PDR

EXXON MINERALS COMPANY, U.S.A.
POST OFFICE BOX 2180 · HOUSTON, TEXAS 77001

OPERATIONS DEPARTMENT

July 6, 1979

FOR INFORMATION ONLY

Re: Solution Extraction R&D Project
Highland Uranium Property
Converse County, Wyoming
License No. SUA-1064
Docket No. 40-8064

Dr. Ray Cooperstein
Fuel Processing and Fabrication Branch
Division of Fuel Cycle & Material Safety
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Dr. Cooperstein:

Attached for your information are copies of the Application to the Wyoming DEQ for our pilot project, DEQ's letter of approval dated October 26, 1978, and the DEQ Quarterly Report for the First Quarter 1979 dated April 19, 1979. The Quarterly Report is attached as it provided the basis for changes to some of the DEQ Upper Control Limits and includes updated list of excursion parameters for monitor wells, Table 1.17, page 62 , of the DEQ Application.

If you have any questions on the attached, please call me.

Sincerely,

Marvin D. Freeman

Marvin D. Freeman

FEE EXEMPT
cert only

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MDF:dh
Attachments

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REQUEST FOR MODIFICATION

TO MINING PERMIT 218C

URANIUM SOLUTION MINE TEST PROGRAM

PROPOSED ACTIVITIES

Exxon proposes to continue its research and development program on solution mining (in-situ leaching) of uranium from the Highland uranium ore deposit in Converse County, Wyoming to evaluate important process variables and to obtain additional operating and cost data.

Solution mining clearly has the potential for increasing the supply of uranium for the uranium fuel cycle through production of uranium from deposits that cannot economically be mined by conventional surface or underground mining methods. In addition, solution mining can recover uranium from typical resources with insignificant environmental costs compared to other mining techniques.

Approval of this request for modification of the mining permit will allow Exxon to continue its research and development efforts in this area which shows considerable promise as an economically and environmentally attractive mining technique.

The proposed leach test site will be a new area of one acre or less located about 1500 feet east of the original test site. Clean-up of the aquifer at the original solution mining test site is nearing completion and continuation of the test program in the new location is necessary for further development of this mining method.

The solution mining R&D project is located on the Highland property where Exxon operates the Highland uranium mine and mill under the authorization of Mining Permit 218C. The location of Exxon's Highland mine in Converse County is indicated on Figure 1.1. The relative locations of the mill, surface mines, overburden deposits, the underground mine, the tailings pond, the original solution mine pilot site and the proposed test site are shown on Figure 1.2. Exxon's Highland uranium mining and milling operation, which has been in operation since 1972, currently employs approximately 600 Exxon personnel and provides employment for approximately 50 contractor and subcontractor employees.

Since 1972, Exxon Company, U. S. A. has been conducting research on solution mining (in-situ leaching) of uranium from sandstone deposits on the Highland property in conjuction with conventional mining operations authorized by the Department of Environmental Quality, Land Quality Division Mining Permit 218C. This test program has demonstrated that substantial quantities of uranium can be recovered by solution mining without safety hazards to employees or to the public and without significant adverse effects on the environment. Encouraged by the initial results, Exxon plans to continue the solution mining research in an area approximately 1500 feet east of the original test site.

In the solution mining process, a solution containing sodium carbonate and sodium bicarbonate and an oxidizing agent is allowed to permeate under controlled conditions through known ore deposits that lie below the regional groundwater level and are sealed at top and bottom by shale intervals. The leach solution is metered and injected through injection wells into the

ore zone and is recovered through nearby producing wells.

Pumps in the production wells create local areas of low pressure in the formation and draw the injected leach solution through the ore zone to the production wells. The leach solution dissolves uranium as it passes through the ore. The resulting uranium bearing solution (pregnant leach solution) is then pumped to the surface and routed to the recovery plant.

In the pilot operation, fluid from the well field is routed to one of the two 500-barrel pregnant solution surge tanks. The leach solution is then pumped from the surge tank through a solid resin ion-exchange unit to one of two 500-barrel barren solution surge tanks. A portion of the barren solution is circulated through a chemical makeup system in which sodium carbonate and sodium bicarbonate are added to increase the concentrations of those compounds to the desired levels. An oxidizer, such as hydrogen peroxide, is then added to the barren solution as it is pumped back to the well field for reinjection into the ore zone for additional uranium extraction. A flow schematic for the recovery plant is shown in Figure 1.3.

Periodically, the uranium is eluted or stripped from the resin in the ion exchange columns by a solution of sodium chloride or other salt. The rich eluate is pumped to a tank where acid is added to break down the uranium complex. Ammonia is then added to cause the uranium to precipitate as a yellowcake slurry. The resulting yellowcake slurry is then transported as

a wet product in a tank trailer over approximately one mile of private road to the Highland uranium mill for drying and packaging in existing mill facilities.

The fluid production rate in the continued test program will be about 60 gpm of pregnant leach solution. This compares with 15 gpm in the original test program. The increased fluid volume will require minor modifications to the existing recovery plant. The most significant of these will be the installation of additional solid resin ion-exchange capacity. Other items in the recovery plant that will require minor modifications are the eluant handling facilities, transfer pumps, metering, and sampling facilities. The existing storage tanks will provide sufficient storage capacity for the pregnant and barren leaching solutions.

The injection well-production well pattern and locations of the observation and monitor wells for the proposed test program are shown in Figure 1.4. In general, the pattern consists of injection wells, each offset by four production wells with observation wells encircling the leach area and monitor wells completed in the aquifer above and below the ore zone.

The observation wells, completed in the ore-bearing sand, will be spaced 250 to 350 feet apart and will be located approximately 200 feet from the outer edge of the production pattern. Monitor wells will be completed in the aquifer above and below the ore zone to detect any leach solu[illegible] which might migrate into these formations. Guard wells may be drilled between the leach area and the observation wells for additional operational control. The distance between the injecti[illegible]d production wells in the test program will be approximately 70 feet.

The solution mining wells will be drilled to the ore zone or to the specified sand interval and completed with a single string of PVC, fiberglass, and/or steel casing. The annular space between the casing and the drill hole will be cemented through the casing with a sufficient volume of cement to isolate the completion zone from the formations above it (Figure 1.5). Data on well elevations, depths and completion intervals are provided in Table 1.16.

All observation and monitor wells for the pilot will be sampled twice per month and the fluid will be analyzed for carbonate, bicarbonate, chloride, and uranium to ensure that the injected fluid is effectively contained within the test area. Electrical conductivity and water level data will also be recorded when the wells are sampled. If any of the leaching solution should reach any of the observation wells, the injection and/or production rates in the adjacent wells will be adjusted as required to control the directional flow of fluid in the aquifer and move the leaching solution back to the desired area. The ability to control the fluid movement by adjusting the injection and production rates has been demonstrated in the initial solution mining test program.

We have completed a hydrological pump test which has verified hydraulic connection between the observation wells and the production area. The pump test also verified the absence of any significant hydraulic connection between the production aquifer and the aquifers above and below it. The hydrological data is submitted as Appendix I to this application.

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GEOLOGY

The ore zone at the proposed test site lies approximately 400 feet below the surface and averages about 27 feet in thickness. A general stratigraphic column for the Highland area is shown in Figure 1.6. A northwest-southeast cross section and a northeast-southwest cross section through the test area showing the ore zone and sealing shales are included in Figures 1.7 and 1.8.

The Highland sands in the original research test site had an average permeability of 1088 millidarcies and an average porosity of 29 percent (Table 1.1). The new test site is expected to have similar permeabilities and porosities and the transmissivity is expected to be in the range of 400 to 800 gallons per day per foot. The pressure in the ore zone aquifer in this area is expected to be 35-40 psi allowing the desired production rates of 6 to 10 gpm per well to be readily achieved.

Pumping tests will be conducted before leaching solutions are injected. Pressure within the aquifers above and below the ore-bearing sandstone unit will be monitored during these tests, and if communication is detected during the pump tests, an appropriate program for minimizing the effect of any such communication will be designed and implemented.

Most of the water wells in the vicinity of the proposed operations are owned and operated by Exxon. Figure 1.9 shows the locations of all known water wells within three miles of the Highland mill and Table 1.12 lists the well depths and the completion intervals where the data is known. A map of the surface topography in the area is included in Figure 1.16.

