UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
URANIUM RECOVERY FIELD OFFICE
BOX 25325
DENVER, COLORADO 80225

MAY 4 1988

URFO:GRK
Docket No. 40-8502
License No. SUA-1341
04008502110R

MEMORANDUM FOR: Docket File No. 40-8502

FROM: Gary R. Konwinski, Project Manager
Licensing Branch 1
Uranium Recovery Field Office, Region IV

SUBJECT: ENVIRONMENTAL ASSESSMENT (EA) FOR MALAPAI RESOURCES, CHRISTENSEN RANCH IN SITU LEACH SATELLITE OPERATION

Attached is the Environmental Assessment (EA) prepared in support of a major license amendment to Source Material License SUA-1341 for Malapai Resources Company, Christensen Ranch Satellite Operation located in Campbell and Johnson Counties, Wyoming.

Gary R. Konwinski, Project Manager
Licensing Branch 1
Uranium Recovery Field Office
Region IV

Approved by: Edward F. Hawkins, Chief
Licensing Branch 1
Uranium Recovery Field Office, Region IV

Attachment: Christensen Ranch In Situ Leach Operation (EA)

Case Closed: 04008502110R

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40-8502/GRK/88/04/07/0

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OFC	URFO	URFO				
NAME	GKonwinski/lv	EHawkins				
DATE	88/04/07	5/4/88				

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UNITED STATES NUCLEAR REGULATORY COMMISSION

ENVIRONMENTAL ASSESSMENT

BY THE

URANIUM RECOVERY FIELD OFFICE

IN CONSIDERATION OF A MAJOR AMENDMENT TO

SOURCE MATERIAL LICENSE SUA-1341

FOR

MALAPAI RESOURCES COMPANY

CHRISTENSEN RANCH IN SITU LEACH SATELLITE OPERATION

CAMPBELL AND JOHNSON COUNTIES, WYOMING

DOCKET NO. 40-8502

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 Background

By letter dated January 5, 1988, Malapai Resources Company (Malapai) submitted an amendment application to Source Material License SUA-1341. The application involves utilizing the existing Malapai facilities located at the Irigaray Mine as a processing site for resins loaded at the proposed Christensen Ranch Satellite Operation. Due to this, the proposed well fields and ion exchange columns located at Christensen Ranch will be commercial scale, but will lack the processing components necessary to produce a marketable product.

Although the proposed action is an amendment to Source Material License SUA-1341, the staff determined that an environmental assessment should be performed in conjunction with the review process. The primary reasons for making this determination were:

1. An environmental assessment had been prepared for the Christensen Ranch Research and Development Operation on March 27, 1985. At that time, the NRC concluded that the research and development operation would have minimal environmental consequences. However, due to the magnitude of the proposed operation, the NRC determined that a re-evaluation of the project would be necessary.

2. The proposal involves an increased flow rate, a larger well field and additional solution evaporation ponds. Therefore, the NRC has chosen to evaluate the impacts associated with these facilities.

The Christensen Ranch Satellite Operation consists of about 14,000 acres, located within the southern portion of the Powder River Basin in Johnson and Campbell Counties, Wyoming, approximately 30 miles north-northeast of the town of Midwest, Wyoming, and 50 miles southwest of Gillette, Wyoming (Figure 1.1.01). Land ownership within the Christensen Ranch Satellite Operation is divided equally between private ownership and Federal or State ownership. Malapai maintains 866 unpatented lode mining claims and two State mining leases within and around the area.

Malapai proposes to in situ leach uranium contained in a basal sandstone member of the Wasatch Formation. The operation will consist of four mining phases, covering a well field area of approximately 14,000 acres. Within the Christensen Ranch Satellite Operation area, the Wasatch Formation has been divided into three uranium bearing fluvial systems. Each of these systems will be, to some extent, mined under the proposal.

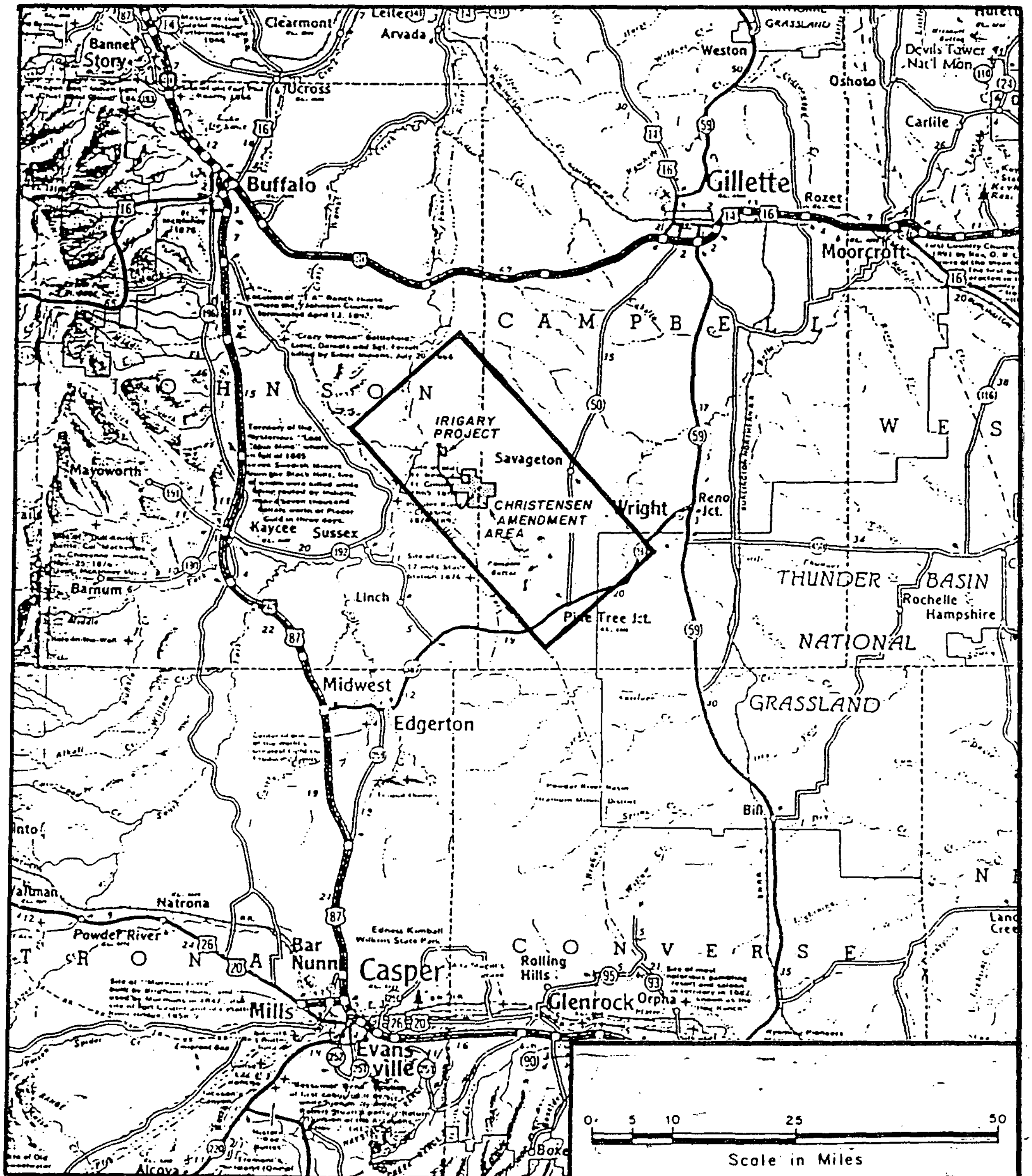


Figure 1.1.01 - General Location of the Christensen Ranch Satellite Operation and the existing Irigaray Facility

During the extraction process, an aqueous solution consisting of either carbon dioxide gas or sodium bicarbonate/carbonate, using gaseous oxygen as an oxidant, will be injected into and then recovered from the uranium bearing strata. Primarily, five-spot patterns will be utilized. Spacing between corner injection wells will range from 50 to 100 feet, but will be primarily 70 feet. Extracted fluids will be pumped to one of four planned satellite operations containing ion exchange columns at a rate of 2500 gpm. During the ion exchange process, uranium and vanadium will be extracted into the ion exchange resin. The loaded resins will then be trucked approximately 13 miles to the existing Irigaray facility for further processing.

Following the uranium recovery operation, Malapai will restore the ground water. Their restoration method will involve ground-water sweep, reverse osmosis with permeate injection, use of a reductant and well-field recirculation. It is estimated that 8 to 15 pore volumes of solution will be treated to achieve the primary goal of restoration, which is to return ground water to baseline conditions.

1.2 Proposed Action

By letter dated January 5, 1988, Malapai requested the amendment of Source Material License SUA-1341. This amendment would allow Malapai to incorporate the Christensen Ranch Satellite Operation as a working protion of the Irigaray facility. Due to the scope of the amendment request, the NRC has determined that an Environmental Assessment and a Safety Evaluation Report will be developed to assess the impacts of the proposal.

1.3 Review Scope

1.3.1 Federal and State Authorities

Under 10 CFR Part 40, an NRC source material license is required to "...receive, possess, use, transfer...any source material..." (i.e., uranium and/or source material license in order to "...receive, possess, use, transfer...any source material..." (i.e., uranium and/or thorium in any form, or ores containing 0.05 percent or more by weight of those substances). In addition, the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) requires persons who conduct uranium source material operations to obtain a byproduct material lciense to own, use or possess tailings and wastes generated by the operation. Malapai currently possesses an appropriate license for their Irigaray operation which they have proposed to modify to incorporate the Christensen Ranch Satellite Operation. Due to the scope of this amendment request, the NRC has

made a decision to prepare an Environmental Assessment under Title 10, CFR, Part 51.

In accordance with 10 CFR Part 51, an Environmental Assessment serves to (a) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact, (b) aid the NRC's compliance with NEPA when no environmental impact statement is necessary, and (c) facilitate preparation of an environmental impact statement when one is necessary. Should the NRC issue a finding of no significant impact, no environmental impact statement would be prepared and the amendment request would be granted subject to modification of the existing license.

The proposed action is to allow utilization of the existing Malapai source material license to cover the operation of the proposed Christensen Ranch Satellite Operation. A sufficient amount of information exists from the research and development operations at the site, as well as commercial scale operations at the Irigaray facility to make an informed decision.

The State of Wyoming, Department of Environmental Quality (WDEQ), administers and implements the State's rules and regulations. Malapai has applied for, and will be required to receive, a permit from the State of Wyoming prior to commencing operation of the proposed facility. Additionally, the NRC has, by letter dated January 28, 1988, solicited comments from the State of Wyoming on the pending licensing action.

1.3.2 Basis of NRC Review

The NRC is preparing this Environmental Assessment in review of the proposed licensing action, in accordance with Title 10, Code of Federal Regulations (10 CFR Part 51, Licensing and Regulatory Policy and Procedures for Environmental Protection).

In conducting this assessment, the staff considered the following:

- Environmental information submitted by the applicant to the NRC dated January 5, 1988, to support their application for a license amendment.

- Operation history including inspection reports, aquifer testing data and well-field restoration information from research and development operations at the Christensen Ranch site as authorized under Source Material License SUA-1337.

- Information supplied in discussion with the State of Wyoming, Department of Environmental Quality, Land Quality Division and Water Quality Division, relating to State permitting actions, as well as comments supplied by letter dated March 9, 1988.

- Information derived from NRC regulations and regulatory guides, as well as independent consultants.

2.0 SITE DESCRIPTION

2.1 Location and Land Use

The project area is located along the Campbell-Johnson County boundary about 30 miles north-northeast of the town of Midwest, Wyoming, and 50 miles southwest of Gillette, Wyoming (Figure 1.1.01).

The land in the vicinity of the Christensen Ranch Satellite Operation is comprised mainly of tablelands of moderate topographic relief. Vegetation consists primarily of rangeland species characteristic of the shortgrass prairie with limited acreages of irrigated hay along Willow Creek. The most common rangeland vegetation type occurs on non-saline soils and has not been improved. Plants frequently found in this area include blue grama, Sandberg bluegrass, junegrass, and western wheatgrass. Big sagebrush and silver sage also occur. Average production from this vegetation type is about 800 to 1,000 pounds per acre. Saline rangelands occur along major drainages and have vegetation consisting of salt-tolerant species. Typical plants include saltgrass and spike rush. Forage production from these lands averages about 2,000 pounds per acre.

The primary use of land within the project area is for livestock and wildlife grazing. At the termination of the proposed activities, the area will be reclaimed, recontoured and returned to its original use as livestock and wildlife grazing land.

The total surface area affected by the proposed amendment area would be approximately 1,701 acres. These acres will be occupied by monitor and mining wells, four satellite extraction plants, evaporation ponds, well fields and access roads. This acreage is only 12.1 percent of the 14,000 acres proposed to be mined. The majority of the area will consist of five-spot well fields on 70 foot spacing.

2.2 Geology and Hydrogeology of the Ore Body

2.2.1 Hydrogeologic Setting

The Christensen Ranch Satellite Operation is situated in the west-central portion of the Powder River Basin near the basins's geologic axis (Figure 2.2.1.01). The Powder River Basin is a broad, gently down-warped asymetrical syncline whose axis lies west of the center of the basin. It is open to the north, and bounded on the south by the Laramie Range and Hartville Uplift, on the east by the Black Hills and on the west by the Big Horn Mountains and the Casper Arch. East of the axis, strata dip less than 3 degrees westerly, but are steeply folded on the west and southwest margins of the basin. Strata at the projected site dip northwesterly at about 1 to 2 degrees. Regional and site specific studies performed by Malapai indicate no evidence of measureable displacement faulting within the proposed well field areas.

The present structural configuration of the basin is primarily attributable to events that took place during the Laramide Orogeny commencing in Late Cretaceous and extenging through the Eocene Epoch. Uplifts in surrounding regions created a basin of deposition along a broad north-trending synclinal trough in which up to 8,000 feet of non-marine clastic sediments were deposited. Most of these non-marine sedimentary rocks have been mapped as the Wasatch, Fort Union and Lance Formations. The sediments comprising the formations were derived principally from the Granite Mountains, Laramie Range and Hartville Uplift and were transported to the basin via large river systems as well as tributary drainages. During Fort Union and Wasatch time, large coal swamps were formed in the flood plain regions resulting in thin discontinuous and thick coal seams. Fluvial sands later became host to the majority of the uranium deposits in the basin. Deposition ceased near the end of Eocene time in response to a cessation of orogenic movements in the source areas. The periods of erosion were followed by deposition of the White River sandstone and tuffaceous clays in Oligocene time. The later rock record has not been preserved. Uplift on a regional magnitude took place at the end of Pliocene time and rejuvenated streams began down-cutting, which is responsible for the current topography.

The rocks exposed in most of the central part of the Powder River Basin are classified as the Wasatch Formation of Eocene Age. They are underlain by the Paleocene Fort Union Formation and older Cretaceous rocks which crop out near the margins of the basin. The White River Formation of Oligocene age is present as a remnant capping of the Pumpkin Buttes and uncomformably overlies the older rocks on the southern margin of the basin which marks the end of the Laramide deformation in the Powder River Basin.

