach the mine access road which takes off at a point located in the NE¼ NW¼ of Section 25, T.44 N., R.76 W. The mine access road is an existing road built by Cleveland Cliffs Iron Company for the initial development of the North Butte orebody. Pathfinder plans to upgrade this road, which is all included within the permit boundary, for a distance of approximately 0.9 miles to the process plant. A complete legal description of the 989 acre permit area is contained in Section 4 (Appendix "C").

The permit area lies within the Willow Creek Drainage with the steam channel running from east to west through the southern tip of the project site. Figure 9.2 (Volume II) is a site plan map that shows the permit area boundary, the planned wellfield locations, the planned evaporation ponds location, and the planned processing plant location. Figure 15.1 (Volume II) is a facilities site plan map that shows additional detail of the processing plant and ponds area.

15.2 ORE BODY DESCRIPTION

At the North Butte permit site there are three mineralized sand members which make up the North Butte mining sand. These members are frequently in vertical conjunction essentially eliminating one of the three sand members. The North Butte mining sand consists of the "A", "B", and "C" sand members, in ascending order, and is a

laterally extensive depositional unit. The individual members of the sand are good aquifers with their groundwater flow direction being essentially south to north. Mineralization occurs in all three sand members although different areas will have mineralization in different sand members and at different depths. The "B" sand member is the primary ore bearing sand with the "A" and "C" sand members contributing lesser, though substantial reserves. The "B" sand member is the more laterally extensive of the three sand members, being well developed over the entire permit area. The "C" sand member has a tendency to shale or pinch out to the east. While the "A" sand member is extensive, it is not as well developed as the "B" sand member and is less mineralized. The individual sand members vary in thickness as follows: "A" sand, 20 to 90 feet; "B" sand 50 to 120 feet; "C" sand 0 to 120 feet thick. The sand members, when they are present, average 40, 80, and 70 feet in thickness, respectively.

Above the "C" sand member is a laterally extensive shale barrier (Upper aquitard) which is continuous over the entire permit area and averages 99 feet in thickness over the "C" sand member. Where the "C" sand member is not present the shale averages 170 feet thick. The upper monitored aquifer or "F" sand lies above this shale layer. The "F" sand averages about 58 feet in thickness and about 340 feet below the land surface. Beneath the "A" sand member lies an impermeable shale barrier (Lower aquitard) between 99 to 275 feet thick. Below this shale barrier lies the "1" sand. The "1" sand consists of a poorly developed, discontinuous series of spotty sand lenses. These lenses do not form a viable aquifer and are difficult to trace from drill hole to drill hole. These upper and lower shale barriers (aquitards) are composed of shales, silty shale, and shaley lignite interbeds. Cross sections through the ore body showing the mining sand, and the upper and lower confining layers are presented as Figures 15.2 through 15.10a (Volume II). Figure 15.11 (Volume II) is provided as a cross section location map (representative geologist's logs at the end of Section 15).

The ore body is a typical roll front type deposit. In the North Butte area the oxidation-reduction zone trends essentially from the southwest to the northeast with several complex permutations occurring. In several areas there are vertically superimposing stacked fronts in a single sand member and frequently two mineralized sand