IMPLEMENTATION

A drilling program was initiated in late 1977 to obtain baseline water quality data in the proposed test area. Fourteen wells were included in the baseline water quality sampling program. The locations of these wells are shown in Figure 1.4, and the results of the test program are summarized in Table 1.13. The remaining wells required for the proposed test will be completed during the first half of 1978. The modifications to the existing pilot plant facilities which are required to handle the increased fluid volume are scheduled to begin in May and will be completed early in the third quarter. Installation of pipelines and other outdoor work will be initiated in the spring of 1978 as soon as favorable weather occurs.

The pipeline system will consist of 3-inch or 4-inch trunklines between the plant and the well field header and 1½-inch or 2-inch flowlines from the header to the individual wells. The individual flowlines will radiate from the header site and will be laid in a common ditch where possible to minimize the surface disturbance. The pipelines will be buried below the frost line at an average depth of about five feet. The lines will be PVC, high density polyethylene, fiberglass, and/or coated and wrapped steel. The pipelines will be hydrostatically pressure-tested with fresh water to one and one-half times the expected operating pressure before being placed in service.

A small building will be installed near the well field to house the header system where the individual flowlines from the production and injection wells will be connected to the trunklines. The header

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building will serve as the primary metering and control point for the individual injection wells and will include provisions for metering and sampling the fluids from the production wells. Producing rates from the production wells will be regulated by selection of the pump size and speed and/or controlling the backpressure on downhole centrifugal pumps. The individual well rates will be adjusted as required to balance the injection and production rates to prevent overinjection.

After the wells and pipelines are completed, Exxon may conduct a short-term aquifer conditioning test program. The test would consist of producing water from the leach pattern, processing it through a water conditioning (softening) system and reinjecting it in the leach area. The purpose of this test is to determine if the concentration of calcium ions can be significantly reduced by this technique.

After the above conditioning test is completed, the leaching operations will be initiated using a solution containing sodium carbonate and sodium bicarbonate concentrations of up to 20 g/l and hydrogen peroxide concentrations of up to 1.5 g/l. As the leaching process nears completion and the concentration of uranium in the produced fluid drops to a relatively low level, the aquifer cleanup process will be initiated. During the cleanup process, fluid from the aquifer will be produced until the concentrations of materials introduced or solubilized by the solution mine process have been returned to acceptable levels. The leaching operation and aquifer cleanup process are expected to take three to five years to complete. The final reclamation of the area and the plugging of the wells will begin shortly after the aquifer cleanup process is completed.

GROUNDWATER MONITORING

The protection of groundwater is the principal environmental concern associated with the implementation of a solution mining program. Therefore, to obtain baseline water quality data, Exxon has drilled and sampled six wells completed in the ore body, six observation wells completed in the ore bearing aquifer and monitor wells completed in the aquifers above and below the ore zone. The water samples from these wells were collected after producing the wells (airlifting) until the conductivity had stabilized. These samples have been analyzed for the water quality parameters set forth in the Department of Environmental Quality Land Quality Division's March 18, 1977 guidelines (Table 1.14). The results of these analyses, which indicate the existing baseline concentrations for these elements, are shown in Tables 1.13 through 1.13-15.

The well field will be encircled by observation wells, and monitor wells will be completed in the aquifer above the ore zone and in the aquifer below the ore zone. All observation and monitor wells will be sampled twice per month and the fluid will be analyzed for uranium, carbonate, bicarbonate and chloride. Electrical conductivity and fluid level will be measured and recorded when the above samples are taken.

If indications of the leach solution should reach any of the observation wells, the production and/or injection rates in the adjacent wells will be adjusted as necessary to increase net withdrawal and move the leach solution back to the desired area. Weekly sampling of the observation well(s) in which an excursion is indicated and the adjacent observation wells will be initiated and will continue until the concentration of the uranium or other indicator in the observation well samples is corrected or until a definite decline is established. During this period, sodium, arsenic, selenium, and pH will be added to the excursion parameter analyses.

If the concentrations of uranium or other parameters detected in the observation well(s) do not begin to decline within 60 days after an excursion is indicated, injection in the area near the excursion will be suspended in order to further increase net withdrawals until a decline trend is established. After a decline trend is established, normal operations will be resumed with the injection and production rates regulated such that net withdrawals from the area will continue until the concentration in the observation well(s) have returned to acceptable levels.

An excursion shall be considered to have occurred if the upper control limit (UCL) for any two excursion parameters exceeds the values specified in Table 1.17, and these levels are confirmed by analyses of two verification samples taken within 48 hours and within 96 hours after the results of the first analyses are received. If an excursion occurs, the DEQ Land Quality Division, will be notified within 7 days after it is verified. Monthly followup reports on cleanup progress and plans would be submitted to the DEQ until an acceptable decline trend is established. The production and injection volumes and a summary of the scheduled observation and monitor well sample data will be included in the quarterly reports which will be submitted to the DEQ.

At the completion of the solution mining process, Exxon will pump wells in the pattern until the concentrations of radioactive materials in the fluids produced are below the maximum permissible concentrations for unrestricted areas as listed in Column 2, Table II, Appendix B, 10CFR20, (Exception: Uranium shall be determined as discussed in Table 1.18; but it shall not exceed one-half of the maximum permissible concentration listed)

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or until such concentrations are no higher than 1.2 times the natural background (baseline) concentration where such background concentrations are in excess of MPC.

Concentrations of non-radioactive elements introduced by the solution mining process will be reduced to levels such that the water will be acceptable for principal uses for which it was acceptable prior to initiating solution mining operations. Since the groundwater present within uranium ore zones at Highland is not suitable for human consumption, the water quality guideline for non-radioactive materials shall be either the criteria as listed in the Wyoming Department of Environmental Quality, Land Quality Division's Guideline No.4 (revised), November 9, 1976, Part II: Water Quality Criteria for Wildlife and Livestock Impoundments (Table 1.15), or concentrations no higher than 1.2 times the natural background (baseline) concentrations, whichever is greater for the specified parameters. Target restoration values for the solution mining production area are listed in Table 1.18.

WASTE MATERIALS

The most significant effluent produced in the solution mining process will be the fluids produced during aquifer cleanup operations. This fluid and all other liquid effluents produced by this operation will be pumped to the existing Highland Mill tailings pond for disposal by evaporation.

The types of liquid effluents expected to be generated are:
(1) wash water used to clean the building floor and equipment;
(2) a brine solution used to regenerate the water softener system;
(3) fresh water used for rinsing the ion-exchange resin; (4) excess

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eluant decanted from the precipitation tank; and (5) fluids produced during the aquifer cleanup phase of solution mining. Although a system bleed is not planned, operating conditions could require implementation of such a system in which 3 to 5 gpm of produced fluid would be routed to the mill tailings pond prior to initiating the aquifer cleanup process.

Water for periodically washing equipment and the building floor in the course of routine maintenance and housekeeping will come from the potable water system and is not expected to contain radioactive materials except for very low levels that might be picked up in the washing process. The brine solution used to regenerate the water softener will result in an average effluent volume of less than 0.1 gpm over the project life. This liquid is expected to contain ion concentrations in the following ranges:

Ca	3,000 - 5,000 ppm
Mg	1,000 - 2,000 ppm
Na	10,000 - 15,000 ppm
Cl	15,000 - 20,000 ppm
Ra-226	Less than 5 pCi/l
Th-230	Less than 5 pCi/l
U	Less than 1 ppm

The rinse water from the ion exchange resin is estimated to average about 250 gallons per day (0.2 gpm) over the life of the project. The radioactive material and other significant ions picked up in the rinse process are expected in the following concentrations:

Na	6,000 - 11,000 ppm
Cl	10,000 - 15,000 ppm
CO_3	500 - 800 ppm
HCO_3	600 - 900 ppm
Ra - 226	100 - 200 pCi/l
Th-230	50 - 100 pCi/l
U	1 - 3 ppm

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The excess eluant or decant from the precipitation tanks will also be pumped to the mill tailings pond for evaporation. This fluid volume is expected to average about 200 gallons per day (<0.2 gpm) over the life of the project. The water is expected to contain the following ranges of material concentrations:

Na	6,000 - 8,000 ppm
Cl	12,000 - 15,000 ppm
Ra-226	100 - 300 pCi/l
Th-230	10 - 30 pCi/l
U	5 - 10 ppm

The most significant volume of liquid effluent from solution mining will be the water produced in the aquifer cleanup process. The native groundwater in the Highland ore zones is naturally high in radium-226 and thorium-230 as illustrated in the pilot program where the baseline water sample had radium-226 and thorium-230 activity levels of 120 pCi/l and 86 pCi/l, respectively. Two water samples obtained from the same ore zone approximately 700 feet east of the pilot showed very low thorium-230 activity but the radium-226 concentrations were 460 and 480 pCi/l. These fluids which will be produced during the aquifer cleanup are the primary radioactive wastes that must be disposed of in the solution mining operation. The cleanup fluids from the operating area are expected to average approximately 40 gpm over a period of about two years. During this period, the water withdrawn will be processed through the ion exchange units and pumped to the Highland mill tailings pond for evaporation.