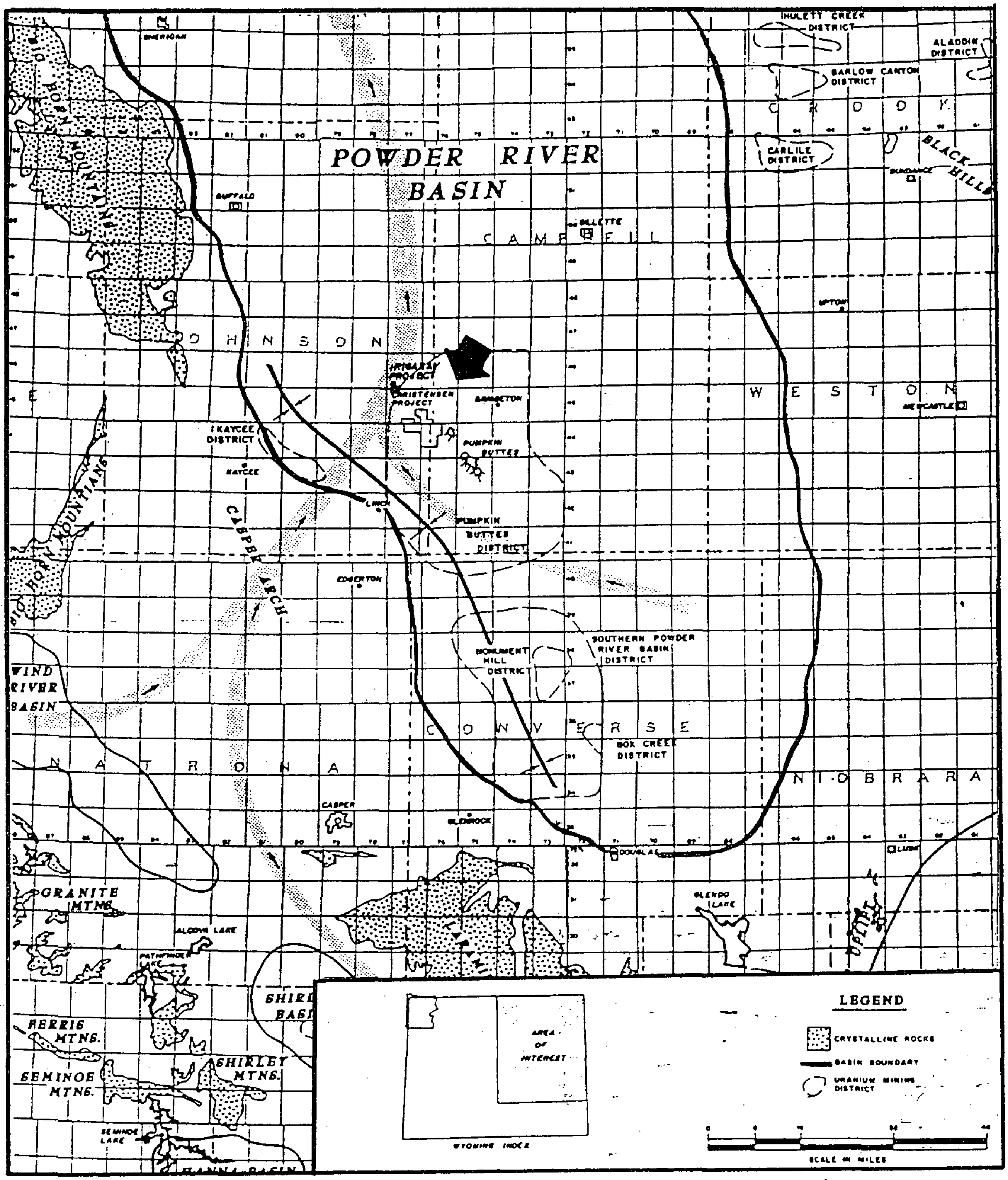


Figure 2.2.1.01 - Geological Setting of the Proposed Christensen Ranch Satellite Operation

The Wasatch Formation is approximately 2,000 feet thick in the Pumpkin Buttes area. It has an unconformable contact with the overlying White River Formation which caps the Buttes. The contact with the underlying Fort Union Formation is not clearly defined in this area.

The upper 1,150 feet of Wasatch Formation exposed on the west flank of North Butte consists of drab brown and pale olive green claystones, siltstones and carbonaceous shales interbedded with light yellow/brown sandstone lenses and thin coal beds. As mapped, there are six sandstone units ranging from 20 feet to 100 feet in thickness. The lateral extent of these sand bodies varies, but the largest is traceable for more than 12 miles northwestward across the area.

The lower 800 to 1,000 feet of the formation is the section underlying most of the Christensen Ranch Satellite Operation area. It consists primarily of shales with interbedded fluvial sandstones. The fluvial sandstones underlying the Christensen Ranch Satellite Operation have been divided into three units for the purpose of mine development. These units are designated as the L, K and J fluvial systems in ascending order. A general stratigraphic column for the site is shown in Figure 2.2.1.02.

The L fluvial system consists of those sediments between the Fort Union/Wasatch contact and the base of the lowest uranium bearing host sandstone. It consists of one to two continuous sandstone aquifers separated by shales, mudstones and siltstones. The L facies of prime concern is the shale/mudstone interval immediately underlying the lowest uranium host sandstone of the K fluvial system. This interval is the lower aquitard which serves as the confining layer separating aquifers of the L and K fluvial systems. The average thickness of the L fluvial system is approximately 241 feet, while the lower aquitard averages 65 feet in thickness.

The K fluvial system consists of those sediments between the lower aquitard at the top of the L system and the upper aquitard. This aquitard serves as the upper confining barrier to vertical fluid migration. The K system is the stratigraphic unit in which solution mining will occur or the production unit. It is composed of fluvial channel sandstones which are the primary hosts for uranium precipitation and deposition. The K fluvial system has three major sandstone units which have been designated K_1, K_2, and K_3 sandstones in descending order. Separation of these units, where it occurs, is caused by thin

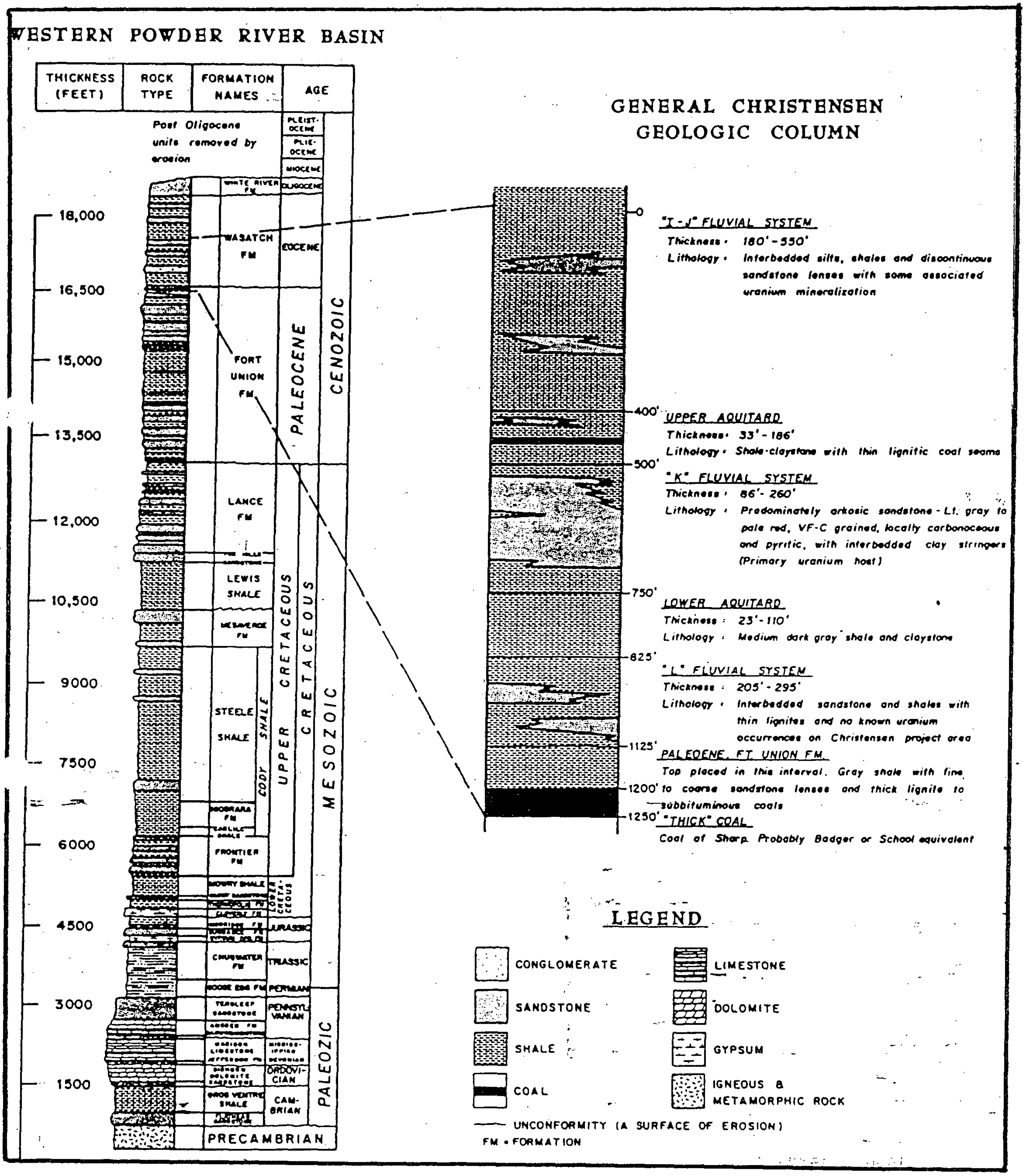


Figure 2.2.1.02 - General Stratagraphic Column of the Christensen Ranch Satellite Operation area

shaley lenses which are of limited extent, both vertically and laterally. The average thickness of the K fluvial system is approximately 177 feet.

The J fluvial system consists of those Wasatch sediments from the base of the upper aquitard to the ground surface. It is dominated by siltstone and mudstone sediments with thin discontinuous sandstone lenses and thin lignitic coal seams. Although the J fluvial system has one sandstone lens known to contain uranium, it is not proposed to be mined. The J facies of primary concern is the carbonaceous mudstone/lignite zone which has been labeled the upper aquitard. The average thickness of the J fluvial system is approximately 348 feet, while the thickness of the upper aquitard varies from 60 to 100 feet. Figure 2.2.1.03 shows the stratigraphical relationship of the various strata from cores obtained throughout the project and adjoining areas.

Uranium mineralization at the Christensen Ranch Satellite Operation is in the form of roll fronts found at the periphery of large altered sandstone tongues. These fronts were created when pre-existing pyrite was oxidized by dissolved oxygen contained in meteoric ground water migrating through the sands. Uranium, and lesser amounts of selenium and vanadium, were deposited at the interface between the oxidized and unoxidized portions of the sands. Uranium-bearing fronts may not be present along the edges of all the oxidized tongues, but tend to concentrate in areas where the necessary physical and geochemical conditions were most favorable. Important factors controlling the uranium deposition are the porosity, permeability and geometry of the sands as well as the quantity of pyrite and carbonaceous material present (controlling the Eh and pH environment). The most common uranium minerals are uraninite (UO_2) and coffinite [$U(SiO_4)(OH)_4$] with minor quantities of tyuyamunite [$Ca(UO_2)_2(VO_4)_2H_2O$]. Additionally, roscoelite (vanadium), gerroselite (selenium) and native selenium have been identified in varying quantities within the ore-bearing sands.

Although distant earthquakes may produce shocks strong enough to be felt in the Powder River basin, the region is considered to be one of minor seismicity. Since 1852, twelve recorded earthquakes have occurred within a 100-mile radius of the Christensen Ranch Satellite Operation. The strongest occurred near Casper, Wyoming, in the years 1894 and 1897. For the period 1965-1974, eight shocks were instrument-recorded and all had intensities of less than 5.4 on the Richter scale. The nearest shock to the proposed site occurred in May 1967, in an area

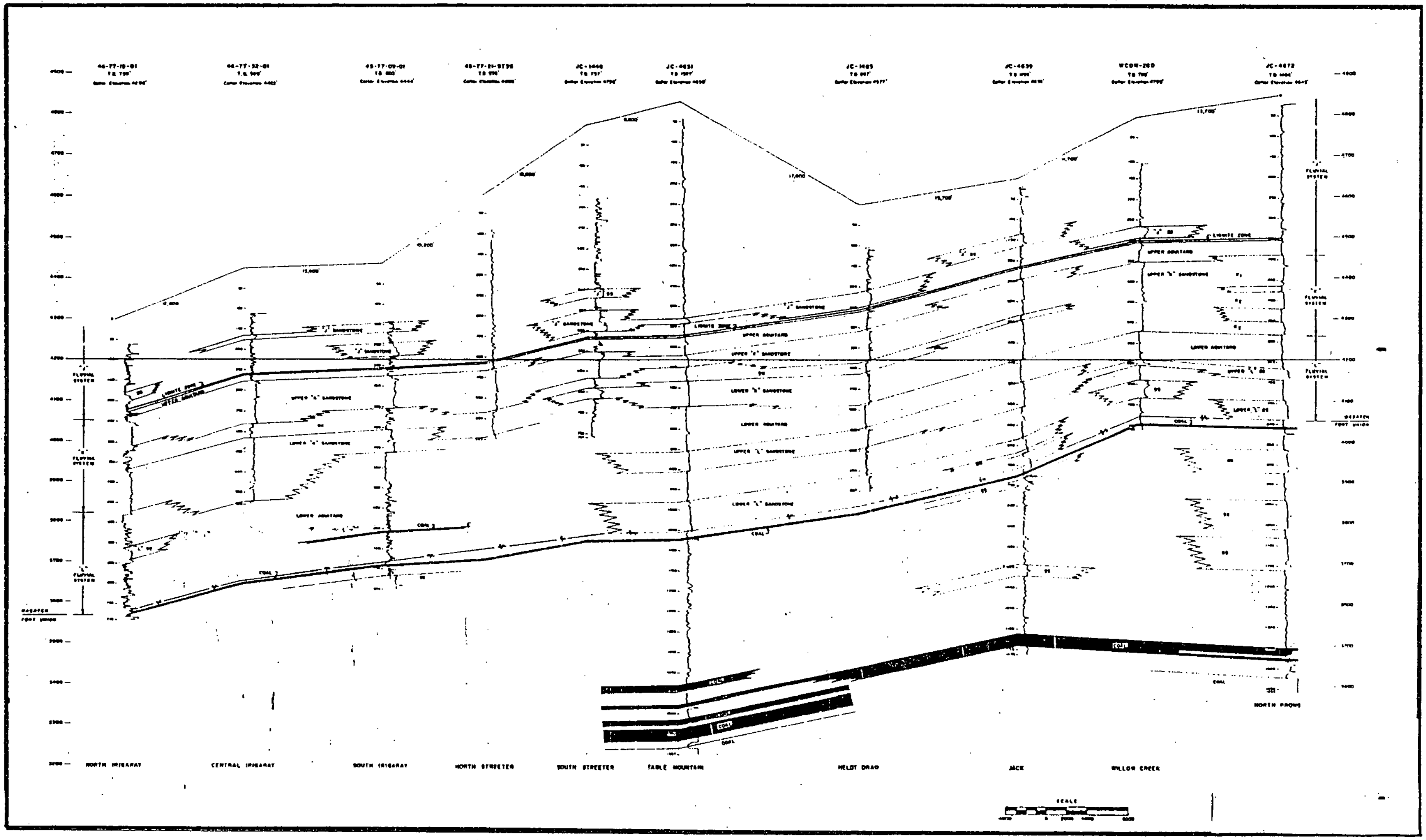


Figure 2.2.1.03 - Stratragraphic Relationships of the J, K and L Fluvial Systems

approximately 2 miles southwest of South Butte and originating at a depth of ±50 km. The recorded intensity was 4.8 on the Richter scale. Another shock centered south of Casper, occurred in October 1984, registering an intensity of 5.6 on the Richter scale.

The hazards resulting from ground shaking to be expected from earthquakes has been quantified by mathematical probability studies into Earthquake Hazard and Seismic Risk maps. These maps indicate that the Christensen Ranch Satellite Operation is located in an area where the earthquake hazard from ground shaking is low. Specifically, there is no more than a 10 percent chance that accelerations greater than 4 percent of the earth's gravity will be experienced in 50 years. Due to this, the ground shaking effects are controlled mainly by earthquakes with magnitudes of 4 or less.

2.2.2 Water Quality, Pump Testing and Ore Zone Confinement

Malapai submitted a compilation of water quality data for 26 wells for characterization of water quality at the Christensen Ranch research and development site, as well as 10 regional monitor wells utilized to typify water quality over the entire Christensen Ranch Satellite Operation area. Figure 2.2.1.01 shows the locations of the monitor wells utilized to characterize ground-water quality over the proposed in situ leach area.

Previous water quality monitoring for the Christensen Ranch Research and Development site, although consisting of 26 wells, will be treated as representing a single monitoring location. Actual monitoring at the site was grouped into four categories of wells: well-field injection and recovery, production zone monitoring and trend, deep aquifer monitoring and shallow aquifer monitoring. These wells were monitored for major ions, trace metals and radionuclides over a 6-year period beginning in 1982, and continuing until the present. An average production unit, baseline water quality having a population of over 50 analyses is shown in Table 2.2.2.01.