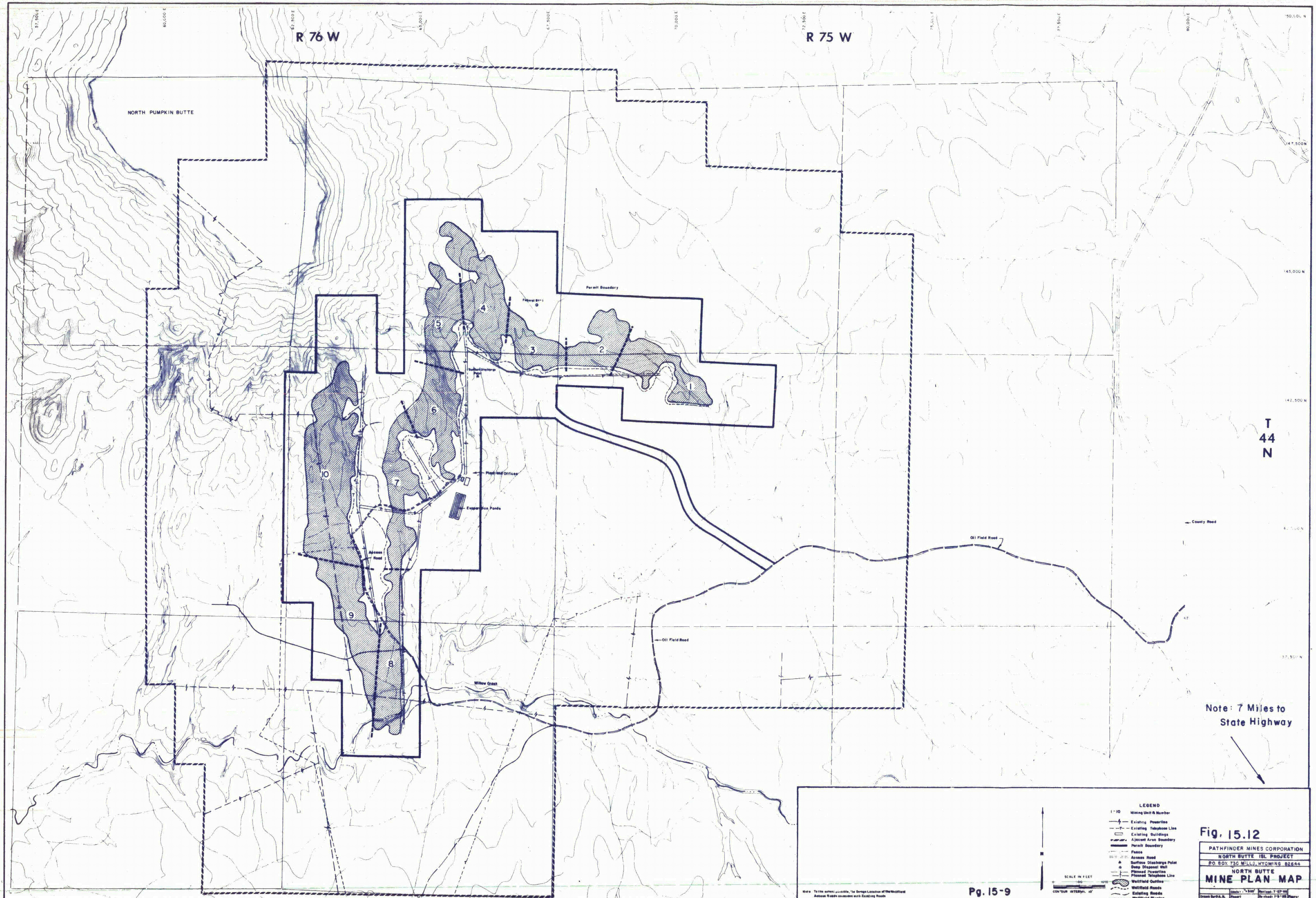


Fig. 15.12

PATHFINDER MINES CORPORATION
NORTH BUTTE ISL PROJECT
P.O. BOX 730 MILLS, WYOMING 82644

NORTH BUTTE
MINE PLAN MAP

Drawn By: P.A.R. | Date: 4-29-88 | Revised: 7-27-88 | Revised: 1-9-89 | Revised: 1-1-92

The average annual net water consumption from the mining sand aquifer from restoration activities is about 45 GPM.

Uranerz plans to use a combination of deep well injection, evaporation ponds, and surface discharge (NPDES) to dispose of the liquid effluent that will be generated at the North Butte site. The evaporation ponds will be used for the temporary storage of water that requires radium settling before surface discharge and for temporary storage during maintenance periods on the deep disposal well. The effluents generated from the above mining and restoration periods will be sampled and classified to determine the disposal approach. The general guidelines and estimated flowrates are:

- Deep disposal well: To accept water with TDS in excess of 5,000 mg/l and/or U_3O_8 in excess of 5 mg/l. Estimated flowrate of 10 - 100 GPM.

- Surface discharge: Water quality dictated by the NPDES permit. Estimated flowrate of 20 - 240 GPM.

15.9 MINE ACCESS ROAD

For access to the North Butte facilities, Pathfinder plans on upgrading an existing access road originally built by Cleveland Cliffs Iron Company for use in developing the North Butte orebody. This plan is opposed to the original Uranerz plan of building a new access road in Section 19, T.44 N., R.75 W, which is approved in this permit document. The existing access road takes off from the main oil field road at a point within the permit boundary located in the NE¼ NW¼, Section 25, T.44 N., R.76 W (see Figure 9.2, Volume II). From this point on, the road will be used exclusively for access to the ISL wellfields and processing facilities. Pathfinder plans to upgrade the existing road, with the road design being limited to minor alignment changes and upgrading the level of service (topwidth, surfacing and grading). A 20 foot topwidth will be provided with approximately six inches of crushed gravel or scoria. Pathfinder's design will include hydraulic investigations to verify the capacity and condition of existing culverts in the road (see Section 15.9.1), and to provide miscellaneous drainage. The upgrading of the existing access road will comply with the landowner's desires as stated in this permit document, and with applicable portions of Land Quality Rules and Regulations Chapter IV, Section 2.(i)(i)-(viii).