Although the composition of the fluids will vary as the water quality is returned to acceptable conditions, the average concentrations of the more significant elements and ions in the fluids produced over the total cleanup period are expected to be in the following ranges:

CO_3	-	300 - 600 ppm
HCO_3	-	400 - 700 ppm
As	-	0.1 - 0.3 ppm
Se	-	0.05 - 0.15 ppm
Ra-226	-	50 - 100 pCi/l
Th-230	-	50 - 150 pCi/l
Gross α	-	2000 - 3000 pCi/l
Gross β	-	2500 - 3500 pCi/l

The total of all fluids going to the mill tailings pond is expected to average less than 5 gpm prior to the start of aquifer cleanup and is estimated to average about 40 gpm over a two-year period during aquifer cleanup operations.

In solution mining, the host sand or rock is not removed from its natural location. Therefore, solution mining has a significant environmental advantage over conventional mining and milling in that no large volumes of solid tailings requiring controlled disposition are generated. All non-radioactive solid wastes such as trash, packing material, etc., will be collected and transported to the existing waste disposal system operated for the Highland Uranium Mill. Any radioactive solid waste from the facility, such as spent ion-exchange resin, will be disposed of in accordance with regulations of the Nuclear Regulatory Commission.

RECLAMATION PROCEDURE

Final reclamation of the test area will be accomplished after the aquifer cleanup has been completed. All wells will be plugged with a cement mixture in an interval extending from the bottom of the hole to a point in the hole which is a minimum of 50 feet above the top of the ore zone. The casing will then be filled with drilling mud or other suitable material to a point of approximately 20 feet below the surface. A cement plug will be

placed from top of mud to within five feet of the surface. The casing will then be cut off at least two feet below the surface and the area will be smoothed and leveled to blend with the natural terrain. The roads and well sites in the area will then be prepared for seeding by disking and/or mulching as necessary.

The reclamation of an area will be initiated as soon as feasible, normally in the next growing season, after an area is no longer needed for the operation. All disturbed areas will be seeded with western wheatgrass, thickspike wheatgrass, and/or other similar grasses approved by the Wyoming DEQ. An area is expected to by fully reclaimed within 2 or 3 years after seeding.

The surface area expected to be disturbed in this program is estimated to be less than 5 acres. This area is comprised of the well field, the roads, and pipeline rights-of-way. Reclamation of some of the areas such as pipeline rights-of-way, can be initiated as soon as the construction is completed.

RECLAMATION BONDING

The proposed solution mine pilot is located in an area scheduled to be disturbed in 1978 as shown in the 1977 annual report for the Highland operations. Therefore, bonding for the surface reclamation costs for this area will be included in the estimated overall cost of reclamation for surface disturbance at Highland.

Other reclamation costs associated with the pilot are the well plugging and aquifer reclamation costs. The estimated cost of plugging the 25

wells included in the pilot program is $7500. For the aquifer reclamation costs it is estimated that to return the aquifer to an acceptable condition, three aquifer pore volumes of fluid will have to be produced after the project is no longer economical. Allowing for a one acre leach area and a twenty foot buffer zone around the leach area, the estimated cost of producing the six pore volumes of water from the area and pumping it to the mill tailings pond is $20,600. To ensure sufficient funds are available, $30,000 will be included in the 1979 Highland reclamation bond calculation to cover this additional reclamation cost.

EMPLOYEE SAFETY

Access to the solution mine pilot plant and well field area is restricted and all gates are posted with appropriate warning signs. The radiation protection and safety program currently in effect for the solution mine pilot will continue in the new program. Thermoluminescent dosimeter (TLD) badges are worn by all employees normally working at the solution mine plant. During the past year, the one employee who has worked continuously in the solution mine pilot operation had a total TLD badge exposure of 0.25 rems, or 5 percent of the permissable annual exposure.

To insure that applicable radon exposure limits are not exceeded, airborne radon daughter samples are collected quarterly within any building containing uranium bearing solutions. The radon daughter concentrations are determined in accordance with the method described in "Radiation Protection in Uranium Mines" ANSI N13.8-1973 (Kunsnetz Method).

Appropriate protective guards and warning signs are used on all operating equipment. Personal protective equipment, including hard hats, safety shoes and safety glasses are required in the processing plant.

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SOLUTION MINE PILOT BACKGROUND DATA

Exxon's uranium in-situ leaching program on the Highland property in Converse County, Wyoming is conducted under the authorization of the Nuclear Regulatory Commision's Source Material License No. SUA-1064 issued November 12, 1970.

Prior to implementing the initial in-situ leaching test, extensive laboratory and field tests were conducted to insure that the area selected was suitable for solution mining and that the environment would be protected. The well pattern selected for the research and development pilot, shown on Figure 1.10, was a single injection well surrounded by six producing wells placed in a circular pattern 90 feet from the injection well. Six observation wells were drilled around the test area at a distance of 150 feet from the injection well to monitor the operation and assure that the injected solutions were maintained in the test area. All the wells were drilled, cased, and cemented with a sufficient volume of cement to insure the formation was isolated from all other sands.

The injection well and all the production wells were cored to obtain data on mineralization and the sand characteristics. The data, summarized on Table 1.1, show that the sand is very permeable and relatively uniform. Net sand thickness averaged 23 feet with an average permeabiltiy of 1088

millidarcys. Pore space averaged 29% of total sand volume. Measured permeability of the shale intervals was found to be less than 0.1 millidarcys; therefore, they are essentially impermeable when compared to the sand. A cross section of the sand and shale intervals in the pilot area is shown on Figure 1.11.

Interference tests were conducted between the center injection well and each of the six producing wells. These tests consisted of pumping fresh water into the center well and measuring the time to pressure response, duration of response, and magnitude of pressure response at individual wells within the pattern. Interpretation of these data permitted calculation of permeability-sand thickness products (Kh) for each pair of wells tested. These data were in good agreement with the values which were measured in the laboratory on cores. The tests established conclusively that fluid communication existed between wells and showed that fluids could be displaced effectively between wells.

Measurements of water levels in the pilot wells were used to determine the direction and rate of groundwater movement over a period of six months prior to initiating the solution mining pilot operation. A maximum of 0.7 feet difference in water levels was observed in wells 150 feet apart. With this observed maximum natural pressure gradient, the maximum natural flow of water within the ore zone was calculated to

be about 0.05 fe[illegible] per day or 18 feet per year. This rate of flow was not considered sufficient to interfere with the solution mining operation.

Water samples obtained from the ore zone and analyzed in the laboratory showed the water was not suitable for human consumption due to the high radioactivity. Table 1.2 sets out typical concentrations of various elements in these samples as determined by standard laboratory techniques. From these data it was concluded that the sand was reasonably homogenous, bounded on top and bottom by zones of impermeable shale, and there was very little natural movement of groundwater within the ore zone.

It was further concluded that direction and rate of fluid movement within the ore zone would be easily controlled by the pressure gradients established by the injection-production operations. The rate of fluid movement within a sandstone aquifer is a direct function of the pressure gradient between two points. In the pilot area, the maximum difference observed in fluid level elevations was 0.7 feet of water between wells 150 feet apart. By contrast, in the leaching operation, with an average pumping level at approximately 280 feet subsurface in the production wells and with a 50 PSI surface injection pressure at the injection well, the differential pressure between the two well bores would be almost 400 feet of water. Even after allowing for frictional pressure losses

in the well bores and their immediate vicinity, the pressure gradient imposed by injection and production of leach solution is many times greater than the natural pressure gradient. From this very high ratio of imposed pressure gradient to natural pressure gradient, it was concluded that fluid movement within the ore zone would be controlled by the injection-production operations.

The leaching solution through most of the early life of the pilot project was essentially in a recirculation process. The uranium-bearing solution pumped from the producing wells was collected in storage tanks at the uranium recovery facility. From storage, the uranium-bearing solution was metered into two ion exchange units connected in series for removal of uranium from the solution. Once uranium had been removed, the barren leach liquor was reconstituted to the desired concentrations of sodium carbonate, sodium bicarbonate, and oxygen, and reinjected into the ore zone for additional uranium extraction.

The uranium was eluted from the ion exchange units by a two-step elution utilizing ammonium nitrate and nitric acid solutions. The resulting eluate solution was held in a tank where the uranium was caused to precipitate by the addition of ammonia. The resulting slurry of ammonium diuranate (yellowcake) was then drawn off into drums or a tank trailer and transported to the Highland uranium mill for drying and packaging.