The water quality data indicates that at the Christensen Ranch Research and Development site, the ground water is slightly alkaline, while the TDS concentration is slightly below the 500 mg/l Wyoming Department of Environmental Quality, Class I standard. Similarly, all monitored trace metals are below the Class I standards. The radionuclide contents of the ground water, as shown by the uranium content, is far below the 5.0 pCi/l standard. However, the radium content is well above

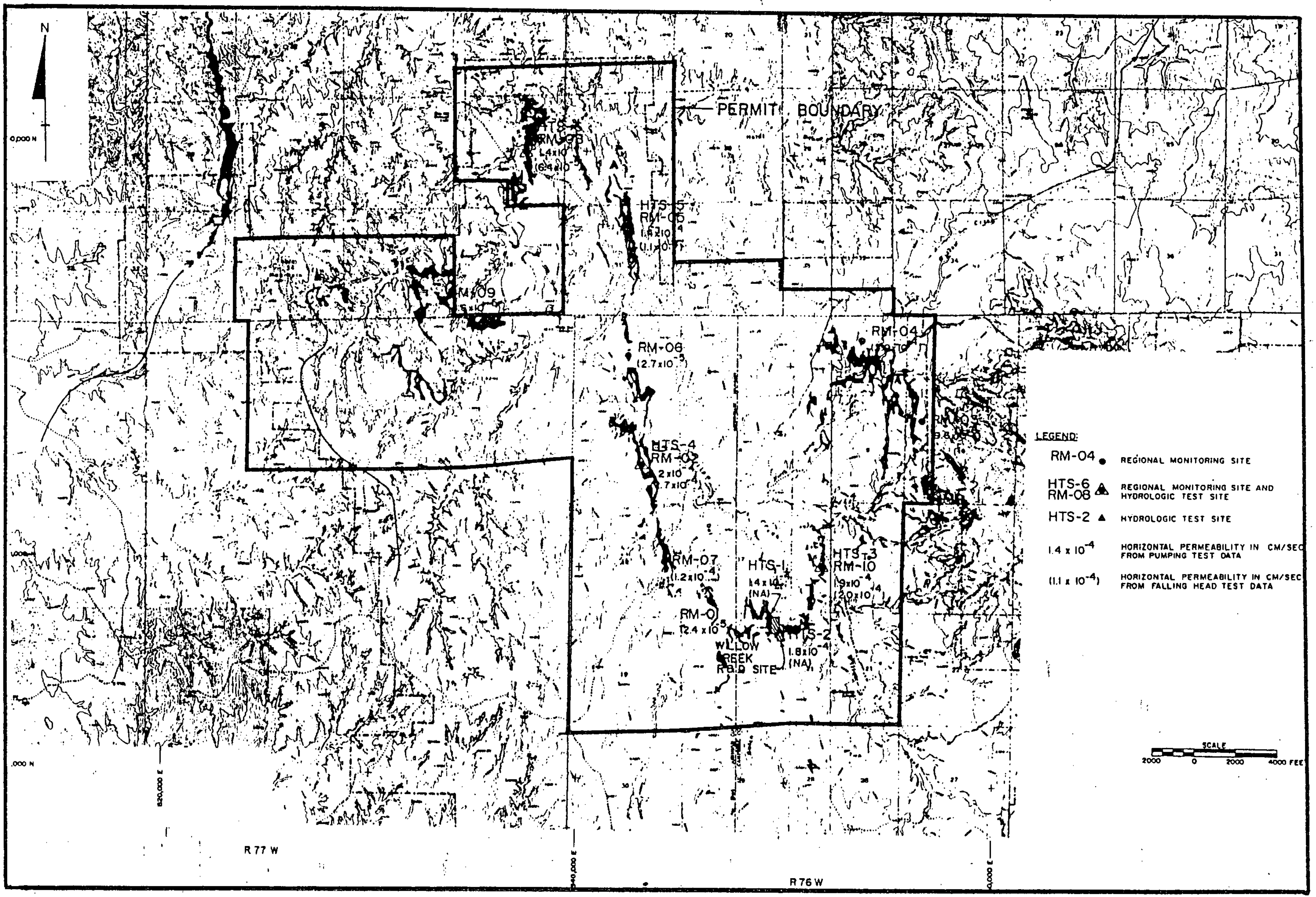


Figure 2.2.2.01 - Regional Ground Water Monitoring Locations

Table 2.2.2.01 - Average Ground-Water Quality of the Christensen Ranch Research and Development Production Zone

MAJOR IONS (mg/l)		TRACE METALS (mg/l)		RADIONUCLIDES (pCi/l)	
Ca	8.6	Al	<0.10	U (mg/l)	0.0354
Mg	1.2	As	<0.0025	Ra-226	73.2
Na	136	Ba	<0.10		
K	2.6	B	<0.11		
CO_3	7.32	Cd	<0.01		
HCO_3	118	Co	<0.01		
SO_4	194.8	Cr	<0.05		
Cl	7.2	Cu	<0.01		
NH_4	<0.05	Fe	<0.06		
NO_2(N)	<0.01	Pb	<0.05		
NO_3(N)	<0.06	Mn	<0.02		
F	0.171	Hg	<0.001		
SiO_2	9.11	Mo	<0.1		
TDS	425	Ni	<0.05		
Cond	653	Se	<0.001		
Alk	109.4	V	<0.1		
pH	8.87	Zn	<0.01		

the 5.0 pCi/l standard. Therefore, without radium removal treatment, the water would not be recommended for human consumption. It should be noted that the State of Wyoming considers ground water with less than 100 pCi/l of radium treateble.

Baseline water quality monitoring for the Christensen Ranch Satellite Operation consists of water quality data for 10 monitor wells located throughout the proposed project area. Each monitoring location consists of three wells. The first well at each location was completed in the production zone (K sandstone), the second well was completed in the first overlying aquifer (J sandstone) and the final well was completed in the first underlying aquifer (L sandstone). Quarterly sampling from these groups of regional monitoring wells indicates that the ground water contained in the production zone is similar to that of the production zone at the Christensen Ranch Research and Development site. The ground water is slightly alkaline, while the TDS concentration at locations RM-03, RM-04 and RM-06 (see Figure 2.2.2.01) is generally above the 500 mg/l, Class I standard. Trace metal concentrations are all below their respective Class I standards; however, arsenic concentrations at monitoring locations RM-01, RM-02, RM-03, RM-04, RM-05, RM-07 and RM-09 are generally higher than experienced at the Christensen Ranch Research and Development site. Radionuclide content of the ground water indicates that uranium concentrations are uniformly low, being only fractions of a pCi/l over the entire area proposed to be mined. Radium-226 concentrations vary over the area with highest average concentrations of approximately 65 pCi/l being found at monitoring location RM-08. Additionally, monitoring locations RM-05, RM-06 and RM-07 indicate that radium-226 concentrations are above the 5 pCi/l standard. Table 2.2.2.01 shows the baseline water quality for each monitoring location, based upon four samples.

Generally speaking, the ground-water quality, based upon the data contained in the amendment application, is very similar to that associated with the Christensen Ranch Research and Development site. Notable exceptions would be the increase in arsenic and TDS at those monitoring locations previously noted. Also notable is the lower radium-226 concentration at the majority of the monitoring sites.

Hydrologic testing of the production unit and monitoring of the upper and lower confining units, as well as the overlying and underlying aquifers, has been performed at numerous locations in the project area. Nine individual aquifer tests have been performed at six locations from 1977 to 1988. Table 2.2.2.03 summarizes the aquifer testing that has been conducted within the proposed Christensen Ranch Satellite Operation area. Additionally, the aquifer testing sites are shown on Figure 2.2.2.01.

Table 2.2.2.02 - Comparison of Regional Monitoring Site Water Quality

Major Ions (mg/l)	RM-01	RM-02	RM-03	RM-04	RM-05	RM-06	RM-07	RM-08	RM-09	RM-10	Detection Limits
Ca	9.7	7.5	31.45	28.5	11.08	8.88	6.05	7.98	6.03	9.33	0.05
Mg	0.26	0.97	4.77	3.7	1.34	1.08	0.58	0.92	0.95	1.69	0.01
Na	132	132.5	221	241	155	135.5	135.8	129.8	125.3	134	0.05
K	1.6	1.4	13.7	3.7	1.6	1.6	4.3	1.4	2.0	2.0	0.1
CO_3	6.9	1.9	2.9	3.4	0.98	6.9	8.4	2.5	1.6	0.9	0.1
HCO_3	106.9	106	118.3	81.4	96.8	106.3	98.7	101.5	120	130.8	0.1
SO_4	193	199	468.8	526	267.8	197.3	202.5	198.1	168	195.3	0.5
Cl	9.4	9.6	5.5	5.6	7.4	9.6	9.3	8.3	10.6	9.2	0.1
NH_4	<0.135	<0.07	0.095	0.075	0.14	0.1	<0.09	<0.06	<0.053	<0.055	0.05
NO_2(N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.013	<0.01	0.01
NO_3(N)	<0.10	<0.018	0.08	0.108	0.04	<0.02	<0.035	0.018	0.025	0.108	0.01
F	0.24	0.25	0.17	0.14	0.17	0.18	0.19	0.22	0.26	0.20	0.10
Si02	8.06	8.75	12.0	9.88	8.58	8.63	8.35	8.13	8.3	7.8	1.00
TDS	429.3	414.5	831	867.5	495.3	441	417.8	423	391	422.5	1.0
COND (umho/cm)	680.8	672.8	1176.8	1241.8	818.5	706.3	671.3	662	622	687.5	1.0
Alk	99.4	90.2	102.2	72.6	81.1	99	95.3	88.4	101.0	108.9	0.1
pH (units)	8.99	8.56	8.78	8.83	8.4	9.0	9.1	8.5	8.5	8.31	1-14
Trace Metals (mg/l)											
Al	<0.10	<0.10	<0.133	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10
As	0.0028	0.003	0.0018	0.002	<.002	<0.0028	0.0028	0.0033	0.0038	<0.0015	0.001
Ba	<0.103	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10
B	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Co	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Cr	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cu	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Fe	<0.053	<0.05	<0.05	<0.05	<0.053	<0.053	<0.05	<0.05	<0.05	<0.05	0.05
Pb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Mn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Mo	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10

Table 2.2.2.02 (cont.)

Ni	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Se	<0.003	<0.001	<0.001	0.018	<0.001	<0.001	<0.001	<0.001	<0.0013	<0.002	0.001
V	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.1	<0.1	<0.1	0.10
Zn	<0.01	<0.01	0.108	<0.01	<0.013	<0.013	<0.015	<0.01	<0.013	<0.108	0.01

Radiochem (pCi/l)	RM-01	RM-02	RM-03	RM-04	RM-05	RM-06	RM-07	RM-08	RM-09	RM-10	Detection Limits
U (mg/l)	0.017	0.027	0.0012	0.0049	0.0148	0.0076	0.0364	0.0413	0.0185	0.0313	0.0003
Ra-226	2.15	4.05	0.58	5.33	33.08	1.0	7.2	65.2	3.4	1.7	0.2
Th-230	<5.25	4.28	<1.025	<5.33	<2.35	<0.2	<0.2	<8.1	<2.5	<1.6	0.2
Po-210	<1.4	<1.0	3.43	<1.7	<3.85	<1.25	<1.98	44	<2.7	1.0	1.0
Pb-210	<2.65	2.7	<7.63	2.68	15.5	<1.9	9.75	129.4	8.0	<4.7	1.0

Note: All values are the arithmetic mean of N measurements.

Table 2.2.2.03 - Summary of Aquifer Testing Data for the Christensen Ranch Satellite Operation

Pumping Test No.	Hydrologic Test Site	Test Performed By	Location	Date	Pumping Well	Observation Wells	Average Flow Rate
1	6	Wyoming Mineral Corp.	NW ¼, SE ¼ Sec 25, 14SN, R77W	8/10/77	PW	OW-1, OW-2, OW-3, OW-4, OW-5, OW-6, OW-7, OW-8,	15
2	1	In-Situ, Inc.	SE ¼, SE ¼ Sec 17, T44N, R76W	10/11/79	WCOW-1	WCOW-1, WCOW-2, WCOW-3 WCOW-4, WCOW-5, WCOW-6, WCOW-7, WCOW-8	17.9
3	1	Nuclear Assurance Corp.	SE ¼, SE ¼ Sec 17, T44N, R76W	8/10/80	AP-1	AI-5, AI-6, OW-1, OW-2, OW-3, OW-4, OW-5, OW-6, OW-7, OW-8	24.5
4	2	In-Situ, Inc.	NE ¼, NW ¼ Sec 20, T44N, R76W	7/24/82	WCPW-21	WCOW-21, WCOW-22, WCOW-23 WCOW-24, WCOW-25, WCOW-26 WCOW-27S, WCOW-28D	13.0
5	3	D'Appolonia	SE ¼, NW ¼ Sec 16, T44N, R76W	9/9/83	WCPW-30	WCOW-30, WCOW-31, WCOW-32 WCOW-33, WCOW-34, WCOW-35S, WCOW-36S, WCOW-37D	9.0
6	2	Canonie	NE ¼, NE ¼ Sec 20, T44N, R76W	6/20/86	RW-1	MW-03, MW-04, MW-05, IW-07 WCOW-27S, WCOW-28D, MW-09S, WCOW-22, TW-02, WCOW-24, MW-08, MW-07, IW-4, IW-1, IW-2, MW-10D	16.0
7	2	Canonie	NE ¼, NE ¼ Sec 20, T44N, R76W	6/16/86	RW-02	IW-04, IW-07, MW-01, MW-08 MW-05, WCOW-21, WCOW-22, IW-02, WCOW-26, WCOW-22, IW-02, MW-04, WCOW-23, MW-07, MW-08, WCOW-23, JOW-01	20.2
8	4	Canonie	Sec 7, T44N, R76W	9/22/86	FPW-01	JOW-02, RM-02, SRM-02, DRM-02, JDS-01, JPD-01	14.5
9	5	Canonie	Sec 31, T45N, R87W	9/22/86	DPW-01	DOW-01, DOW-02, RW-07, SRM-05, SRM-05, DRM-05, DPS-01, DPD-01	14.6

The majority of the aquifer testing has been directed at the production zone. As previously discussed, the production zone, locally known as the K Fluvial system, consists of three major sandstone units designated as the K_1, K_2 and K_3 sandstones. Based upon data collected during the various aquifer testing programs, their cumulative thickeness averages 177 feet. The K Fluvial systeem has an average transmissivity of 569 gpd/ft and an average hydraulic conductivity of 1.5E-4 cm/sec. Additional data on each aquifer test is shown in Table 2.2.2.04.

Additionally, data has been collected and summarized for the upper and lower aquitards. Although lesser data has been developed for these confining units, the tests have been more comprehensive and generally supply more data. These data indicate that the upper aquitard has an average thickness of 76 feet, with a hydraulic conductivity varying from 1.3E-7 to 9.5E-9 cm/sec. Similar data indicate that the lower aquitard has an average thickness of 92 feet, with a hydraulic conductivity varying from 1.35E-6 to 8.6E-9 cm/sec. A data summary for the upper and lower aquitards is shown in Table 2.2.2.05.

The individual aquifer testing programs that have been performed for the Christensen Ranch Satellite Operation adequately characterizes the production unit and the confining layers. The data indicate that the production unit has a hydraulic conductivity which is three to five orders of magnitude greater than that of the confining units.

This data would theoretically indicate that ground-water flow would be contained by the aquitards and concentrated within the production zone. Further evidence of the confining characteristics associated with the units bounding the production zone has been evidenced by the successful operation of the Christensen Ranch Research and Development operation.

Uranium production and restoration efforts took place within the production zone for a period of 12 months. These efforts continually stressed the confining characteristics of the aquitards without a reported excursion. The operational data from the research and development site maintain a 3 to 5 percent bleed which continually drew injected mining solutions as well as natural ground water into the areas being mined. This slight overproduction consumes some ground water, while at the same time maintaining control of the mining solutions. The proposed commercial scale operation would maintain a bleed of approximately 1 percent. Although this is not as much as experienced during the research and development phase, it will maintain a gradient into the various production units while minimizing the amount of ground water that is utilized.