Uranerz, U.S.A. had planned to construct a new access road for entrance to the North Butte project. The corridor for this road is contained within the permit boundary and is some 1.6 miles in length starting near the corner of the southeast quarter of Section 19, T.44 N., R.75 W., where it departs the main oil field road (see Figure 9.2, Volume II). Pathfinder does not intend to construct this road at this time, but has left the information regarding the roadway intact within this document, should a necessity arise in the future to construct the road. For this reason, this particular road has been redesignated the "auxiliary access road", and the discussion pertaining to this road within this document will remain. The legal description of the auxiliary access road is presented in Section 4 (Appendix C).

The auxiliary access road will be approximately 20 feet in width and will cross two small drainages identified as Crossing A and Crossing B on the Site Plan Map (Figure 9.2, Volume II). Culverts will be used at both crossing locations to maintain all weather access. The auxiliary access road will be constructed by blading the top six to eight inches of soil to each side and constructing a drain on each side with the topsoil windrowed to the outside of each drain. The subsoil from the construction of the drain will be placed in the bottom of the drain and seeded. A typical road cross section is presented in Figure 15.23. A three to six inch layer of gravel or scoria will be placed on the road bed surface. A listing of topsoil volumes and soil types for the auxiliary access road are found in Table 15.1a. A two feet buffer zone will exist on each side of the road where topsoil will not be placed.

There are no areas along the proposed auxiliary access road route that will require any significant cutting. At the two culvert crossings some fill material will be required. The fill material will be obtained from sites adjacent the road and within the permit area. The "A" and "B" horizon topsoil will be removed, stockpiled and seeded from the sites used for obtaining fill material.

Following the completion of all mining and reclamation activities, the land owner desires that the auxiliary access road be reclaimed (if built) as described in Section 17.3 of this document. Briefly, reclamation of the road consists of picking up the gravel or scoria from the road bed, discing, re-apply the stored topsoil and seed. Even if the stored topsoil is not re-applied to the road bed, the existing 3-plus feet on the average of remaining in place topsoil will provide sufficient plant growth material to re-establish vegetation.

The proposed method of road construction for this short 1.6 mile segment is simple and inexpensive to construct, and causes minimal impact to the land resource. Other techniques which require the stripping of all topsoil along the road route take native land out of use at the stockpile locations and a substantial amount of fill (gravel or scoria) must replace the topsoil to prevent large erosion channels from forming on the road. The land from where the fill material is obtained is impacted unnecessarily by this method. The land owner has successfully used the proposed method of road construction on the ranch property.

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TABLE 15.1a

North Butte Project
Soils Crossed by the
Auxiliary Access Road

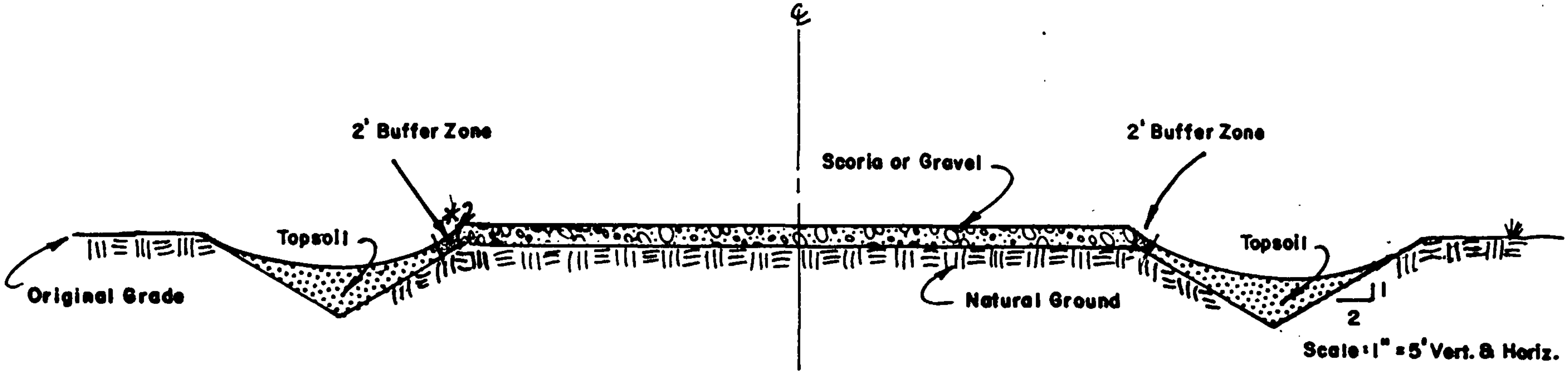
Map Symbol	Soil Type	Soil Horizons and Depths(in.)		
		E	A	AB
50/AB	Bidman	0-3		
75/BC	Cushman		0-3	3-6
45/AB	Forkwood		0-4	4-6
a62/AB	Hiland		0-7	
KI/AB	Kishona		0-3	
PA	Parmleed		0-4	
SH-G	Shingle		0-3	
TA	Taluce		0-3	
TUR	Turnercrest		0-4	