The groundwater cleanup plan required pumping from all seven of the wells in the pattern to pull natural groundwater through the formation, flushing the leach solution to the producing wells until the concentration of uranium in the produced solution was reduced to levels acceptable for unrestricted areas.

SUMMARY OF SOLUTION MINING PILOT OPERATION

Injection of a solution of sodium carbonate and sodium bicarbonate along with oxygen was was begun on March 1, 1972, and was terminated on November 7, 1974. During this period, a total of 274,000 barrels of solution were injected into the ore body through a single injection well. During this same period 245,000 barrels of solution were withdrawn from the six producing wells which surround the injection well. The produced solution was recycled to the injection well after the uranium had been extracted by ion exchange. Since injection of leach solution was discontinued, approximately 500,000 barrels of fluid have been withdrawn from the ore body by pumping all seven wells in the test pattern. Currently, fluid is being withdrawn from the test area at a rate of about 500 barrels per day (15 gallons per minute).

The uranium concentrate produced during the test has been transported as a slurry in covered steel drums or a tank trailer to the Highland Uranium Mill about 3,500 feet southwest of the solution mining test site.

Uranium concentrations in the produced fluid during the third quarter of 1977 averaged about 1.7×10^{-5} µCi/ml, or 0.030 grams per liter. Radium-226 and thorium-230 concentrations in the produced fluid for the same interval averaged 11.8×10^{-8} µCi/ml and 1.1×10^{-7} µCi/ml, respectively, which are essentially at baseline groundwater concentrations (12.0×10^{-8} µCi/ml and 0.86×10^{-7} µCi/ml, respectively) measured before any leaching solution was injected. Data on radium and thorium concentrations are shown in Table 1.11.

Monitoring for migration of injected leach solution beyond the injection-production pattern has been accomplished by sampling and analyzing fluids from the six observation wells which are evenly spaced on a circle of 150-feet radius around the injection well. The dissolved uranium concentration has been used as the primary indicator of the presence or absence of leach solution at the observation wells.

Detectable uranium concentrations appeared at observation wells in mid-1973 and again in mid-1974. Both times by controlling injection and production operations such that the average fluid withdrawal rate exceeded the average fluid injection rate, the leading edge of the leaching solution was drawn back toward the injection well.

Data on the uranium concentrations observed at the six observation wells are tabulated in Table 1.3. The observation wells are sequentially numbered in a clockwise direction, beginning with the northernmost observation well designated as well number 7 (Figure 1.10). As shown in Table 1.3, no detectable uranium concentrations appeared at an observation well until June 25, 1973. At that time a total of 98,000 barrels of leach solution had been injected into the ore body through the injection well and a total of 58,000 barrels of fluid had been produced from the six production wells. This arrival of detectable uranium concentrations at the observation wells was earlier than predicted. The principal reason for early arrival is that the stratification (variation in permeability at different depths) of the sandstone ore zone is greater than had been estimated. This stratification caused the leaching solution to move more rapidly in the more permeable intervals and created a "ragged" leading edge of the displacement front.

By continuing injection and production operations such that the average fluid withdrawal rate exceeded the average fluid injection rate, the leading edge of the leaching solution was forced back toward the injection well. By March of 1974, uranium concentrations at the observation wells were not detectable.

Difficulties with production well pumping equipment during the period from May, 1974 until August, 1974 restricted the fluid producing rate. During this period, because the average injection rate exceeded the average production rate, uranium-bearing fluid again appeared at some of the observation wells, but observed uranium concentrations again began dropping as the production rate was increased relative to the injection rate.

On November 7, 1974, injection of leach solution was discontinued. Pumping of the production wells and the former injection well at an average total rate of about 500 barrels per day has continued since that time. Because of the drop in the fluid pressure in the ore body in the pattern area which occurred when injection was discontinued, the low-volume airlift sampling system for the observation wells ceased to function, and samples from the observation wells had to be obtained by a thief sampler on a wire line. By June 1975, uranium concentrations at the observation wells had dropped to undetectable levels.

To overcome the difficulty in sampling the observation wells, the airlift sampling system was revamped and a large air compressor was obtained. Early in August 1975 about 30 barrels of fluid was airlifted from each of the observation wells. Since the vigorous airlift treatment, significant uranium concentrations have appeared in samples from observation wells 7 and 8. These concentrations, which are declining with time, are probably the result of the airlift treatment's temporarily pulling uranium-bearing solution back toward the two observation wells. Monitoring of the uranium concentrations at the observation wells has continued as the cleanout of leach solution progressed and this data is included in Table 1.3.

Exxon intends to continue the current program of withdrawing fluids from the test area by pumping the wells in the test pattern, causing the natural groundwater in the sandstone formation surrounding the ore body to flow through the ore body and flush the remaining leach solution to the producing wells. Production will continue until the concentration of uranium in the produced fluids and the concentration of uranium in the observation wells is below the MPC level for unrestricted areas as listed in Column 2, Table II, Appendix B, 10CFR20 and the concentrations of nonradioactive elements are down to acceptable levels. Recent carbonate and bicarbonate concentrations observed at the six observation wells are tabulated in Table 1.4. This

data shows the bicarbonate and carbonate levels in the observation wells are essentially at baseline levels.

Although data on average and maximum uranium concentrations found in the produced fluids during the operation of the pilot are considered proprietary, recent concentrations of uranium, carbonate, and bicarbonate in the fluids produced during cleanup are tabulated in Tables 1.5 and 1.6. Although the uranium concentrations in some of the wells remain at levels higher than the MPC, the 1976-1977 data (Figures 1.12 through 1.15) show definite decline trends. The carbonate and bicarbonate concentrations in fluids produced from the wells are currently approaching baseline levels. These data indicate that carbonate and bicarbonate concentrations will be down to near-baseline levels by the time the uranium concentrations are below MPC for unrestricted areas.

Since all uranium-bearing materials handled in the solution mine pilot plant were in the form of either solutions or slurries in liquids, airborne uranium concentrations in work areas were very low. As shown in Table 1.7, airborne uranium concentrations in the solution mine pilot buildings where individuals work have consistently been well below the applicable MPC. Radon daughter concentrations have, on occasion,

exceeded MPC in the pump building; however, the potential exposure of individuals to radon daughters is limited by the very short duration of work periods in the pump building. In addition, a forced-draft ventilation system has been installed in the pump building to reduce further the airborne radon daughter concentrations.

The only heavy metals other than uranium expected to be present in sufficient concentrations to be of concern in regard to water quality were arsenic and selenium. The produced fluids have been monitored for arsenic and selenium over the past two years and this data is tabulated in Table 1.8.

To confirm that other undesirable materials were not being mobilized in significant quantities, samples from pilot wells in varying stages of cleanup were taken and analyzed for elements included in the Wyoming Department of Environmental Quality's Guideline No. 4 for livestock water impoundments. The results of the analyses, summarized in Table 1.9, indicate that none of the materials, other than arsenic and selenium, are mobilized to the extent that would cause concern relative to groundwater quality.

Although no wells within the pattern area were completed in the aquifers above or below the ore zone for the purpose of monitoring the aquifers, the potable water well for the solution