Table 2.2.2.04
Summary of Aquifer Testing Data
Production Zone (K Fluvial System)

Test No.	Hydrologic Test Site	Date	Test Performed by	Approximate Thickness of Aquifer (ft)	Mean Transmissivity (gpd/ft)	Major Transmissivity (gpd/ft)	Minor Transmissivity (gpd/ft)	Direction of Major Transmissivity	Mean Hydraulic Conductivity (cm/sec)	Storativi
1	6	8/10/77	Wyoming Mineral Corp.	89	264	450	155	N3°W	$1.4X10^{-4}$	$8.7X10^{-5}$
2	1	9/11/79	In-Situ, Inc.	195	621	863	446	N20°E	$1.5X10^{-4}$	$1.4X10^{-4}$
3	1	9/10/80	Nuc. Assur. Corp.	190	529	709	392	N30°E	$1.4X10^{-4}$	$1.5X10^{-3}$
4	2	7/24/82	In-Situ, Inc.	178	679	1466	314	N56°E	$1.7X10^{-4}$	$7X10^{-4}$
5	3	10/09/83	D'Appolonia	255	1030	1107	957	N13°-24°E	$1.9X10^{-4}$	$3.7X10^{-4}$
6	2	6/20/86	Canonie	175	543	704	418	N54°W	$1.5X10^{-4}$	$9X10^{-5}$
7	2	6/16/86	Canonie	162	501	654	362	N47°W	$1.3X10^{-4}$	$9X10^{-5}$
8	4	9/22/87	Canonie	175	419	660	266	N15°W	$1.2X10^{-4}$	$1.2X10^{-4}$
9	5	9/27/87	Canonie	175	536	750	383	N5°W	$1.4X10^{-4}$	$1.2X10^{-4}$

Table 2.2.2.05
Summary of Aquifer Testing Data
Upper and Lower Confining Layers

Test No.	Hydrologic Test Site	Date	Test Performed by	Upper Aquitard Properties: Hydraulic Conductivity (cm/sec)	Upper Aquitard Properties: Specific Storage ft^{-1}	Upper Aquitard Properties: Thickness (ft)	Upper Aquitard Properties: Lithological Description	Lower Aquitard Properties: Hydraulic Conductivity (cm/sec)	Lower Aquitard Properties: Specific Storage ft^{-1}	Lower Aquitard Properties: Thickness ft	Lower Aquitard Properties: Lithological Description
1	6	8/10/77	Wyoming Min. Corp.	N/A	N/A			N/A	N/A		
2	1	9/11/79	In-Situ, Inc.	N/A	N/A	50	shale/mudstone	N/A	N/A	120	shale/silt/ mudstone
3	1	9/10/80	Nuc. Assurance	N/A	N/A	46	mudstone	N/A	N/A	119	mudstone
4	2	7/24/82	In-Situ, Inc.	N/A	N/A	70	mudstone	N/A	N/A	120	mudstone/clay
5	3	10/09/83	D'Appolonia	$3.0X10^{-8}$	4.2X10	145	N/A	$1.8X10^{-7}$	$1.3X10^{-6}$	80	N/A
6	2	6/20/86	Canonie	$1.2X10^{-7}$				$1.2X10^{-7}$			
7	2	6/16/86	Canonie	N/A	N/A	60	mudstone/coal	N/A	N/A	120	mudstone/ siltstone
8	4	9/22/86	Canonie	$<8.6X10^{-9}$ $9.75X10^{-7}$	N/A N/A	100	siltstone/ claystone w/coal or lignite seam	$4.1X10^{-8}$ $<8.6X10^{-9}$ $1.35X10^{-6}$	N/A	48 51	clayey shales siltstones
9	5	9/27/86	Canonie	$9.5X10^{-9}$ $<8.6X10^{-9}$	N/A	34	claystone/ shale/silt-stone with coal seam	$<8.6X10^{-9}$ $7.9X10^{-9}$	N/A	51 N/A	claystone/ shalestone

A comparison of the geology at the Christensen Ranch Research and Development site and the proposed Christensen Ranch Satellite Operation indicates that units of hydrologic importance are, for the most part, continuous over the area. The lithological properties vary slightly, but for the most part, the geology data as well as the hydrologic testing data indicate that similar ground-water responses can be expected over the entire area proposed to be mined.

3.0 PROCESS DESCRIPTION

3.1 In Situ Leaching Process

The in situ leach method of uranium recovery was first applied in south Texas in 1975. Since that time, numerous facilities have been developed on both the research and development as well as the commercial scale. For the most part, these ventures have shown that uranium can be economically recovered and the aquifer restored to baseline or premining class of use standards.

There are many environmental advantages to in situ leaching of uranium over conventional mining methods such as open pit mining or underground mining. Conventional extraction methods can produce a significant impact on the environment. The greatest impact of the in situ leach extraction method is to the ore zone ground-water quality which, in most instances, can be restored to near its baseline quality, premining use, or potential use category. In situ leaching permits economic recovery of deep, low-grade sandstone uranium deposits currently economically unrecoverable by conventional mining methods. The extent to which in situ leaching can be conducted is limited in that the ore zone conditions must be sutiable for containing and controlling lixiviant during the leaching process.

The mechanics of in situ leaching are relatively simple in theory. An oxidant-charged lixiviant is injected into the production zone aquifer through injection wells. The uranium is oxidized and solubilized when contacted by the lixiviant. Following this, the uranium-rich solution is drawn to a recovery well where it is pumped to the surface and transferred to the processing facility for extraction and precipitation.

During production, there is a constant sweeping of lixiviant through the aquifer from the injection wells to the recovery wells. The injection and recovery wells can be arranged in any of a number of geometric patterns depending on ore body configuration, aquifer permeability and operator preference. Monitor wells surround the well-field pattern area, both vertically and horizontally, and are screened in appropriate stratigraphic horizons (production and

non-production zones) to detect any lixiviant migration that may occur.

Once the uranium-rich solution reaches the processing facility, it is pumped through a bed of ion exchange resin where the uranium is adsorbed onto the resin. The barren solution (tails) coming out of the ion exchange vessel is cycled back to the injection circuit for chemical reconstitution and reinjection.

When the resin bed becomes saturated with uranium, the resin is eluted by passing a strong chloride solution through the resin bed. The resultant concentrated uranium solution is transferred to tanks where the uranium is precipitated out of solution by addition of hydrochloric acid, sodium hydroxide and hydrogen peroxide.

3.2 The Orebody

The production zone at the Christensen Ranch Satellite Operation consists of the K_1, K_2 and K_3 sands in the form of roll-type uranium deposits. The uranium minerals occur as coatings on sand grains as well as in interstitial fillings. The uranium was leached from volcanic and granitic deposits by oxygenated waters. The uranium rich solution was then transported through an aquifer until reducing conditions were encountered. At this point, the uranium as well as other dissolved metals became insoluable and precipitated as mineral coatings and pore fillings.

The physical shape of an ore deposit is dependent on the local permeability of the matrix material as well as its continuity and distribution in the geologic unit. The ore body which is proposed to be mined is meandering in nature and covers somewhat less than the 1,071 acres of disturbance that was previously discussed. For in situ leaching to be successful, the ore deposit must (1) be located in a saturated zone, (2) be bounded above and below by suitable confining layers, (3) have adequate permeability, and (4) be amenable to chemical leaching.

As explained in the previous section, the proposed mining area has favorable hydrological characteristics to allow in situ leaching of uranium. Hydraulic conductivities indicated that mining solutions will be contained within the production zone. Actual operating evidence of this is associated with the mining that took place during the research and development phases at Christensen Ranch.

3.3 Well Field Design and Operation

The proposed mining area is divided into four phases: Willow Creek, Heldt Draw, North Prong and Table Mountain. Each of these phases is

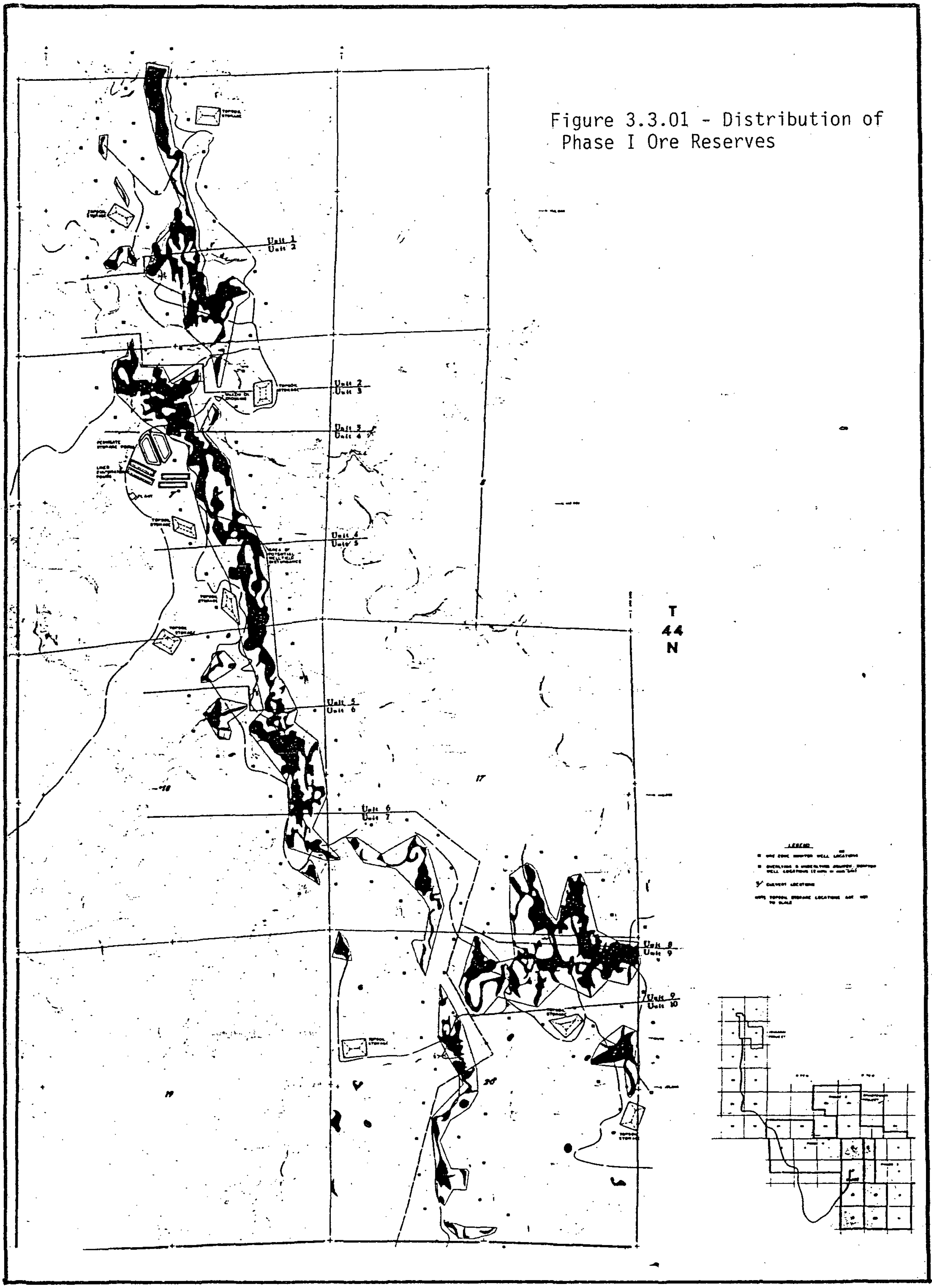
designed to have about the same amount of reserves as well as a geographical unit which will allow for efficient placement of each of the four satellite facilities. Exploration work to date indicates that Phase 1 ore reserves represent 8,000,000 pounds of U_3O_8 that will be mined in 10 production units with a distribution as shown in Figure 3.3.01.

It is possible that during well field installation, additional ore reserves will be encountered and may be developed. This could change the configuration of the orebody as currently depicted. Due to this, the actual configuration of the well field and the ultimate final boundaries of the production units will be determined when the well fields are installed.

The mining phases are, in turn, divided into production units. Each production unit consists of groups of five-spot well patterns installed to correspond to the geometry of the orebody. Generally, a polygonial pattern of 5 spot wells will cover the production unit. However, the tendency of the roll fronts to change directions abruptly may result in the five-spot pattern being abandoned at the edge of some production units.

A single five-spot pattern is roughly rectangular and consists of four injection wells surrounding one center recovery well. Spacing between the corner injection wells will typically be 70 feet, although it could range from 50 to 100 feet, depending upon the topography and ore characteristics. A typical well installation pattern is shown in Figure 3.3.02. In areas where very narrow portions of roll fronts exist, alternating line drives may be utilized. An alternating line drive consists of a line of wells spaced along the strike of the ore. One well will be an injector, the next a recovery well, the next an injector, and so on. This type of configuration allows the well function to be reversed or changed at appropriate times to improve mining and restoration efficiency. A staggered line drive may be utilized where the roll front is too wide for an alternating line drive. In this configuration, the injection wells are installed on one side of the roll front and midway between them, on the opposite side of the front, will be the recovery wells. As with the alternating line drives, well functions can be reversed at appropriate times to control injection and recovery of fluids.

Figure 3.3.01 - Distribution of Phase I Ore Reserves



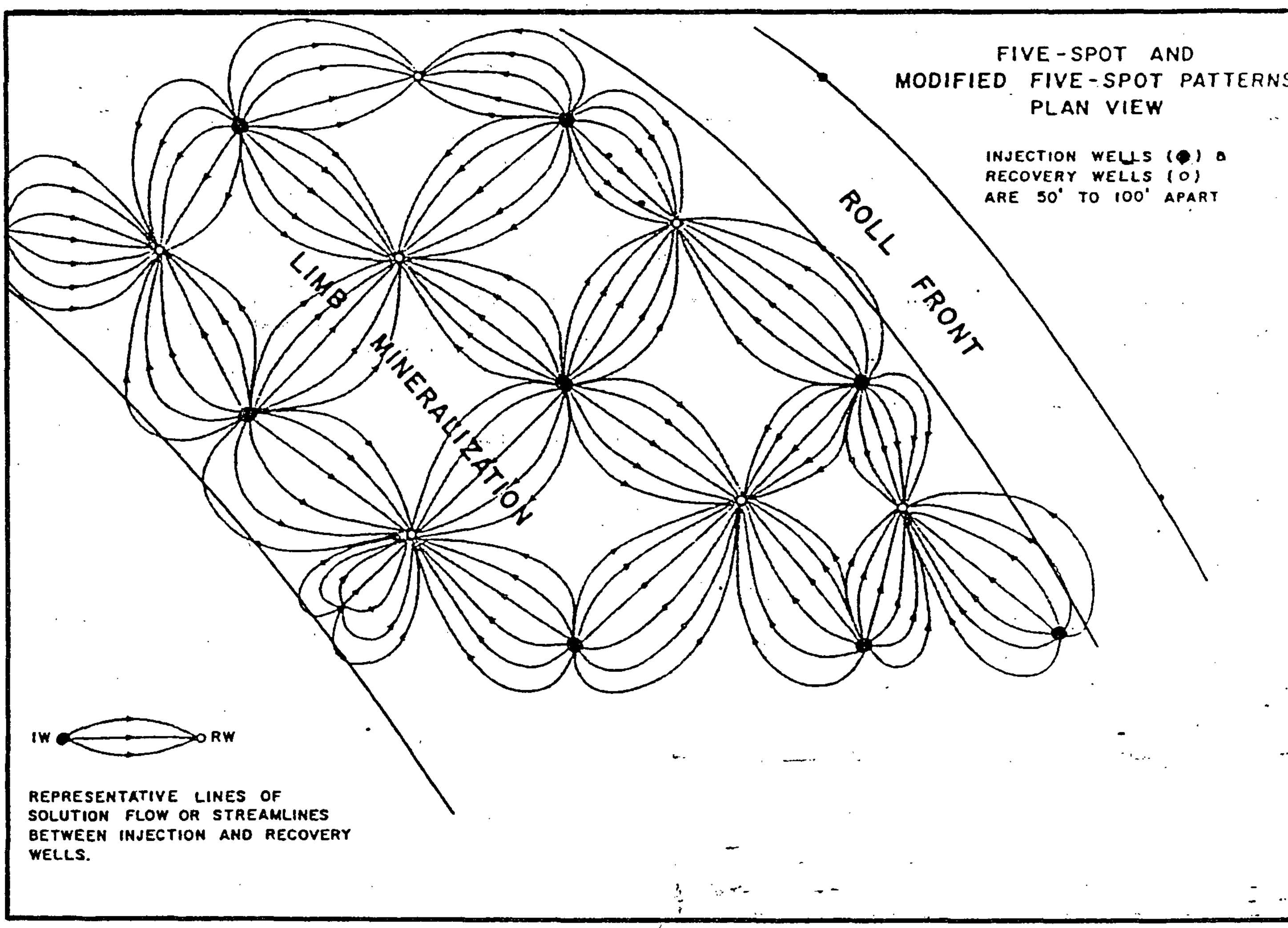


Figure 3.3.02 - Typical Well Installation Pattern

Figure 3.3.03 shows how the various well patterns may be combined to form an individual production unit within a mining phase. As shown in this configuration, it is estimated that the five-spot pattern would have a 1.5 to 1 ratio of injection wells to recovery wells. Based upon this ratio, phase 1 mining area would contain approximately 2,589 injection and 1,926 recovery wells.

All injection and recovery wells will be drilled and completed in a similar fashion. This allows for alternating the well function to improve mining as well as restoration efficiency. The completed interval in the injection wells will be limited to the mineralized zone intercepted by the hole. The completed interval in the recovery wells may be limited either to the intercepted mineralized zones or greater intervals corresponding to the uppermost and lowermost depths of the ore as measured in the adjacent injection wells. An example of a uranium roll front deposit showing the typical completion intervals of injection and recovery wells is shown in Figure 3.3.04.

The wells will typcially be drilled utilizing a 5-inch diameter pilot hole from the surface through the ore zone. Following pilot-hole installation, the hole will than be geophysically logged to determine the mineralization. If sufficient mineralization is not encountered to warrant well completion, the hole will be plugged by filling it with abandonment gel over its entire depth. It will then be capped by either a poured concrete plug at the top, terminating approximately 2 feet below the surface, or by emplacing a tapered cement plug at about the same depth. The hole will then be marked on the surface for identification.

If the hole contains sufficient mineralization, it will be completed by reaming to a 6-3/4 inch to 7-7/8 inch diameter. Injection and recovery wells will be cased with nominal 4-½ inch inside diameter polyvinylchloride pipe. The casing will be emplaced utilizing polyvinylchloride centralizers on the top and bottom casing sections with additional centralizers uniformly spaced over the entire casing length to keep the casing centrally located with respect to the side walls.