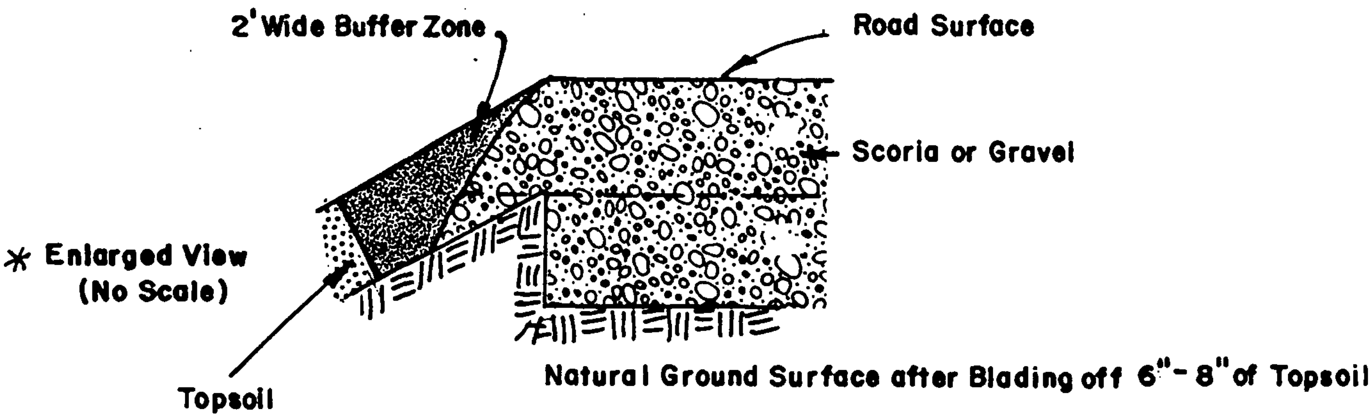
TABLE 15.1a (continued)

North Butte Project
Auxiliary Access Road
Topsoil Volumes

Soil Type	Feet of Roadway	Acres	Volumes (cu.yd.) A Horizons
Bidman	1,920	2.29	2,475.3
Cushman	380	0.45	486.4
Forkwood	2,730	3.26	3,523.8
Hiland	535	0.64	691.8
Kishona	340	0.41	443.2
Parmleed	100	0.12	129.7
Shingle	530	0.63	681.0
Taluce	1,385	1.65	1,783.5
Turnercrest	430	0.51	551.3
	TOTALS	9.96	10,766.0

NOTE: Width of mine access road surface and ditches is 52 feet (20 foot surface with 16 feet for ditching on either side).





Note: Blade 6" to 8" of Topsoil to sides with slight Crown in middle. Blade Drainage Ditch on each side then line Drainage Ditch with Topsoil. Fill Roadbed with 3" - 6" of Gravel or Scoria.