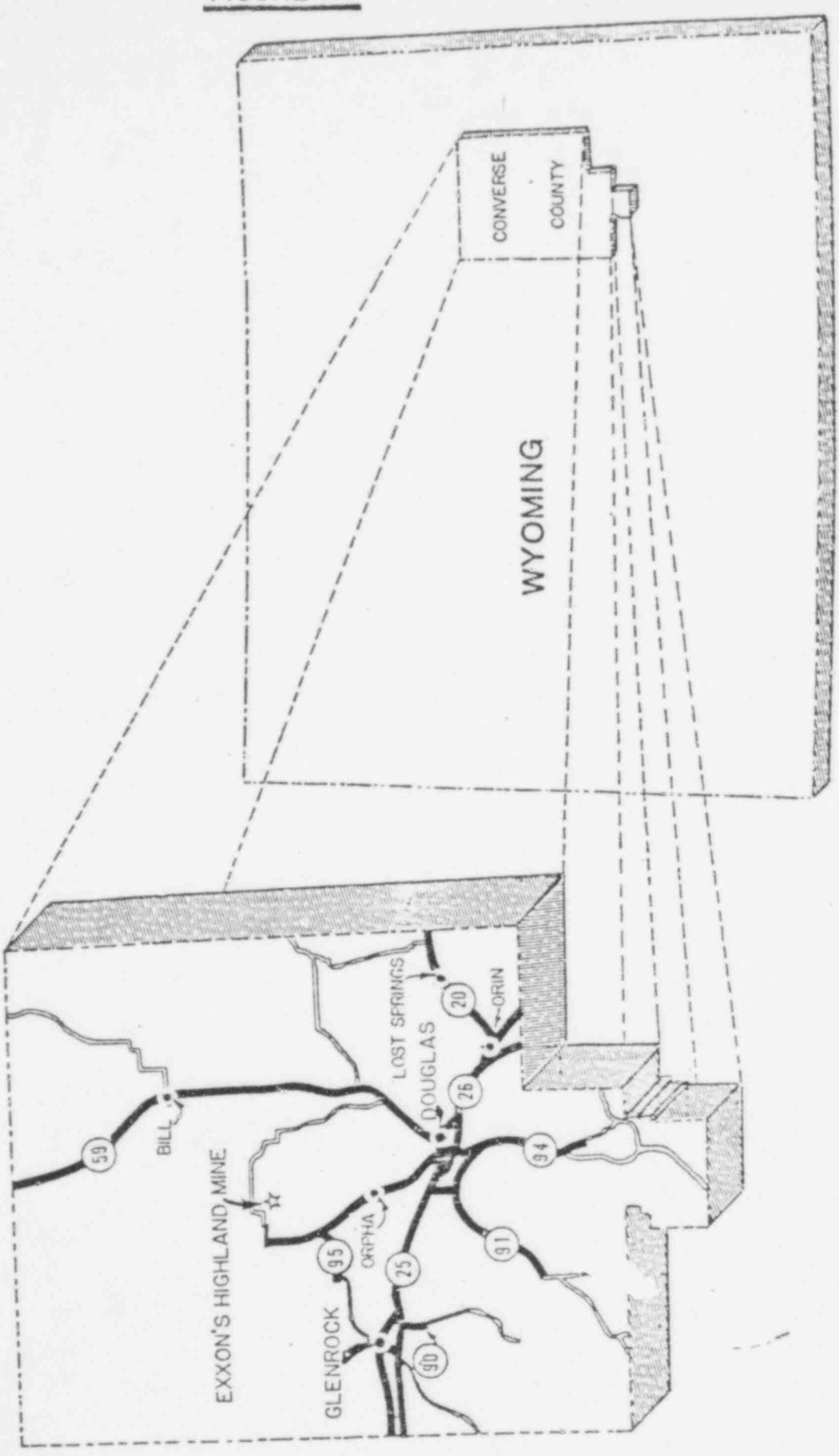
029

mine pilot, completed in the aquifer above the ore zone, was located only about 200 feet northeast of the pilot injection well. This well was analyzed quarterly to determine suitability of water from it for human consumption. In the results of this monitoring program, summarized in Table 1.10, no communication with the aquifer above the ore zone is indicated.

From these data and our five years experience with the solution mine pilot operation, we have concluded that solution mining operations can be conducted in the Highland area with no significant long-term adverse effect on the groundwater or the environment. It is further concluded that this can be insured by adequate monitoring of injection and production rates and through the use of observation wells around the solution mining area and monitor wells in the aquifer above and below the ore zone.