Following casing placement, cement will be pumped down the casing. Pressure will cause the cement to move through the weep holes at the bottom of the casing, and up the annulus between the casing and the borehole wall. This procedure will continue until cement returns to the surface. The mineralized intervals of the well will be made accessible to leaching solutions by either drilling through the bottom of the casing or by underreaming or perforating through the casing and cement. A typical well completion is shown in Figure 3.3.05.

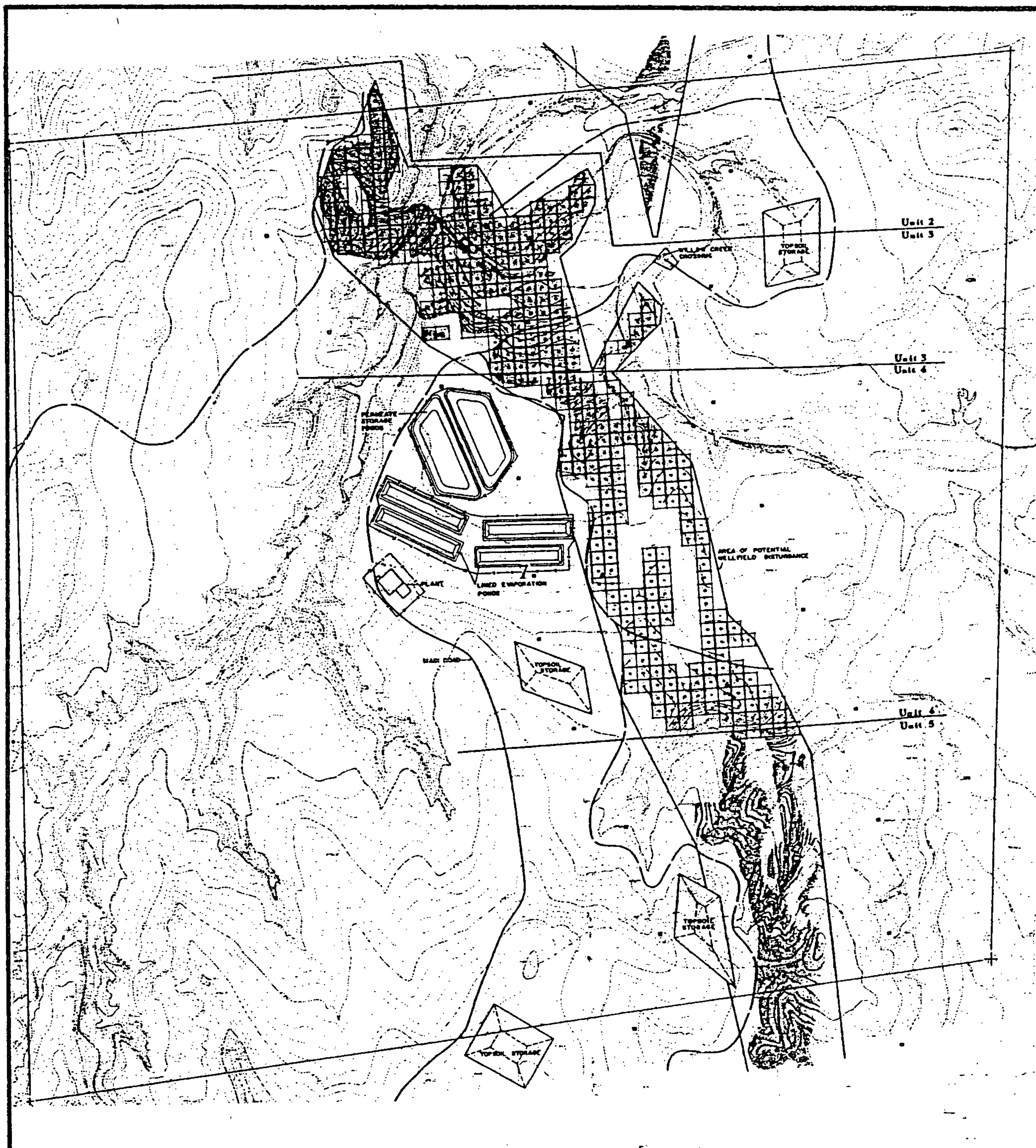


Figure 3.3.03 - Well Field Installation Pattern in
Phase I, Production Units 3 and 4

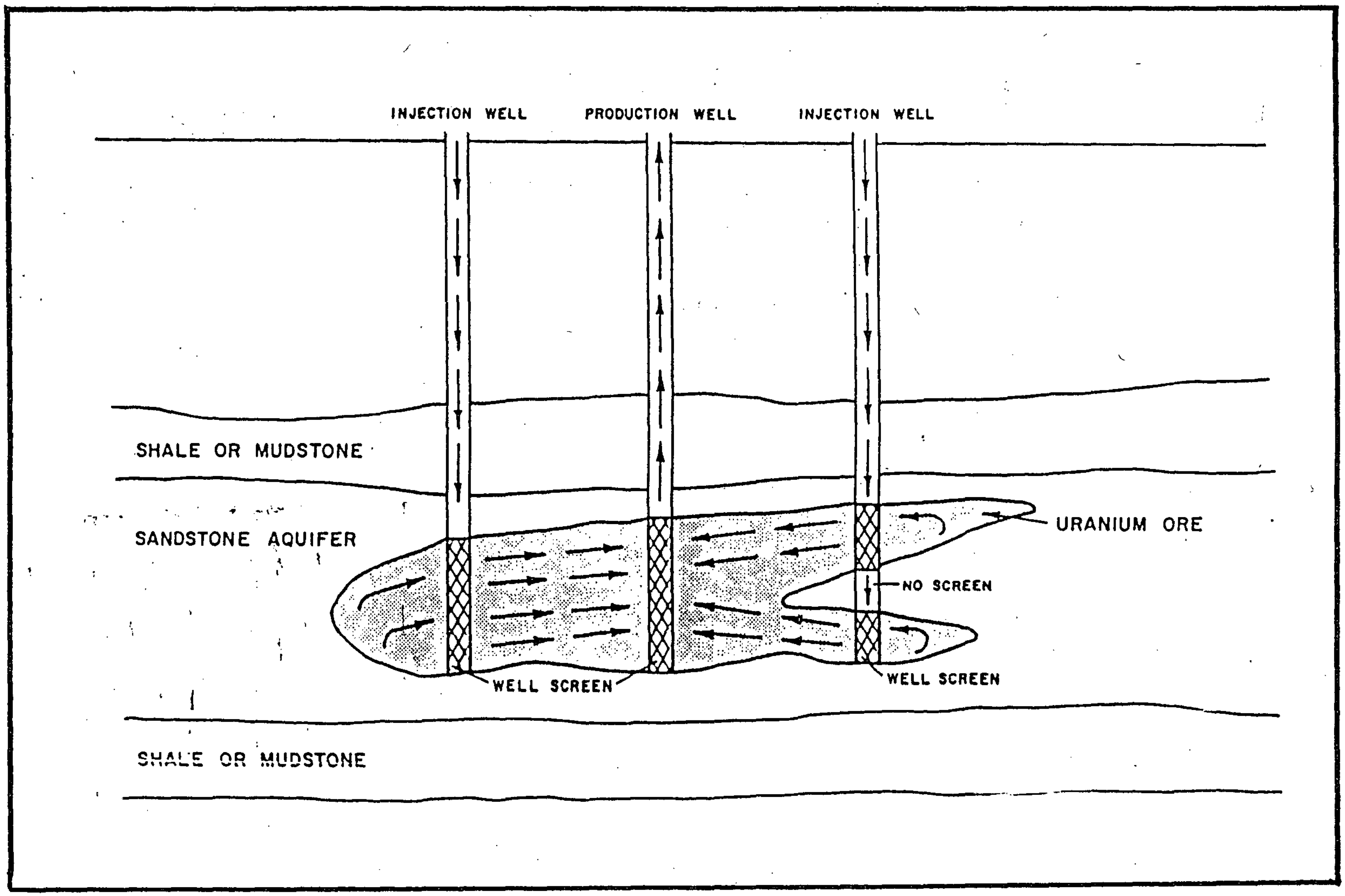


Figure 3.3.04 - Typical Completion Intervals of Injection and Production Wells

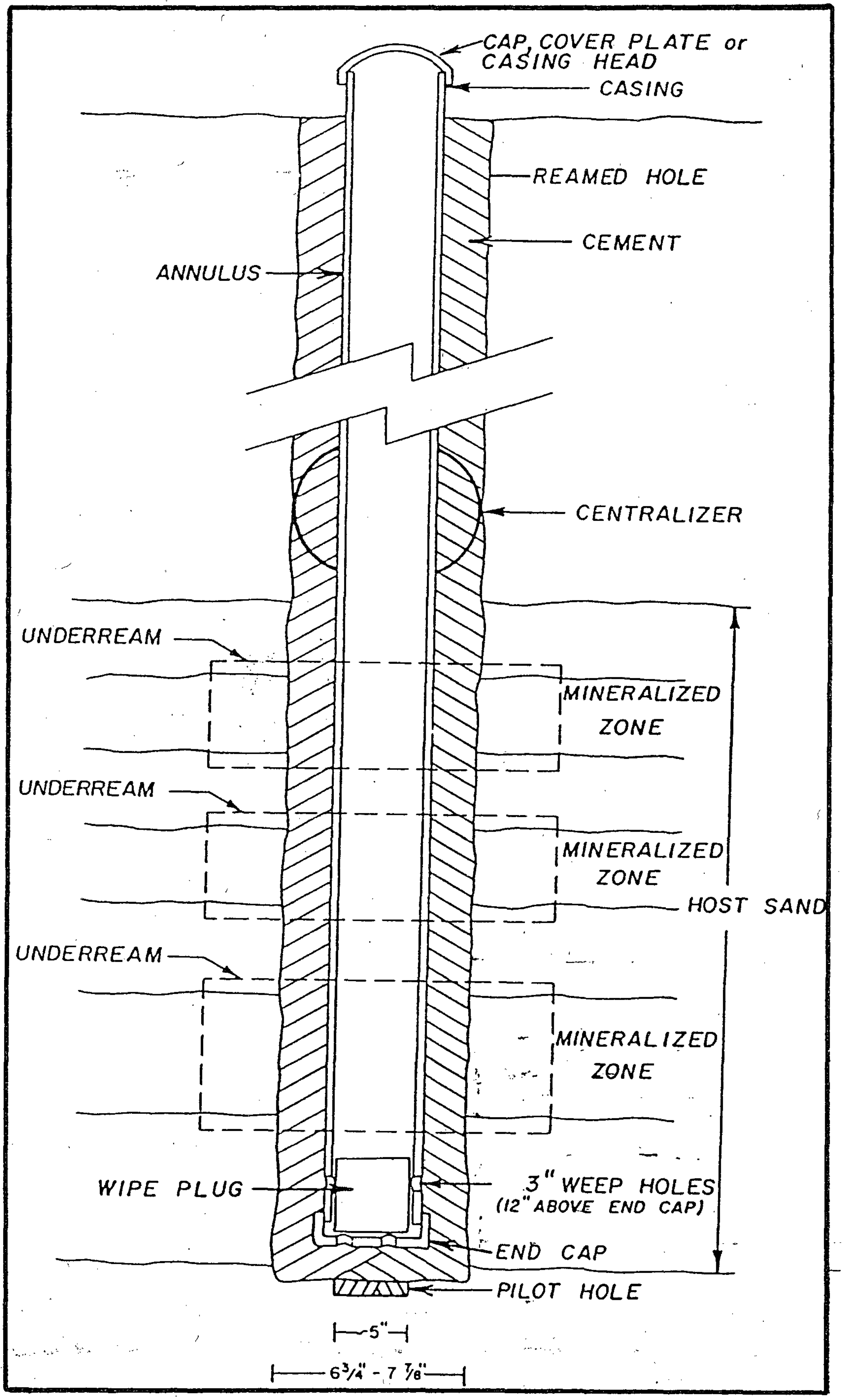


Figure 3.3.05 - Typical Well Completion

All cased wells will be tested for integrity after completion. The testing procedure will utilize a packer pressure test, with a specified pressure loss criteria. Wells will also be retested for integrity after undergoing any physical alteration from underreaming, or after any workover operation wherein the casing could be damaged. The integrity of operating wells will be routinely tested on a schedule of once every 5 years.

Each well casing to be utilized for injection or recovery purposes will be required to maintain the maximum operating pressure plus 20 percent for a 10 minute period. If the measured pressure loss during the first 10 minutes after pressurization is greater than 10 percent of the test pressure, the well will be retested. Should retesting of the well indicate that leakage remains greater than 10 percent of the test pressure, the well will be considered incompetent. All wells which have repeatedly failed the integrity test procedure will be considered incompentent and will be repaired or replaced and then retested.

The integrity testing program will ensure that fluids injected or recovered during mining are entering and returning the well bore in the production zone. This not only develops an economical mining operation, but also controls the spread of lixiviant into nonproducing areas, thereby minimizing the effort needed for restoration.

3.4 Lixiviant Chemistry

The proposed chemicals to be mixed with the recirculated ground water will consist of either carbon dioxide gas or sodium bicarbonate/carbonate, utilizing gaseous oxygen as an oxidant. The concentration of the above chemicals may vary slightly, based upon the mineralogy of the production zone. For instance, if sufficient carbonates are available in the production zone, only carbon dioxide gas may need to be dissolved into the recirculated well field waters. Similarly, additional carbon dioxide may be required for effective mining if pH control is necessary or if additional carbonates are needed. Regardless of the chemical composition of the lixiviant, the concentrations of each component, based upon mining experience at the Christensen Ranch Research and Development site, will be within the following ranges:

Bacarbonate	1,500 to 3,000 mg/l
Oxygen	400 to 500 mg/l
Sodium	750 to 1,200 mg/l

Utilizing chemicals within these ranges is known to oxidize the uranium and efficiently recover it from the production zone.

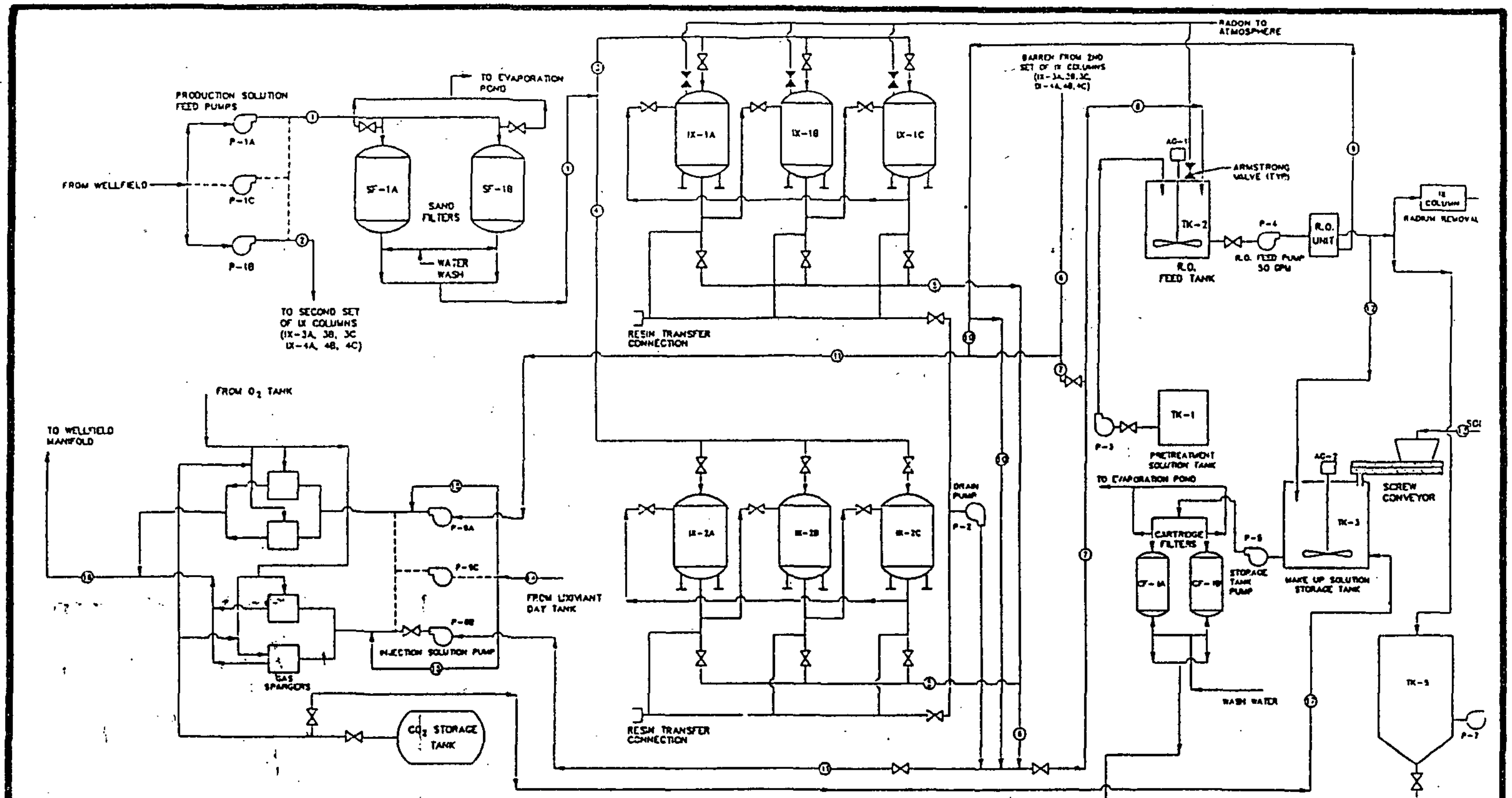
Furthermore, and of equal importance, is the known response of these chemicals to the restoration methods planned for the production zone.