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Revised: 5-10-90
Revised: 1-29-90

PATHFINDER MINES CORP.		
NORTH BUTTE ISL PROJECT		
AUXILIARY ACCESS ROAD TYPICAL CROSS-SECTION		
GEOL:	SCALE: None	FIGURE: 15.23
DRAWN BY: R.A.H.	DATE: 1-18-89	

15.9.1 STREAM CROSSINGS; CULVERT AND FORD DESIGNS

During the life of the permit, it will be necessary to construct six road crossings on ephemeral channels within the North Butte permit area. These stream crossings will consist of either a gravel bottomed ford in places where the channel and flood plain geometry allows for easy crossing or culverts where a ford is not practical. These stream crossing locations and contributing drainage basins upstream are presented on Figure 10.6 (Volume II). Figure 10.9 (Volume II) also presents the drainage basin divides and the cross section locations. There are three proposed culvert crossings and three ford crossings of tributaries to Willow Creek of the Powder River. Table 15.2 presents the drainage basin parameters used in the analysis which are labeled SC1 through SC6. In the larger basins in which culverts will be used in the construction, the drainage basins have been broken into several sub-basins. This was performed in order that unique areas of each basin could be modeled separately.

The 10-year, 6-hour meteorological event has been used in the design as agreed upon in discussions with WDEQ personnel. The 2-year, 6-hour event was also used in combined ford and culvert crossings. The point rainfall depths associated with the 10-year and 2-year events have been determined to be 2.25 and 1.43 inches, respectively. These depths were obtained by the use of the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Atlas of the Western United States - Wyoming Atlas 2 (Miller et al, 1973). The storm distributions were determined through regression techniques presented in the NOAA Atlas. The cumulative rainfall depths for the 5-minute, 15- minute, 60-minute, 2-hour and 3-hour intervals are 0.493, 0.969, 1.70, 1.85 and 1.98 inches, respectively, for the 10-year event and 0.293, 0.576, 1.01, 1.10 and 1.23 inches, respectively, for the 2-year event.

The HEC-1 computer model, adapted for a microcomputer, (Army Corps of Engineers, 1985) was used to calculate the peak flow and run-off hydrographs using the above rainfall depths. HEC-1 is a flood hydrograph package developed by the Army Corps of Engineers and used extensively in their applications. The SCS Dimensionless Unit Hydrograph option of the model was employed in this design. This model

17.2.8 COVER AND PRODUCTION EVALUATION

When revegetation is considered a success, quantitative cover and production data will be collected from the reclaimed and extended reference areas. Methods used to collect this data will be those outlined in DEQ Guideline No. 2, Vegetation. Data will be collected from the reclaimed area and reference areas for two consecutive years and compared by standard statistical procedure (confidence level = 80%, 0.2). The goal of equal cover and production will be achieved for two consecutive years before revegetation is considered successful.

17.2.9 SPECIES DIVERSITY AND COMPOSITION

One of the goals of reclamation is to insure that post-mining plant communities have sufficiently diverse species composition and sufficient species diversity to support the post-mining land use. The species diversity and composition will be analyzed using the Motyka Index of Similarity. A similarity index of at least 80 percent will be considered acceptable. The index of similarity will be based on cover data for the following life form divisions:

Perennial Native Grass
Annual Grass
Grasslike
Perennial Forb
Annual Forb

All data collected during reclamation success studies will be evaluated and reported relative to the ability of the area to support livestock grazing.

17.3 ROAD RECLAMATION

17.3.1 ACCESS ROADS

The access road connecting the processing plant with the oil field road is an existing road approximately 0.9 miles in length. The landowner has requested that Pathfinder leave this road for ranching access when operations are completed. Pathfinder has agreed to this, however for WDEQ purposes, third party costs for reclaiming the road have been included in the reclamation bond estimate until an agreement with the landowner is reached in writing. If the 1.6 mile long auxiliary access road is constructed by Pathfinder, the landowner desires that this road be reclaimed following all mining and restoration activities. The landowner does, however, want the option of leaving the road unreclaimed, if constructed. Pathfinder has no plans to construct the auxiliary access road at this time.

If the auxiliary access road is constructed, the first step in reclamation is to pick up and remove the scoria/gravel on the road surface. Once the scoria/gravel has been removed the road bed will be disced or ripped. Next, the topsoil stored in the ditch will be re-applied on the road surface. Finally, the road surface will be mulched and seeded with the permanent seed mix.

17.3.2 WELLFIELD ACCESS ROADS

The wellfield access roads allow vehicular traffic to move from the plant to the wellfields and from one wellfield to another wellfield. The construction design for the wellfield access roads is presented in Section 15.10. At the time of decommissioning the land owner will decide which wellfield access roads he wants to remain unreclaimed. Those roads not desired by the land owner for continued use will be reclaimed.

The first step in reclaiming the wellfield access road is to pick up and remove the scoria/gravel so that the road bed is back to the approximate original grade. Next, the road bed will be either disced or ripped, and then the disturbed area will be mulched and seeded with the permanent seed mixture.

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