FIGURE 1.1

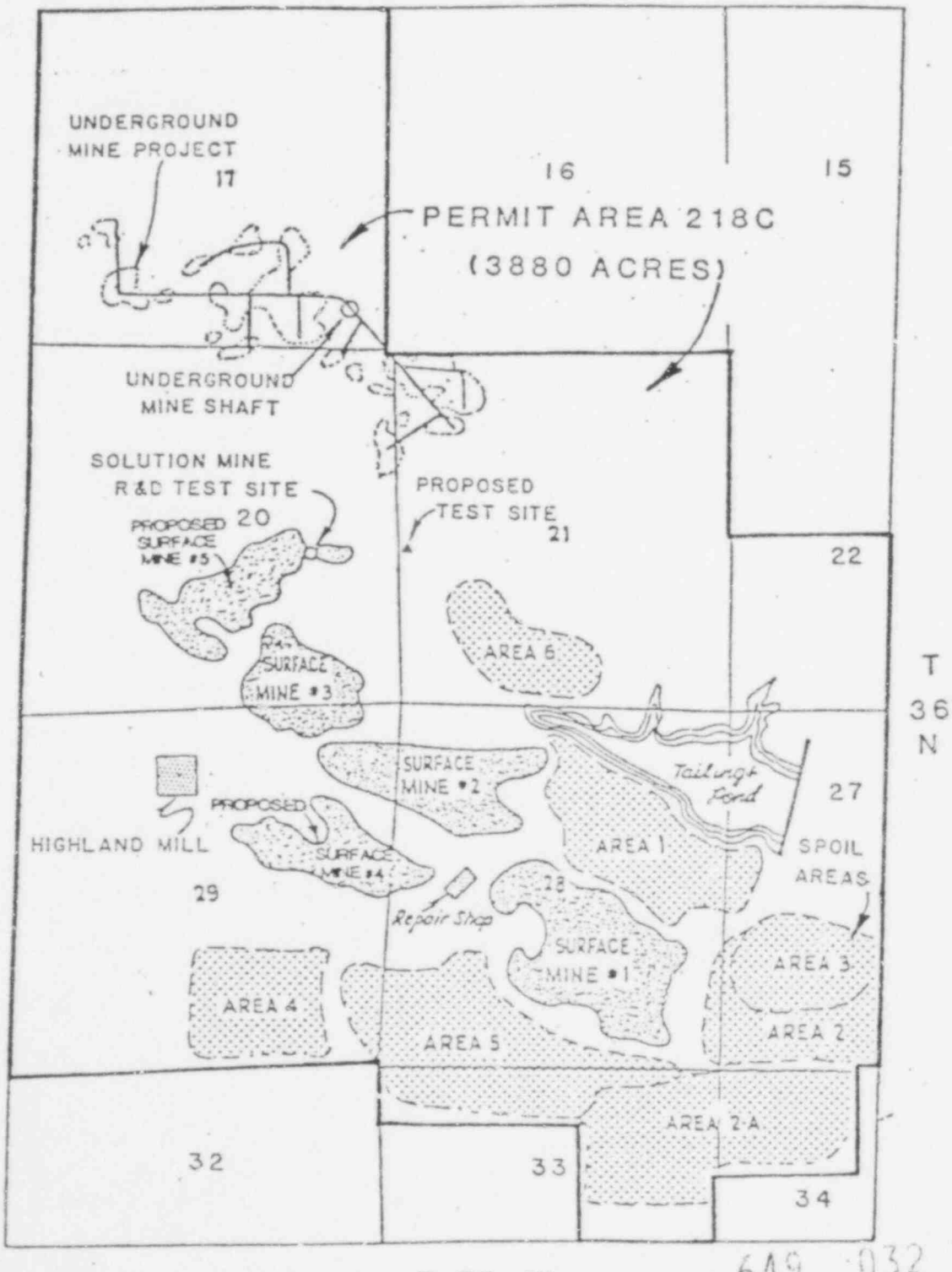
CONVERSE COUNTY, WYOMING



649 031

FIGURE 1.2

EXXON MINERALS CO., U.S.A.
HIGHLAND OPERATIONS
CONVERSE COUNTY, WYOMING

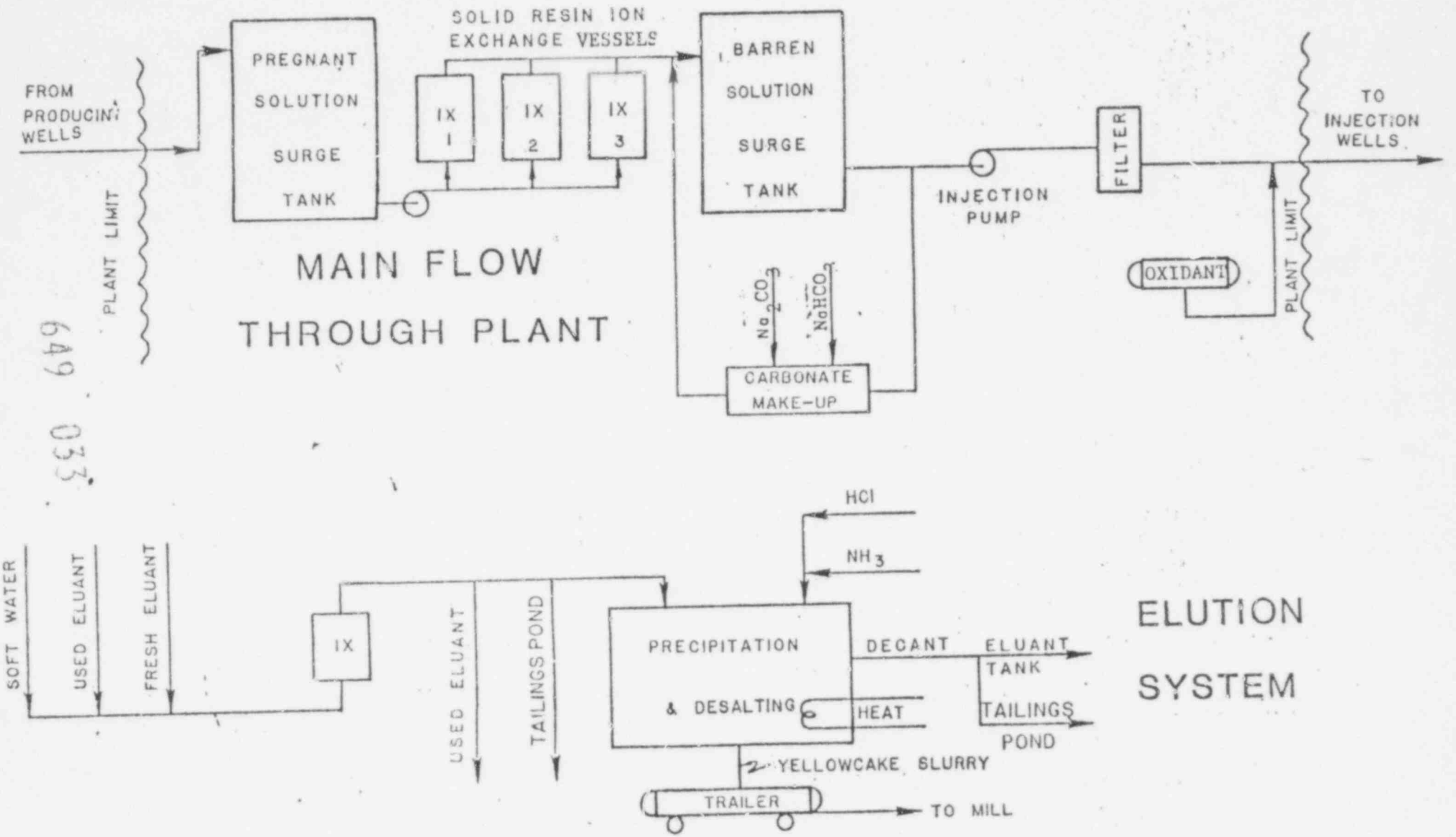


649 032

FIGURE 1.3

SCHEMATIC FLOW DIAGRAM

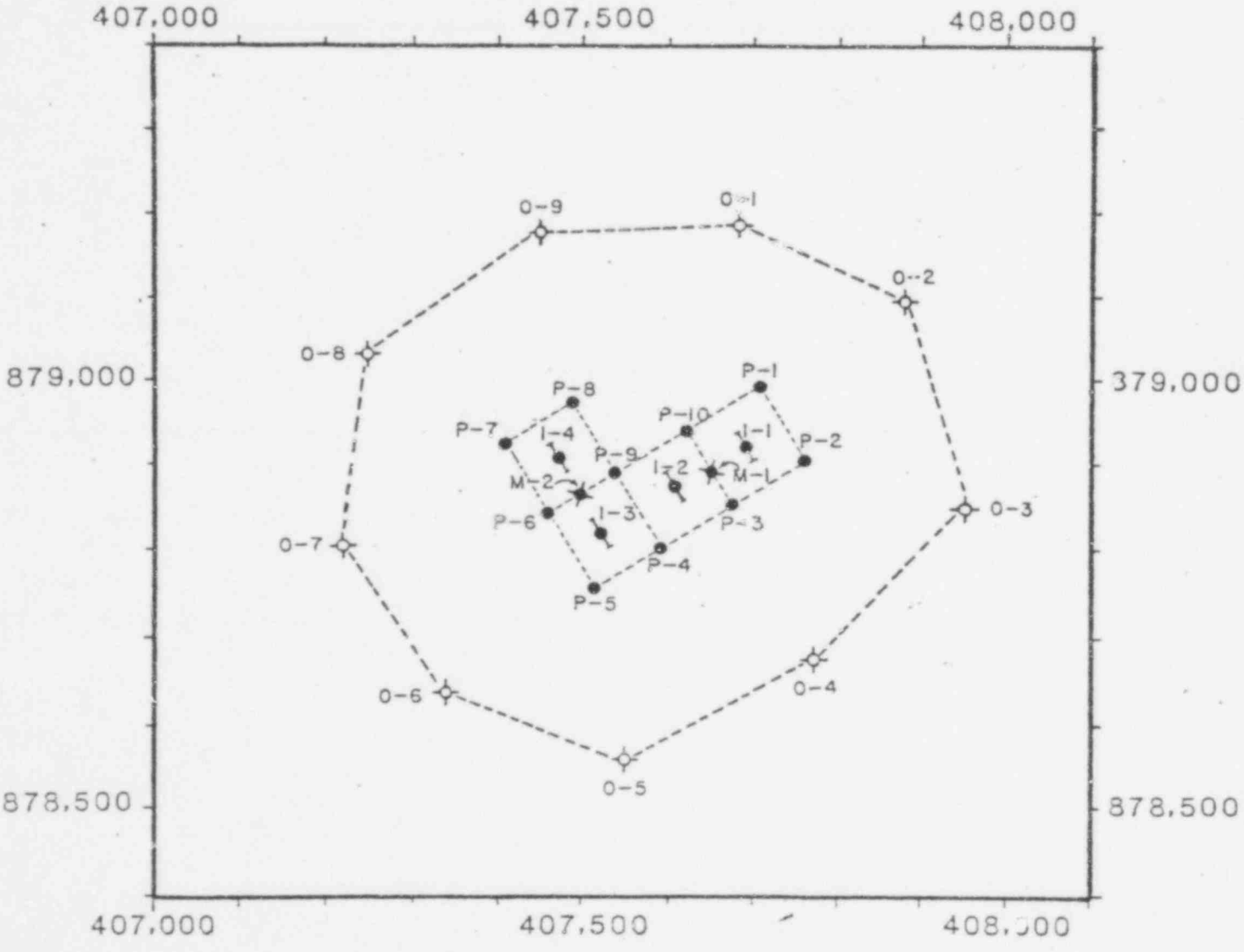
SOLUTION MINE PLANT



649 033

FIGURE 1.4

SOLUTION MINE WELL PATTERN
HIGHLAND R&D PROGRAM
CONVERSE COUNTY, WYOMING



LEGEND

- PRODUCTION WELL
- INJECTION WELL
- OBSERVATION WELL
- MONITOR WELL

PROPOSED BASELINE SAMPLE WELLS

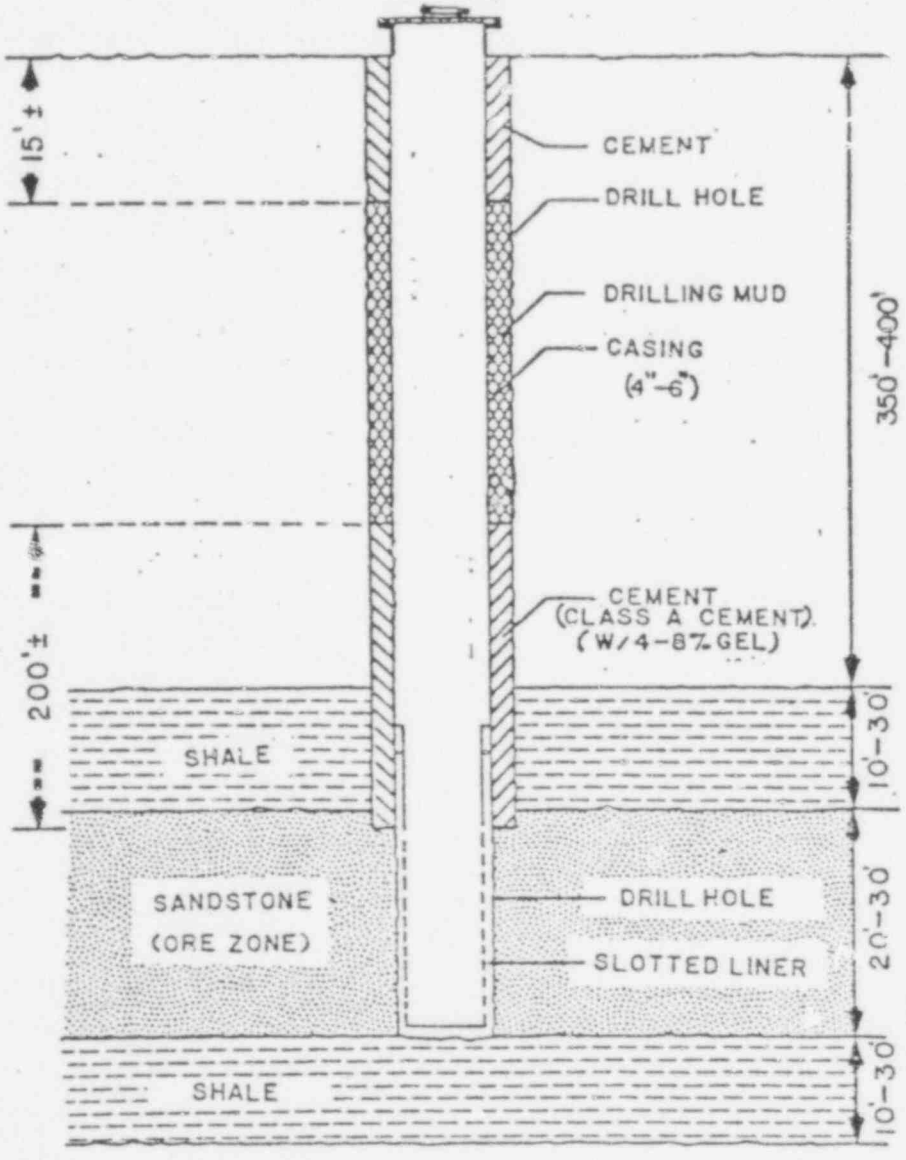
M-1	O-2
I-1	O-3
I-3	O-5
P-3	O-6
P-5	O-8
P-7	O-9
P-9	M-2

649 034

FIGURE 1.5

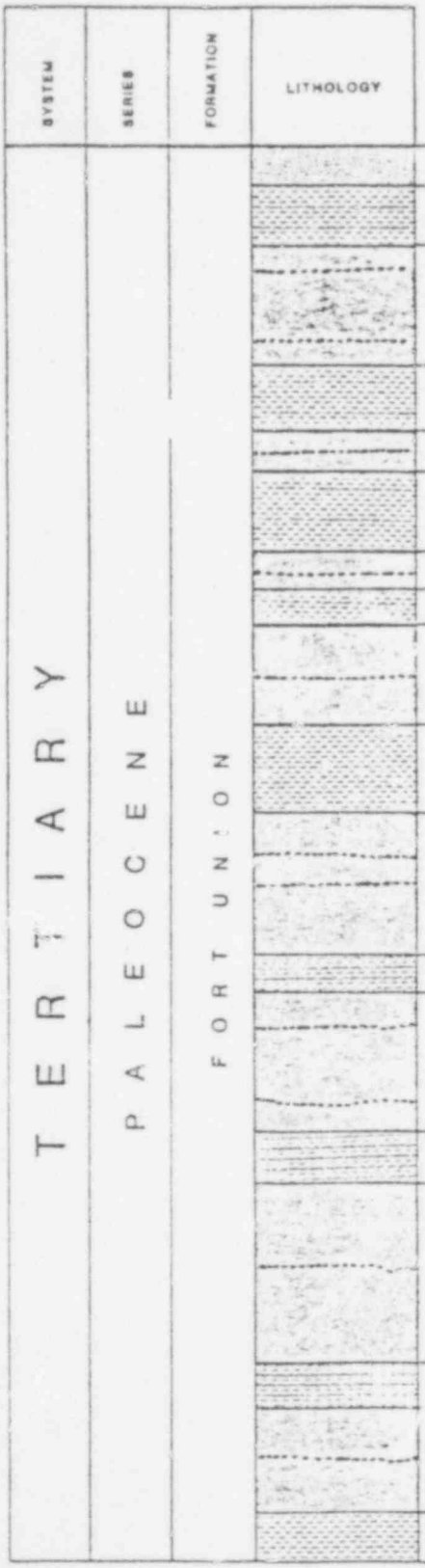
TYPICAL WELL COMPLETION

SOLUTION MINING PROGRAM



649 035

FIGURE 1.6
GENERALIZED STRATIGRAPHIC COLUMN
HIGHLAND AREA
CONVERSE COUNTY, WYOMING



Soil & Weathered Zone

Siltstone and claystone (shale): Color varies from olive orange to gray green.

Sandstone: Thickness varies from 0-35; color varies from shades of gray to yellow-olive to red; grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; scattered conglomerate and siltstone beds less than 2 feet thick; sandstone contains varying amounts of shale and siltstone clasts; beds vary from loose friable sand to well cemented (carbonate) sandstone, does not contain uranium mineralization.

Siltstone and claystone (shale): Generally gray green, may contain thin interbedded sandstone and lignite beds; thickness varies from locality to locality.

Sandstone: Same as above.

Siltstone and claystone (shale): Generally gray green; may contain thin interbedded sandstone and lignitic beds thickness varies from locality to locality.

Sandstone: Same as above.

Siltstone and claystone (shale): Same as above.