3.5 Uranium Recovery Process

The uranium, mobilized as a carbonate-complex, will be mined from the production units at a flow rate not to exceed the maximum plant capacity of 2,500 gpm. The well field waters will be enriched with uranium as well as several other metals associated with clays in the formation. Data collected from the Christensen Ranch Research and Development site indicate that trace metals such as arsenic, selenium, vanadium, aluminum, iron and manganese are liberated during the leaching process and travel with the uranium. The metal-enriched solution is transferred from the well fields by utilizing buried pipelines. It then enters a series of ion exchange columns. It is within the ion exchange columns that the uranium as well as trace amounts of other metals are absrobed onto the resin beads. The solution exiting the ion exchange columns is enriched with uranium and trace metals. The remaining solution will require lixiviant makeup in order to once again dissolve uranium and its associated metals. Therefore, prior to reinjection of the solution into the production unit, gaseous oxygen and carbon dioxide in various concentrations are added. Additional filtering may be required prior to lixiviant injection to assure that debris from processed production waters is not being reinjected. A general process flow diagram is shown in Figure 3.5.01.

The loading of the ion exchange resin will be the final processing step at any of the four proposed satellite processing facilities. When the resin is fully loaded with the uranium complex, it will be trucked approximately 13 miles to the Irigaray facility. At the Irigaray facility, the uranium-laden resin will be eluted on three fixed-bed ion exchange units. In the elution process, the uranium is stripped from the resin beads with a concentrated solution of sodium bicarbonate and sodium chloride. The ion exchange column product will be a pregnant eluant that will be discharged into a holding tank. At this time, the product, a uranium and vanadium rich slurry, will be piped to a holding tank prior to entering the vanadium separation circuit. As a consequence of stripping the uranium and vanadium from the resin, a barren resin will exist. The resin will be washed, transferred to a tanker trailer, transported to the satellite facility and reloaded into the columns to be utilized as a precipitation medium.

The vanadium that will coleach and precipitate with the uranium is an undesirable constituent in the yellowcake product; therefore, it will be necessary to remove it from the product. This will be



ITEM \ LINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LIQUID TPH	331.5	331.5	165.8	165.8	165.8	331.8	0.63	13.27	3.27	1.63	326.6	3.75	0.33	4.22	2.11	637.4	0.14	6.25
S.G.	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.28	1.26	1.06	1.00	-	1.12	1.12	1.061	-	1.0
FLOW RATE GPM	1250	1250	625	625	625	1250	25	50	10.6	5.0	1230	15.0	-	15.0	7.5	2475	-	25.0
U_3O_8 lb/HR	38.8	38.8	19.8	19.9	1.0	-	0.04	0.08	0.08	0.04	2.0	-	-	-	-	4.8	-	-
V lb/HR	4.65	4.65	2.3	-	0.3	-	-	0.02	0.02	-	-	-	-	-	-	1.2	-	-
HCO_3 lb/HR	928.6	928.6	464.3	464.3	464.3	928.6	18.6	37.2	35.34	17.6	920.6	0.7	-	768	389	2625	-	126
Na^+ lb/HR	431.8	431.8	215.6	215.6	215.6	431.2	8.6	17.2	16.34	8.2	430.8	0.12	290	290	145	1152	-	0.54
Cl lb/HR	99.5	99.5	49.8	49.8	49.8	99.5	2.0	4.0	3.6	1.8	99.3	0.15	-	-	-	[illegible]	-	0.25
U_3O_8 PPM	60	60	3.0	3.0	3.0	3.0	3.0	3.0	-	-	-	-	-	-	-	3.0	-	-
HCO_3 PPM	1400	1400	1400	1400	1400	1400	1400	1400	21g/l	21g/l	1422	95.0	-	102g/l	102g/l	1996	-	93
Na PPM	650	650	650	650	650	650	650	650	34g/l	34g/l	654	43	-	37g/l	37g/l	877	-	43
Cl PPM	150	150	150	150	150	150	150	150	300	550	152	20	-	-	-	-	-	20

Figure 3.5.01 - Satellite Facility Process Flow Diagram

accomplished by installing a vanadium removal circuit at the Irigaray facility. It will consist of a holding tank and a precipitation circuit, which will produce a calcium vanadate product. The product will be filtered in a pressure filter press to make a wet cake which can be marketed for its vanadium content. A process flow diagram and material balance for the Christensen Ranch Satellite Operation and its interaction with the Irigaray recovery facility is shown in Figure 3.5.02.

The yellowcake products from the Irigaray and Christensen Ranch operations will be blended together for final shipping of a slurry yellowcake product. It is anticipated that the Christensen Ranch Satellite Operation could add approximately 600,000 pounds of yellowcake product per year to that produced at the Irigaray facility. The Irigaray facility is currently sized and licensed to produce up to 1,000,000 pounds of yellowcake on an annual basis. Furthermore, the Irigaray facility, during the 1987 license renewal, was environmentally evaluated up to a production rate of 1,000,000 pounds annually. Therefore, the additional slurry from the satellite operation will not increase the impacts associated with the Irigaray site, but simply bring it up to its full production capacity.

3.6 Description of Process Plant, Ponds and Wastes

3.6.1 The Process Plant and Support Facilities

Four satellite facilities will eventually be constructed for uranium recovery at the proposed Christensen Ranch Satellite Operation. All facilities will be constructed, operated and maintained in essentially the same fashion. A 2,500 gallons per minute satellite uranium in situ leach processing plant will consist of a 100 ft X 100 ft prefabricated building which will house an ion exchange circuit, a lixiviant makeup system and a water treatment system for management of waste waters. An adjoining 57 ft X 60 ft prefabricated building will house the restoration equipment. The ion exchange circuit will consist of four IX trains, with each train having three fixed-bed IX columns connected in series. The columns are designed to process 2,500 gallons per minute of well field recovery solutions. The size of the columns and the number of trains used are based on the mining results of the Christensen Ranch Research and Development Operation. Figure 3.6.1.01 shows a general arrangement drawing of the satellite extraction facility.

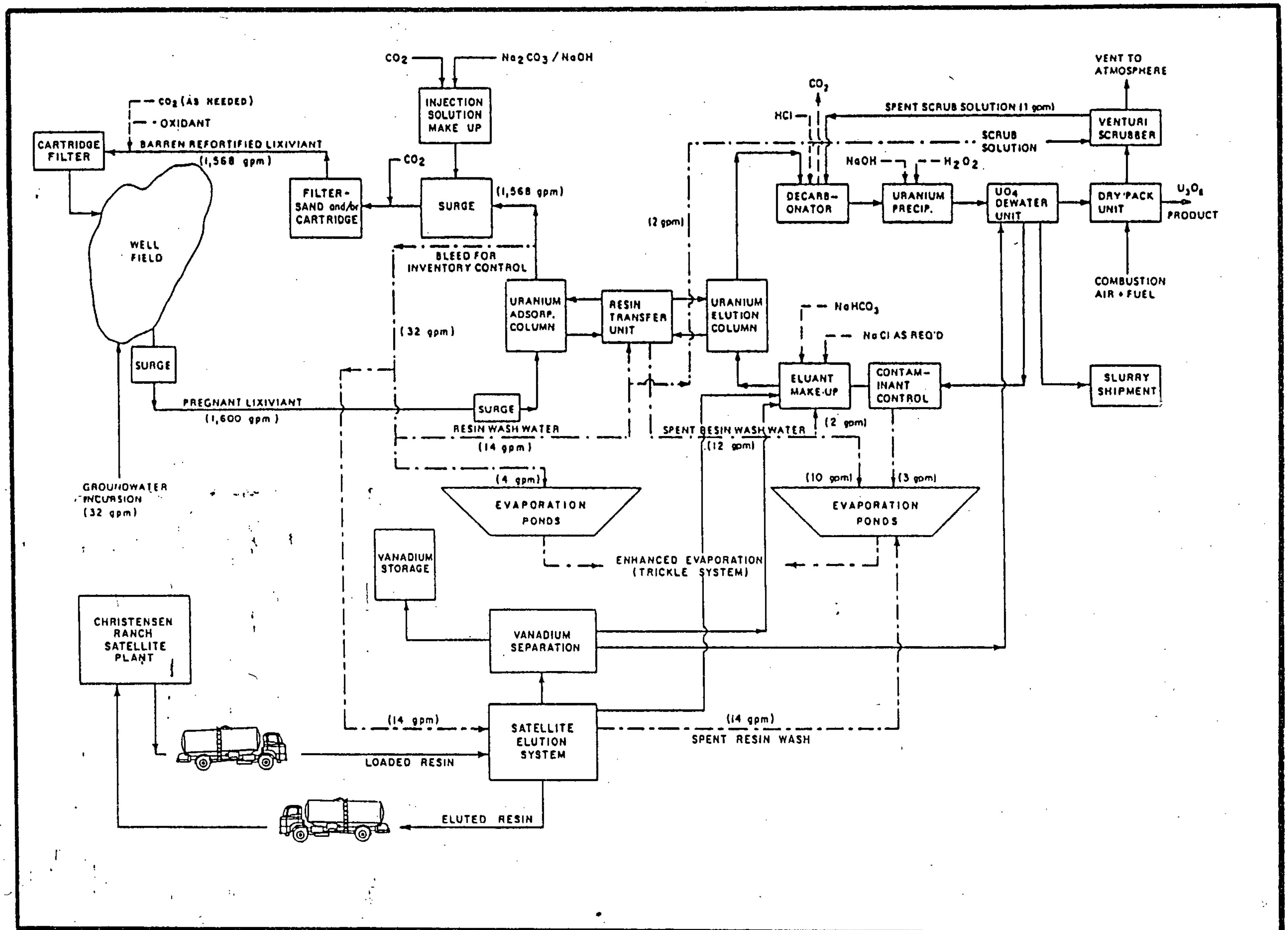


Figure 3.5.02 - Process Flow Diagram for the Irigaray Recovery Facility

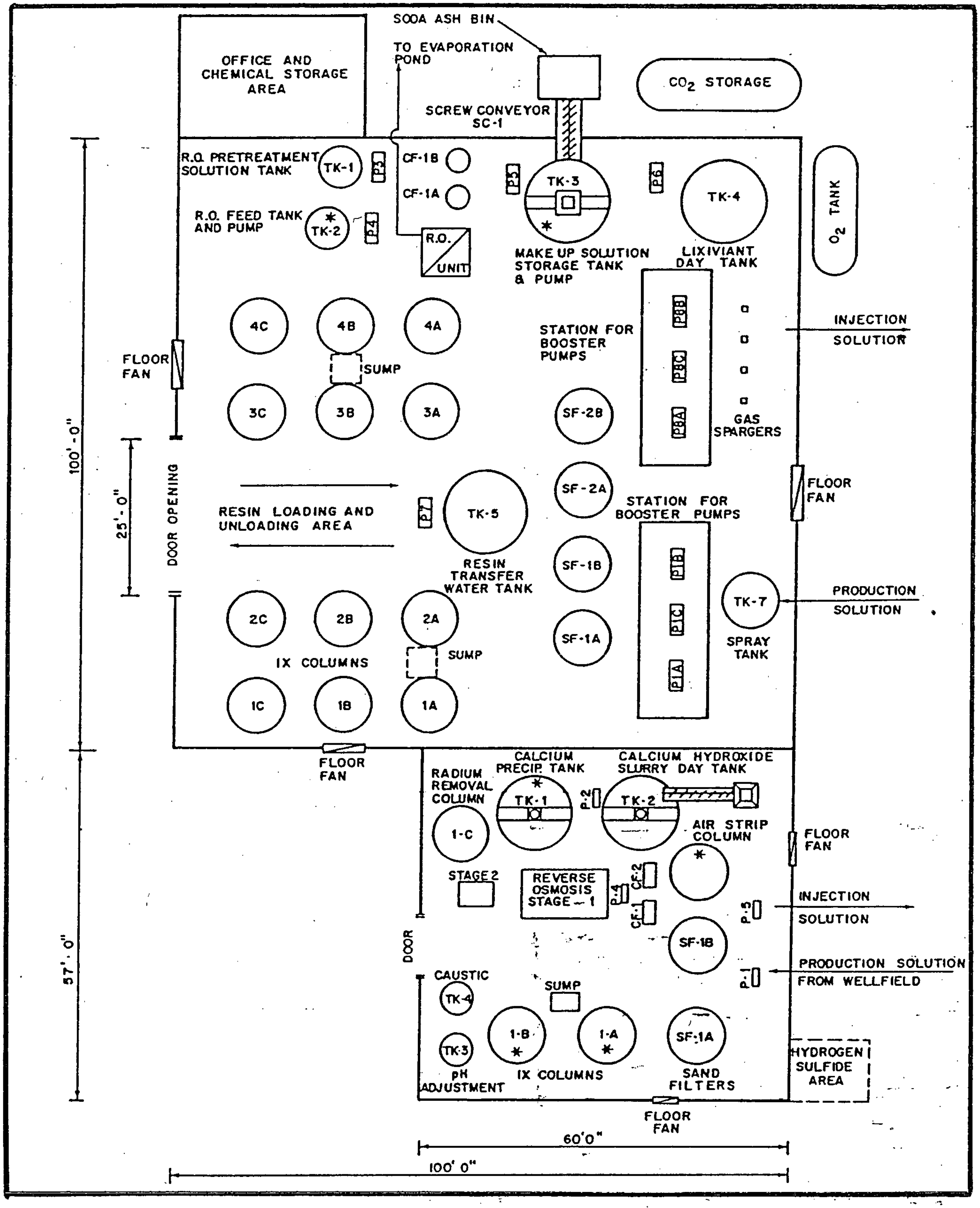


Figure 3.6.1.01 - Satellite Facility Process Plant

The lixiviant makeup system will consist of chemical mixing tanks as well as outside storage containers for solid chemicals such as soda ash. The bleedstream from the ion exchange columns will be circulated through a 50 gallon per minute reverse osmosis unit, thereby producing 40 gallons per minute of high quality permeate for use in lixiviant makeup and restoration, plus 10 gallongs per minute of brine. The 10 gallons per minute of concentrated brine produced may be recycled back to the injection stream, thereby reducing the chemicals required for lixiviant makeup and the waste volumes requiring pondage. If CO_2 alone is used as the lixiviant, the lixiviant makeup system may be bypassed. During this operation, CO_2 will be added directly into the injection stream prior to leaving the plant.

Chemicals utilized and stored at the satellite plant site will consist of carbon dioxide gas, gaseous oxygen, hydrochloric acid and/or sulfuric acid, solid soda ash or sodium bicarbonate and sodium chloride crystals. Propane for heating, as well as gasoline and diesel fuel, will also be present on site. All chemical storage tanks outside of the plant building will be bermed to contain the volume of their contents in the case of a tank rupture.

3.6.2 Solar Evaporation Reservoirs

A high-quality permeate will be produced from reverse osmosis processing to form the 1 percent well-field bleed. This permeate will be stored in two unlined storage ponds for use in aquifer restoration. Lined evaporation ponds equipped with leak detection systems will be utilized for the retention of brine waste from the process. The general configuration of the permeate and brine storage ponds is shown in Figure 3.6.1.02.

The permeate storage ponds will consist of two earthen-lined ponds with identical inside dimensions. The ponds will not require synthetic lining or leak detection systems since they will only be used to store the reverse osmosis permeate which will meet NPDES water quality limitations. Drainage ditches will be used where required to channel surface runoff away from the ponds. The storage ponds will have a normal operating depth of 16 feet with an additional 2 feet of freeboard for a total depth of 18 feet. The maximum depth of water stored behind the embankment is 10 feet, resulting in a maximum embankment storage capacity of 19.2 acre-feet. An additional 6.8 acre-feet of storage capacity is created by below-grade excavation.