Sandstone: Thickness varies from 0-50 feet; color varies from shades of gray to yellow-olive to red; grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; scattered conglomerate and siltstone beds less than 2 feet thick; sandstone contains varying amounts of shale and siltstone clasts; beds vary from loose friable sand to well cemented (carbonate) sandstone, [illegible] uranium in highland area.

Siltstone and claystone (tailings dam shale): Thickness varies from 5-40 feet thick; generally gray green with thin beds of sandstone.

Sandstone (upper highland sandstone): Thickness ranges from 0-50 feet; color varies from shades of gray to yellow-olive to red; grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; scattered conglomerate and siltstone beds less than 2 feet thick; sandstone contains varying amounts of shale and siltstone clasts; beds vary from loose friable sand to well cemented (carbonate) sandstone; no economic uranium in solution mine area.

Siltstone & claystone: Thickness varies from 5-30 feet; generally gray green.

Sandstone (middle highland sandstone): Thickness varies from 0-50 feet thick; color varies from shades of gray to yellow-olive to red; grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; scattered conglomerate and siltstone beds less than 2 feet thick; sandstone contains varying amounts of shale and siltstone clasts; beds vary from loose friable sand to well cemented (carbonate) sandstone; major ore bearing unit in highland area.

Siltstone and claystone: Thickness varies from 0-50 feet; generally gray green; may contain interbedded sandstone units.

Sandstone (lower highland sandstone): Thickness varies from 0-50 feet thick; color varies from shades of gray to yellow-olive to red; grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; scattered conglomerate and siltstone beds less than 2 feet thick; sandstone contains varying amounts of shale and siltstone clasts; beds vary from loose friable sand to well cemented (carbonate) sandstone; major ore bearing unit in highland area.

Siltstone and claystone: Thickness varies from 5-80 feet; color generally gray green.