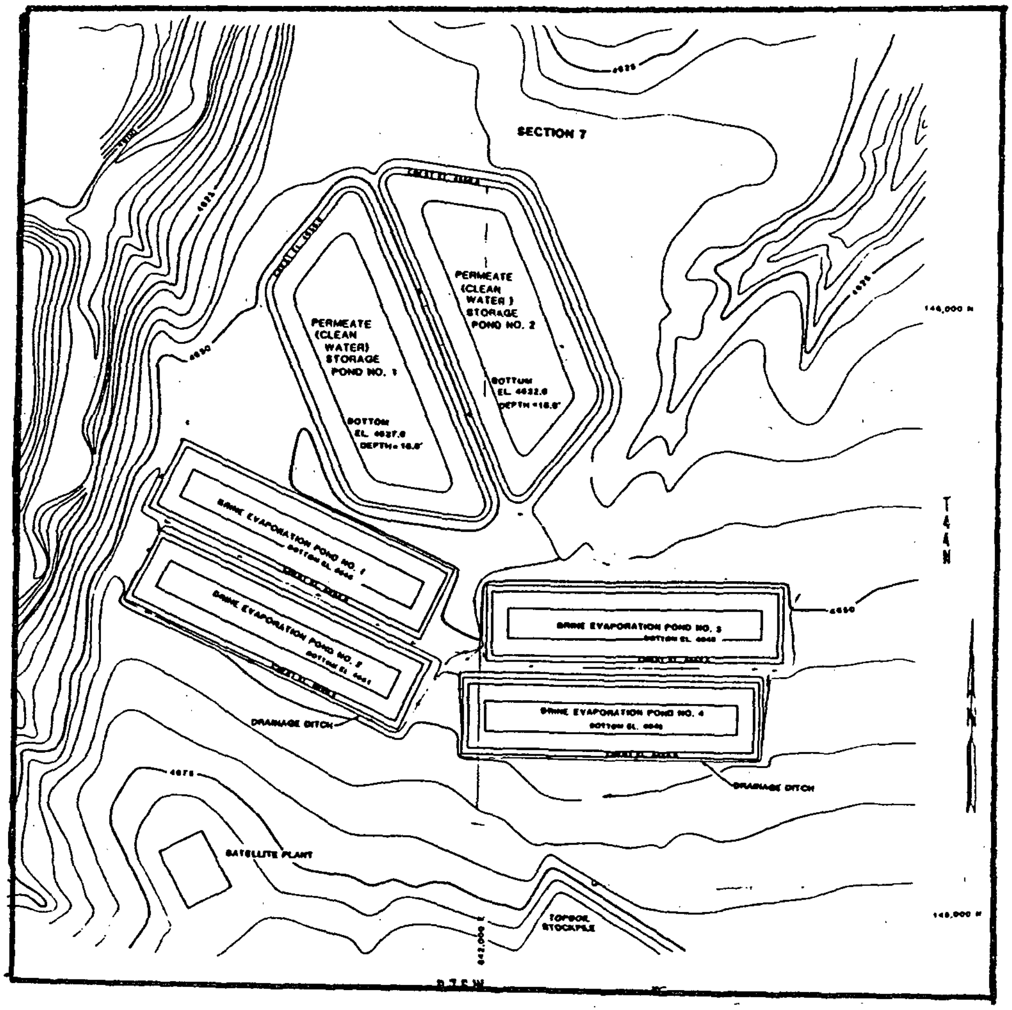


Figure 3.6.1.02 - Configuration of Permeate and Brine Storage Ponds

The combined capacity of the two storage ponds is approximately 52 acre-feet. This capacity is adequate to provide storage for the reverse osmosis bleed stream and the 1 percent bleed stream for approximately 1.3 years of plant operation neglecting evaporation. After this period, the permeate will be utilized during well-field restoration and thereby create more storage capacity.

The brine storage ponds are lined with 36 mil reinforced Hypalon. The lined solar evaporation ponds have been design to meet the requirements of the USNRC Regulatory Guide 3.11, as well as to provide a surface area and capacity capable of evaporating a 5 gallon per minute process effluent stream. The four pond system is capable of evaporating the 5 gallon per minute effluent stream over the planned 10-year period of mining operations. The calculation of the required capacity for the lined ponds involved two major design considerations. First, the pond system is capable of evaporating the process effluent over a 10-year period. Secondly, the pond system is configured to have the capability for totally emptying the contents of one pond into the remaining pond(s) in the event of a detected leak. Only two of the four ponds will be constructed initially; the other two ponds will be constructed as process demands require.

The liner consists of 36 mil reinforced Hypalon, which will be placed over sand or fine gravel. The sand will drain to leak detection piping which will consist of a 3-inch diameter slotted polyvinylchloride pipe in gravel-filled trenches at the perimeters of the pond bottoms. The base 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-feet long sections on each side of the pond to drain to six sumps which will serve as collection points for the leak detection system. Taps consisting of 4-inch diameter polyvinylchloride pipe will be installed at each of the six sumps to allow inspection and sampling.

The use of leak detection sand beneath the Hypalon liners in the evaporation ponds should reduce the need for constructing vents in the liner material. Any gases produced under the liner will be vented to the atmosphere through the leak detection media, thereby eliminating any pressure buildup. After construction, water will be placed in the ponds to prevent billowing of the liner.

All suitable topsoil will be removed and stockpiled prior to pond construction. Any organic or vegetative material remaining after topsoil stripping will be removed. Similarly, rocks and protruding roots will be removed prior to and during final grading. The bottoms of the ponds will be graded toward the berms, and the trench

for the leak detection piping will be dug. The leak detection piping will be installed in a sloping fashion and covered with clean, washed gravel.

After the leak detection piping and gravel have been installed, the underdrain system, pond bottom and sides will be covered with clean, washed sand which will be smoothed to the design grades and slopes. At this point, the Hypalon liner will be installed in accordance with the manufacturer's specifications. The reinforced Hypalon liner will be anchored in backfilled trenches 3 feet from the crest of the berm.

3.6.3 The Wastes

Based upon the information submitted in the Christensen Ranch Satellite Operation Application, the wastes will consist of liquid and solid materials. Liquid effluents from the operation will be generated from both the mining and aquifer restoration processes. As previously discussed, two liquid effluent streams will be produced during the mining operation. The first stream is the 1 percent bleed taken from the plant process to control lixiviant migration in the well field. The 1 percent bleed will consist of 25 gallons per minute of high-quality reverse osmosis permeate which will be stored in two onsite ponds. The 10 gallon per minute concentrated stream from the reverse osmosis process, or brine stream, will be recirculated back to the injection stream of the process and will not require ponding. The additional 15 gallons per minute of permeate produced by the reverse osmosis process will be used for lixiviant makeup, sand filter backwash, resin wash and resin transfers.

The second liquid effluent stream from the process will consist of the sand filter backwash solutions, resin wash water and plant washdown waters. These solutions will comprise a maximum of 5 gallons per minute, on a periodic basis. They will be collected in floor sumps or within selected piping and will be diverted to lined solar evaporation ponds.

Additionally, several waste streams associated with ground-water restoration will be produced. A portion of these waste streams will be discharged to the solution evaporation ponds for eventual loss, by way of evaporation, to the atmosphere. Additionally, larger volumes of fluid will be produced during ground-water sweep. These fluids will be treated to meet NPDES specifications and will be discharged into an unnamed draw at the site.

Minor amounts of solid wastes will be produced during the satellite operation. Solid residues from the sand filter systems, tank

sediments and sump sediments, as a result of the process effluent stream, will remain in the lined evaporation ponds until final decommissioning. These materials will be designated as low level radioactive materials and will be disposed of in a NRC-approved disposal area. Calcium carbonate solids which are generated during the restoration process will be held in the lined evaporation ponds until final decommissioning, or disposed of as needed in a NRC-licensed disposal site.

Other solid wastes such as trash, spent resin and contaminated equipment will be generated during the mining process. Waste materials and trash which are not contaminated will be disposed of in a land fill. Unuseable contaminated equipment, spent resin or other contaminated materials will be stored in a secured area until final disposition in a NRC-approved disposal area.

3.7 Ground-Water Restoration, Reclamation and Decommissioning

3.7.1 Ground-Water Restoration

Ground-water restoration is defined as the returning of affected ground water to its baseline condition or to a condition consistent with its premining or potential use upon completion of leaching activities. The primary purpose of the restoration process is to reduce to acceptable levels the concentration of toxic contaminants remaining in the ground water after cessation of leaching activities. Malapai has proposed, as their primary restoration goal, to return all ground water affected by the leaching activities to baseline quality and to a quality of use consistent with the uses for which the water was suitable prior to mining operations.

Ground-water restoration conducted at the Christensen Ranch Research and Development Operation incorporated four restoration methods; ground-water sweep, reverse osmosis permeate injection, reductant utilization and final well-field recirculation. Approximately 13 pore volumes of fluid were processed for the ground-water restoration, assuming that horizontal flaring affected an area 30 feet outside the well field perimeter.

The first phase of restoration was a ground-water sweep operation with surface discharge of the ground water, following treatment for uranium and radium removal. The effect of the ground-water sweep was to induce movement of leaching solutions into the center of the well field from within the well field itself and from the surrounding margin outside of the well field which had been affected by horizontal flaring. Well field solutions were first processed through the ion exchange columns for uranium removal, then were routed to an evaporation pond where barium chloride was added for

radium precipitation and removal. The pond solution was then routed back to the plant and processed through an ion exchange column containing a radium-complexing resin prior to surface discharge. All discharged solutions will meet the water quality criteria of Malapai's NPDES permit. Approximately seven pore volumes were produced and surface discharged during the initial ground-water sweep phase.

The second phase of the restoration program involved the processing of well field solutions through a reverse osmosis unit and the injection of the resultant permeate back into the well field. The brine from the reverse osmosis unit was routed to the evaporation pond for disposal. The effect of the permeate injection was to significantly reduce the total dissolved solids concentration of the ground water within the well field perimeter. Approximately three pore volumes were processed during the permeate injection phase.

The third phase of the restoration program involved the injection of a reducing agent. Concentrations of some trace metals, notably arsenic and selenium, remained elevated following the permeate injection phase; it was determined that chemical reduction would be effective in lowering the concentrations of these metals. Prior to the use of the reductant, ground-water sweep was conducted for an additional 0.38 pore volumes to draw in surrounding native ground water, as well as recover any flared chemicals. The reducing agent chosen for the process was hydrogen sulfide (H_2S) gas. During H_2S usage, the well field was circulated in a closed loop for safety resaons. Due to this, where was no bleed stream. The gas was introduced into the injection stream and circulated through the well field for approximately one pore volume. The concentrations of arsenic and selenium were reduced by approximately 90 percent at the end of the reductant usage.

Some increase in total dissolved solids concentrations was noted following the reductant usage. Therefore, an additional 1.05 pore volumes of ground-water sweep and 0.34 pore volume of permeate injection were processed to further reduce the total dissolved solids concentrations. The final step of ground-water restoration, well-field recirculation, was initiated at the end of the permeate injection. The effect of the recirculation was to equally distribute the injected permeate and to homogenize the well field solutions. Recirculation of the well field was conducted for 0.38 pore volumes.

The actual restoration sequence that will be utilized for any one production unit will be a combination of the above steps. The proposed sequence of restoration for the initial production unit is

shown in Table 3.7.1.01. It is estimated that 8 to 15 pore volumes of solution will be treated for any given production unit. Restoration activities on a production-unit basis will follow mining by approximately 1 year.

The ability of the licensee to restore the ground water, utilizing the principals noted above, has been demonstrated at the Christensen Ranch Research and Development Operation. The results as shown in Table 3.7.1.02, indicate that the ground water at the site was restored to baseline concentrations for the majority of the chemical constituents, and to the quality of premining use for all parameters. Parameters which did not meet baseline concentrations at the end of restoration are bicarbonate, total alkalinity, arsenic, selenium, uranium and radium.

Of the parameters which remain above baseline concentrations, bicarbonate and total alkalinity, which are intimately involved with one another, are of minor concern. These parameters represent chemicals that were added during mining and may be further reduced during more efficient use of reverse osmosis units. Additionally, there is no water quality standard for these constituents. Due to this, the slightly elevated levels of these constituents should not present a restoration problem on a commercial scale operation.

The metals are ground-water constituents which require closer examination. The constituents of arsenic, selenium, uranium and radium all have use standards associated with them. Arsenic, selenium and uranium concentrations following restoration exceed the baseline concentrations; however, they are below the drinking water standard. Due to this, the water remains fit for human consumption and compatible with premining water use as it exists in the area. Furthermore, as the residual reductant in the formation continues to react, arsenic, selenium and uranium will continue to decrease.

Table 3.7.1.01 - Proposed Restoration Processes and Sequence of Operation

ASSUMPTIONS: 1 Pore Volume = 22.5 X 10^6 gallons
Flow Rate = 625 gpm

Restoration Method and Sequence	Number of Pore Volumes Required	Treatment Time (days)	Primary Result	Solution Distribution and Destination
1. Ground-water Sweep	2	50*	Recall mining solutions into well field area; lower overall TDS.	Surface discharge all solutions
2. Ground-water Recycle	3-6	75-150*	Reduce bicarbonate, uranium, radiu, TDS concentrations	Surface discharge 1% bleed; all other solutions reinjected into well field
3. Reverse Osmosis	3-4	75-100	Significantly reduce TDS to below baseline	Permeate reinjected into well field (85%-90% processed flow). Brine disposal into deep injection well or evaporation pond (15%-10%)
4. Reductant, Recirculation	0-3	0-75	Reduce trace metal concentrations, homogenize well field solution	No bleed produced
TOTALS	8-15	200-375		

*Flow rate will most likely be greater than 625 gpm (up to 1250 gpm), thereby reducing treatment times

Table 3.7.1.02 - Christensen Ranch Research and Development Ground-Water Quality Concentrations

	BASELINE	POST-MINING	RESTORATION						POST RESTORATION STABILITY							CLASS I STANDARDS
MAJOR IONS (mg/l)	N=52 to 55 04/86	N=7 12/10/86 02/05/87	N=3 02/25/87	N=9 03/24/87	N=5 04/16/87	N=5 05/13/87	N=4 06/22/87	N=7 07/14/87	N=5 07/23/87	N=5 08/24/87 ENERGY LAB	N=5 08/31/87 WAMCO	N=5 09/24/87 ENERGY LAB	N=5 10/26/87 ENERGY LAB	N=3 11/11/87 ENERGY LAB	N=5 12/21/87 ENERGY LAB	
Ca	8.6	90.2	52.5	42.2	20.9	3.2	18.1	7.59	7.8	13.8	9.6	12.0	12.9	13.3		
Mg	1.2	14.0	8.1	7.1	3.3	0.51	2.3	1.19	1.20	1.98	4.2	1.8	1.6	1.57		
Na	136	780.4	382.3	383.3	252.2	84.96	228.3	140.2	123.6	148.4	134.2	142.2	144.6	142		
K	2.6	5.4	4.1	3.6	2.5	0.83	2.0	1.41	1.76	1.8	1.6	1.7	1.5	1.7		
CO3	7.32	0	0	0	0	4.62	0	0	0.42	0	0	0	0	0		
HCO3	118	1701.3	775.7	675.7	383.2	161.2	348.2	232.7	188.12	180.2	201.2	195.2	209.4	191.0		
SO4	194.8	387.3	270.3	265.2	221.4	41.6	225.3	118.8	109.2	198.0	151.4	159.4	163.8	177.0		250
Cl	7.2	152.3	66.0	66.1	27.1	5.7	19.5	12.3	11.2	10.6	13.2	11.3	10.9	10.4		250
NH4	<0.05	0.11	0.06	0.09	0.17	0.11	0.28	<0.07	<0.06	<0.07	0.16	0.086	<0.05	<0.06		0.5
NO2(N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01		1.0
NO3(N)	<0.06	0.22	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.06	<0.03	0.02	0.02	0.05		10.0
F	0.171	<0.11	0.18	0.24	0.23	<0.1	<0.1	<0.1	<0.1	<0.10	0.13	<0.11	<0.12	<0.10		1.4-2.4
SiO2	9.11	22.0	13.5	10.5	9.7	6.5	6.6	12.7	9.3	11.8		12.9	12.6	12.8		
TDS	425	2406.3	1328.7	1237.3	776.4	239.6	673.0	418.9	356.8	457.6	452.4	448	435.6	432.7		500
Cond	653	3457.1	1823.0	1709	1165.8	402.6	1113.0	657.6	581.4	753.6	705	698.8	714.2	764.3		
Alk	109.4	1447.5	636.0	553.3	313.8	140.8	285.5	190.7	154.9	147.6	165	159.9	168.4	156.7		
pH	8.87	7.4	8.0	7.84	8.06	8.52	7.53	7.98	7.86	7.32	7.77	7.986	7.51	7.59		6.5-9.0
TRACE METALS (mg/l)																
Al	<0.10	0.66	0.81	0.47	0.26	<0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		
As	<0.0025	0.148	0.068	0.223	0.198	0.088	0.074	0.097	0.045	0.031	0.009	0.027	0.0298	0.0227	0.0206	0.05
Ba	<0.10	0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		1.0
B	<0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.014	<0.10	<0.10	<0.10		0.75
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<.002	<0.01	<0.01	<0.01		0.01
Co	<0.01	<0.02	<0.01						<0.01							
Cr	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05		0.05
Cu	<0.01	0.05	0.09	0.04	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		1.0
Fe	<0.06	0.12	0.16	0.07	<0.076	<0.052	<0.058	<0.057	<0.05	0.36	0.22	0.22	0.22	0.24		0.3
Pb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		0.05
Mn	<0.02	0.09	0.05	0.04	<0.02	<0.01	0.028	<0.017	0.012	0.04	0.04	0.04	0.03	<0.03		0.05
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<.0002	<0.001	<0.001	<0.001		0.002
Mo	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		
Ni	<0.05	<0.05	<0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	<0.05	<0.05	<0.05		
Se	<0.001	3.094	1.846	2.544	1.475	0.405	0.044	0.073	0.061	<0.011	<0.022	<0.014	<0.0088	<0.015	<0.0076	0.01
V	<0.1	2.61	2.66	9.03	6.48	2.86	0.93	0.91	0.36	<0.021	<.10	<0.11	<0.18	<0.10		
Zn	<0.01	0.11	0.02	<0.02	0.04	0.01	<0.02	<0.011	<0.01	<0.01	<0.007	<0.012	<0.01	<0.01		5.0
RADIOCHEM (pCi/l)																
U (mg/l)	0.0354	36.4	53.9	22.9	9.80	2.36	4.46	2.42	1.802	1.17	1.321	1.35	1.52	1.359		5.0
Ra-226	73.2	1225.7	515.3	473.9	207.3	59.2	133.6	94.9	93.4	147.52	41.2	120.18	132.1			5.0

*N= Number of samples (data points) used for arithemetic averaSamples taken from wells RW-01, RW-02, WCPW-21, IW-01, IW-02, IW-03, IW-04, IW-06 and IW-07.

Radium-226 background concentrations averaged approximately 73 pCi/l. Following mining, the radium-226 concentration was raised to 1,226 pCi/l. Restoration efforts reduced this concentration to a low of 59 pCi/l. Since that level, post-restoration stability monitoring indicates that radium-226 concentrations average 107 pCi/l.

Vanadium concentrations during baselining indicated that they were below 0.1 mg/l. During oxidation of the production zone, they were raised to over 9 mg/l. Restoration was successful in diminishing these concentrations back to the baseline concentration. This is, in part, due to the coprecipitation of vanadium with uranium as well as effects of residual reductant in the production zone.

The restoration demonstration from the Christensen Ranch Research and Development Operation indicates that the majority of the monitored ground-water constituents can be returned to baseline concentrations. Additionally, all parameters have been returned to class of use standards. There are, however, several metals which appear to be more difficult to restore. Specifically, arsenic, selenium, uranium and radium remain above baseline concentrations in the production zone. It should be noted that this phenomenon is related to liberation of existing trace metals, due to a change in the oxidation state of the formation and not due to the addition of trace metals from lixiviant injection.

It appears from the data collected over the stability monitoring period that metals of concern are continually diminishing. This is in part due to the residual reductant that remains in the ground water as well as the natural movement of reduced ground waters into and through the area.

The overall effect of the in situ recovery of uranium and subsequent restoration at the Christensen Ranch Research and Development Operation is to restore 30 of 36 monitored parameters to baseline concentrations. Of the six elevated parameters, four metals are slgithly elevated above background concentrations, but continually declining due to residual reducing reactions in the production zone. Because the water remains within the previously established Class I standards, the effect on the water quality is minimal.

3.7.2 Reclamation and Decommissioning

The principal objective of the surface reclamation plan is to return disturbed lands to a production level that is compatible with the premining land use. The reclaimed lands will therefore be capable of supporting livestock grazing as well as provide stable habitat for native wildlife species. Soils, vegetation, wildlife and

as the depth to the shallowest aquifer, the staff concludes that the impact of pond leaks on ground-water quality will not be an issue.

Spills from the solar evaporation reservoir resulting from berm failure could result in unacceptable contamination of surface water and ground water. However, since the ponds have been designed in accordance with U.S. Nuclear Regulatory Commission Regulatory Guide 3.11, and since Malapai has proposed acceptable freeboards, it is considered that spills from the solar evaporation reservoir will be highly unlikely. Therefore, the impacts associated with spills are considered to present a remote possibility of occurring.

4.1.3 Ground-Water Restoration

As previously discussed, the restoration demonstration at the Christensen Ranch Research and Development Operation was not completely successful in returning all monitored parameters to baseline concentrations. However, all parameters were returned to class of use standards. As a result of this, the quality of the water has been slightly diminished due to elevated levels of bicarbonate, total alkalinity, arsenic, radium, selenium, uranium and vanadium. However, the use for which the water is suited has not been altered. The reduction in ground-water quality represents a temporary situation as reducing conditions will eventually re-establish themselves. Due to this, it is considered a short-term impact with minor environmental consequences.

4.2 Radiological Impacts

4.2.1 Introduction

This section discusses estimated radiological impacts associated with the proposed in situ mining. Because the mining process takes place below the ground and produces a wet slurry product, radiological impacts are extremely small fractions of those activities associated with conventional mining and milling.

4.2.2 Offsite Impacts

Because only liquids are brought to the surface during the leaching process and the product will be packaged as a wet slurry, the release of radioactive particulates to the atmosphere from the proposed in situ operation is considered to be nonexistent. This conclusion is in part based upon the absence of any drying of the yellowcake products. Furthermore, the product will be loaded onto resin beads and transported to the Irigaray facility for packaging. Therefore, there is no possibility of radioactive particulates originating from the satellite facilities. Operational particulate

monitoring at the Irigaray facility, as well as at the Christensen Ranch Research and Development Operation, confirm this conclusion.

Some radon-222 will be released from the leach solutions and will be vented to the atmosphere from the various process facilities. However, this incidental increase had previously been evaluated during the renewal efforts associated with the Irigaray commercial license. At this time, the NRC utilized the computer code MILDOS to determine the projected radionuclide emissions associated with a 1,000,000 pound annual production rate. Emissions in this study were found to be so minimal that concentrations of 1 MPC would not exist beyond the walls of the Irigaray process facility. It should be noted that the 1,000,000 pound annual production rate represents a total that will not be exceeded by the combined production from the Irigaray and Christensen Ranch Satellite Operations.

To assure that radionuclides are not higher than expected, the licensee will maintain an air monitoring program. It will consist of several air monitoring stations that will be compared with the previously collected background information. Additional details on this program are given in Section 5.2.

4.2.3 In-Plant Safety

Malapai will be required to develop and perform an in-plant radiation safety program containing at least the basic elements required for, and found to be effective at, similar uranium extraction facilities. This program will have as its basic objective to assure that exposures will be as low as reasonably achievable (ALARA). The scope of the program will take into account the size of the proposed project. In general, the program will include the following basic elements:

1. Airborne and surface contamination sampling and monitoring.

2. Personnel exposure determination.

3. Qualified management of the safety program and training of personnel.

4. Written radiation protection procedures, and

5. Periodic audits and frequent inspections by individuals meeting certain qualifications to ensure that the program is being conducted in a manner consistent with the ALARA philosophy.

The staff considers the proposed program of in-plant safety sufficient to protect plant personnel by keeping radiation exposure

ALARA. Additionally, Malapai's inspection history and previous ALARA audits for the Christensen Ranch Research and Development Operation, as well as the commercial scale Irigaray facility, indicate that a corporate policy of radiation protection by a qualified staff exists.

4.3 Waste Disposal

The NRC has taken the position in regulations on uranium milling (10 CFR 40, Appendix A, Criterion 2) that the wastes generated at in situ operations should preferably be disposed of at existing tailings disposal sites or other licensed radioactive waste disposal sites to avoid proliferation of waste sites. Several disposal options are available to the licensee. Malapai is currently negotiating the disposal of wastes and contaminated debris with a licensed facility. The most economical and preferable option would be to dispose of wastes within a mill tailings impoundment. The volume and type of waste that the proposed operation would produce is completely compatable with such an operation and would, therefore, have no impact at the disposal site.

5.0 MONITORING

5.1 Ground Water

5.1.1 Water Quality Monitoring

The licensee has monitored ground-water quality from 27 regional monitor wells. This data will serve as the basis for defining water quality over the entire Christensen Ranch Satellite Operation. The regional monitoring was performed in the production zone, the first overlying aquifer and the first underlying aquifer. During operations, the satellite facility will, on a production unit basis, have the ground water monitored. It will be monitored at the perimeter of the production zone as well as in the first overlying and underlying aquifer. The purpose of this monitoring is to determine if lixiviant is either migrating laterally out of the mineralized production zone or moving vertically through the aquitards.

The density of the monitoring wells will be much greater in the production zone than in the overlying and underlying aquifers. This is primarly due to the relative inability of the mining solutions to move through the aquitards. Operational data at the Christensen Ranch Research and Development Operation, as well as at the neighboring Irigaray facility, indicate that monitoring on a production unit basis with one set of centrally-located overlying and underlying monitor wells as well as lateral monitoring wells at

the margins of the production units are adequate. Therefore, the licensee will be required to monitor a deep and shallow monitor well in addition to production unit monitor wells.

These wells will be monitored on a frequency that is acceptable to the State, the licensee and the NRC. The samples will be analyzed for parameters are greatly increased during mining operations and would rapidly sense a loss of control of mining solutions.

If results of water quality monitoring indicate that an excursion has occurred, the licensee will immediately determine the cause of the excursion and initiate corrective actions accordingly. Previous operational data indicate that leaching solutions, which have left the production zone, are relatively easy to recover. Furthermore, such events are relatively rare.

For comparison purposes, the licensee will establish background concentrations of monitored ground-water parameters in several areas. The underlying and overlying aquifers as well as the perimeter monitor wells will have background water quality established for purposes of detecting an excursion. Similarly, the wells in the production zone will have background water quality established for purposes of ground-water restoration. Each of these wells will be baselined by collecting Wyoming Department of Environmental Quality Guideline 8 analyses in sufficient quantity and detail to adequately determine the water quality.

In addition to the monitor wells, a system bleed of 1 percent will be maintained throughout the leaching phase of the project. This slight overproduction will create a hydraulic cone of depression within the various well-field areas. This procedure will allow a net in-flow of ground water into the well field which inhibits the outward flow of lixiviant, further reducing the risk of an excursion.

5.1.2 Evaporation Pond Leak Detection Monitoring

The standpipes at the solar evaporation reservoir will be inspected daily during the operation of the facility. Should water be detected in the inspection sumps, a sample will be collected and analyzed for chloride, alkalinity, uranium sulfate and conductivity. Additionally, the NRC, Uranium Recovery Field Office, shall be notified by telephone within 48 hours of verification of a leak, and the pond fluid level lowered by transferring its contents into the other cell so that repairs can be made. Water quality samples shall be taken at the standpipes at least once every 7 days during the leak period and once every 7 days for at least 2 weeks following completion of repairs if any liquid is detected in the sumps.

Weekly samples shall be analyzed for total carbonate, sulfate, chloride and electrical conductance. Additionally, once per month, samples shall also be analyzed for the parameters noted above.

5.2 Environmental Monitoring

Malapai has performed a baseline surface radiological monitoring program for air, ground water, surface water, soils, sediments, flora and fauna. The premining data correlates well with other data collected at neighboring sites in the area. Table 5.1.1.01 summarizes the types and locations of data collected. All samples have been and will continue to be collected and analyzed as described in Regulatory Guide 4.14.

During operations, the licensee will continue with an environmental monitoring program. It will monitor the various environs to determine if the Christensen Ranch Satellite Operation has caused any measurable changes. Operation data from the Christensen Ranch Research and Development Operation as well as the Irigaray facility indicate that no changes have been detected in any monitored environment other than ground water within the production unit. The results of the environmental monitoring program will be reported to the NRC on a semiannual frequency.

5.3 Quality Assurance and Health Physics Manual

Malapai has developed a quality assurance (QA) program for all sampling and analytical work performed as part of the in-plant radiation safety and environmental monitoring programs which includes all of the recommended elements of a QA program as specified in Regulatory Guide 4.15. Additionally, a health physics manual exists which includes all aspects of the health safety program. These two documents have been reviewed and approved by the NRC in conjunction with the Irigaray renewal effort.

6.0 ALTERNATIVES

6.1 Introduction

The action that the Commission is considering is to grant an amendment to Source Material License SUA-1341 pursuant to Title 10, Code of Federal Regulations, Part 40. The alternatives available to the Commission are:

1. Accept the application subject to NRC license conditions and grant the amendment.

2. Deny the application and not issue the amendment.

Table 5.1.1.01 - Radiological Preoperational Monitoring Program
Christensen Ranch Satellite Operation

Type of Sample	Sample Collection: Number	Location	Method	Frequency	Sample Analysis: Frequency	Type of Analysis
AIR						
Particulates	Four	Plant site and three others	High volume air sampler	80 hours per quarter	Quarterly composite	U-nat, Th-230 Ra-226, Pb-210
	One	Nearest residence	Same	Same	Same	Same
	One	Prevailing upwind	Same	Same	Same	Same
Radon Gas	Six	Same as particu- lates	Track Etch, Continuous	Quarterly	Each sample	Rn-222
WATER						
Ground water	Ten	Ore zone wells	Pumped Grab	Quarterly	Each sample	U-nat, Th-230, Ra-226, Pb-210 Po-210
	Nine	Overlying aquifer	Pumped Grab	Quarterly	Each sample	U-nat, Th-230, Ra-226, Pb-210, Po-210
	Eight	Deep aquifer	Pumped Grab	Quarterly	Each sample	U-nat, Th-230, Ra-226, Pb-210, Po-210
	Six	Livestock and Domestic wells in Phase I	Pumped Grab	Quarterly	Each sample	U-nat, Th-230, Ra-226, Pb-210 Po-210

Table 5.1.1.01 (cont.)

Type of Sample	Sample Collection: Number	Location	Method	Frequency	Sample Analysis: Frequency	Type of Analysis
SURFACE WATER						
	Four	Willow Creek, upstream and three downstream	Grab	Monthly, when water is available		U-nat, Th-230, Ra-226, Pb-210, Po-210 semiannually
	Four	At the mouth of drainages in Willow Creek	Grab	Monthly, when water is available	Each sample	U-nat, Th-230, Ra-226, Pb-210, Po-210 seniannually
SEDIMENT						
	Eight	Generally upstream and downstream from proposed plant site	Grab	Twice	Each sample	U-nat, Th-230, Ra-226, Pb-210
SOIL						
Surface	One each	At air sampling stations	Grab	Once	Each sample	U-nat, Th-230, Ra-226, Pb-210
	20	Samples taken at 300 meter intervals along a 1500 meter radii from the proposed plant location in the direction of the prevailing winds (NW, NE, E, SE)	Grab	Once	Each sample	Ra-226 all samples, 10% for U-nat, Th-230, Pb-210

Table 5.1.1.01 (cont.)

Type of Sample	Sample Collection: Number	Location	Method	Frequency	Sample Analysis: Frequency	Type of Analysis
SUBSURFACE SOIL						
	One each	At air sampling stations	One-third meter composites to a depth of one meter	Once	Each sample	Ra-226 on all samples, U-nat, Th-230, Pb-210 on one sample
VEGETATION						
	One each	At the air sampling locations	Grab	Beginning, middle and end of growing season	Three times	U-nat, Ra-226, Th-230, Pb-210, Po-210
FOOD						
	Two livestock samples	Range fed livestock	Grab	Time of slaughter	Once	U-nat, Ra-226, Th-230, Pb-210 Po-210
FISH						
	One	Downstream from proposed plant on Willow Creek	Grab	Early summer and late summer	Twice	U-nat, Ra-226, Th-230, Pb-210, Po-210

Table 5.1.1.01 (cont.)

	Sample Collection				Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
DIRECT RADIATION						
	Six each	At the air sampling stations	Dosimeter	Continuous	Quarterly	Gamma exposure rate
	Minimum of 275 readings	Transects across ore trend radii from the proposed plant location	Dose rate	Once	Once	Gamma exposure rate

The selection of either alternative is based on a consideration of a number of factors related to protection of health, safety and the environment. Because this application incorporates added yellowcake production, the language in Section 40.32 of 10 CFR 40 applies. Accordingly, Section 40.32 of 10 CFR 40 states that an application for a specific license will be approved if, among other things:

1. The application is for a purpose authorized by the Atomic Energy Act;

2. The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life or property;

3. The applicant's proposed equipment, facilities and procedures are adequate to protect health and minimize danger to life or property; and

4. The issuance of the license will not have an adverse effect on the common defense and security or the health and safety of the public.

If the Commission finds, based on its evaluation of the application, that these stipulations are met, its only choice is to make a finding of no significant impact and issue the amendment allowing production of uranium loaded resins from the Christensen Ranch Satellite Operation.

6.2 No Amendment Alternative

The NRC can choose not to amend Source Material License SUA-1341 to incorporate the Christensen Ranch Satellite Operation. This decision would be based on an evaluation of environmental and public health and safety considerations as required by NRC regulations. If, however, the license application meets all applicable regulatory requirements, the NRC would have no basis for denial of the license.