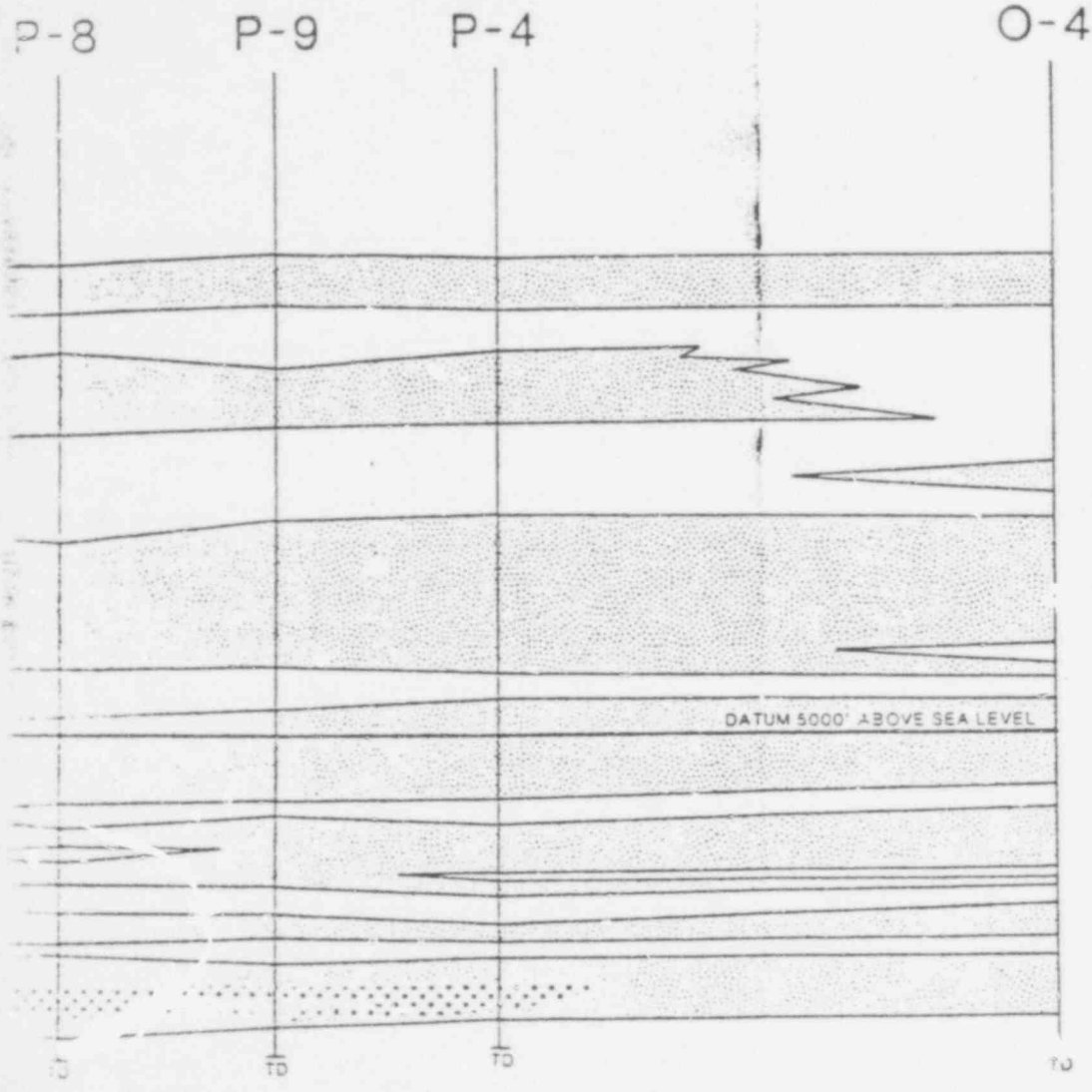
Sandstone: Thickness varies from 0-60 feet; color varies from shades of gray to yellow-olive to red; grain size varies from medium-grained sand to gravel, most commonly medium to very coarse-grained sand; scattered conglomerate and siltstone beds less than 2 feet thick; sandstone contains varying amounts of shale and siltstone clasts; beds vary from loose friable sand to well cemented (carbonate) sandstone; does not contain economic amounts of uranium in highland area.

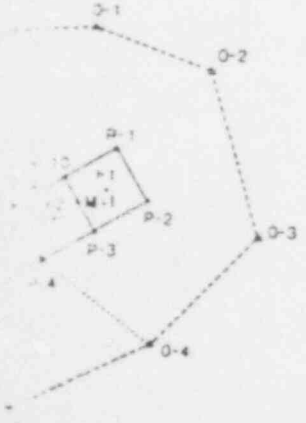
Siltstone & claystone (shale): Same as above.

NOTE: The stratigraphic section above and names varies in thickness relative to the elevation of the surface. As the surface elevation rises, the thickness of the sequence of beds increases. The lithological units are similar to those described in this columnar section, however, the number of units and their thickness will vary from locality to locality.

FIGURE 1.7

SE





EXXON MINERALS COMPANY, U.S.A.

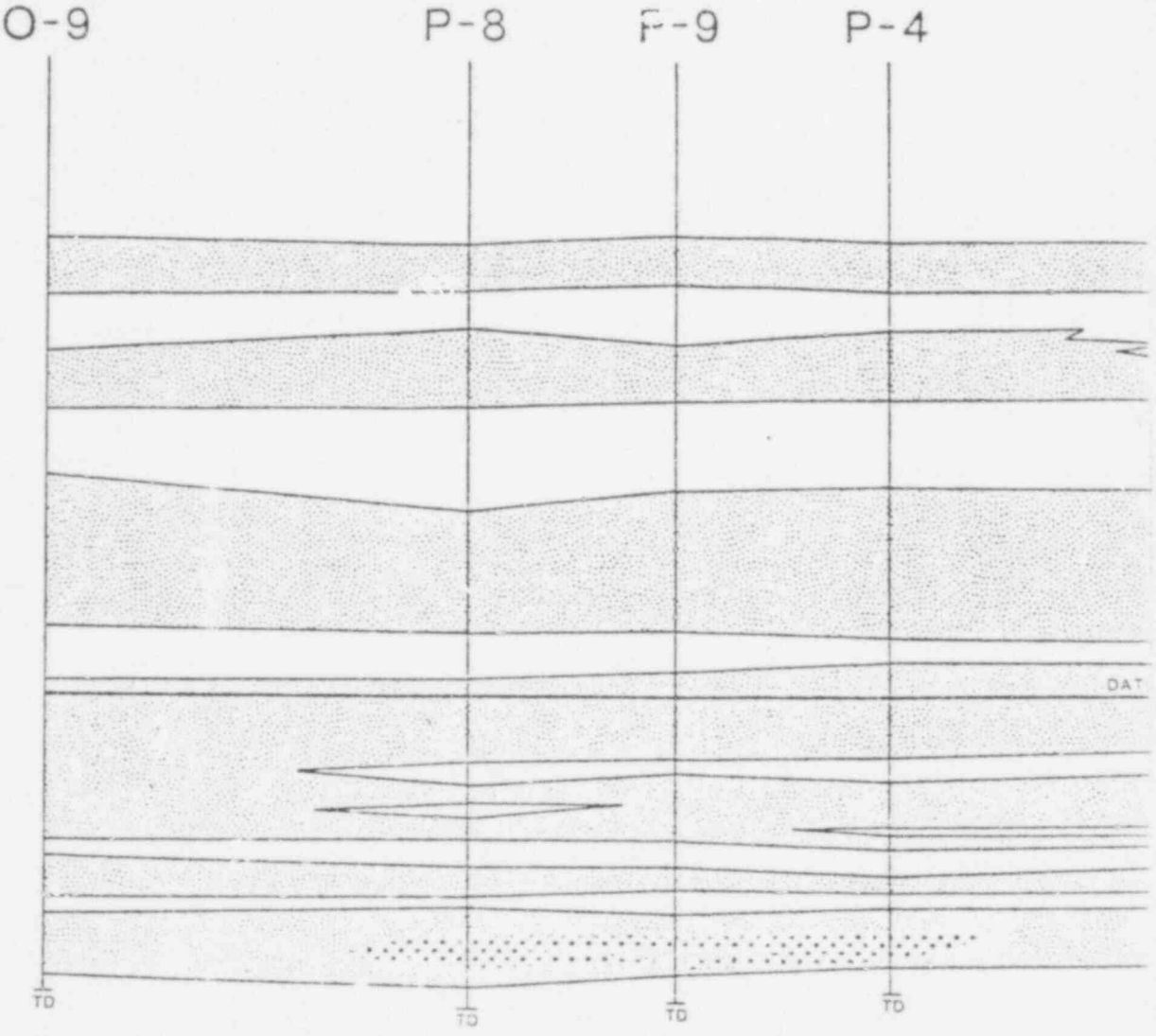
X-SECTION NW-SE

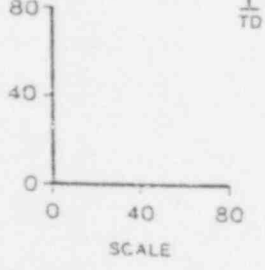
PROPOSED SOLUTION MINE R&D AREA

CONVERSE COUNTY, WYOMING

649 037

NW



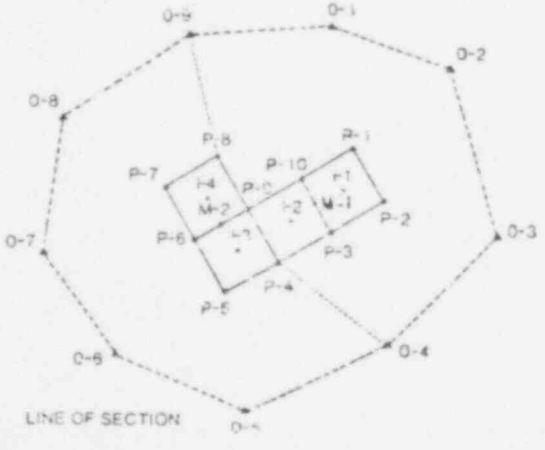


LEGEND

SANDSTONE

SHALE

URANIUM ORE



EXXON MINERA

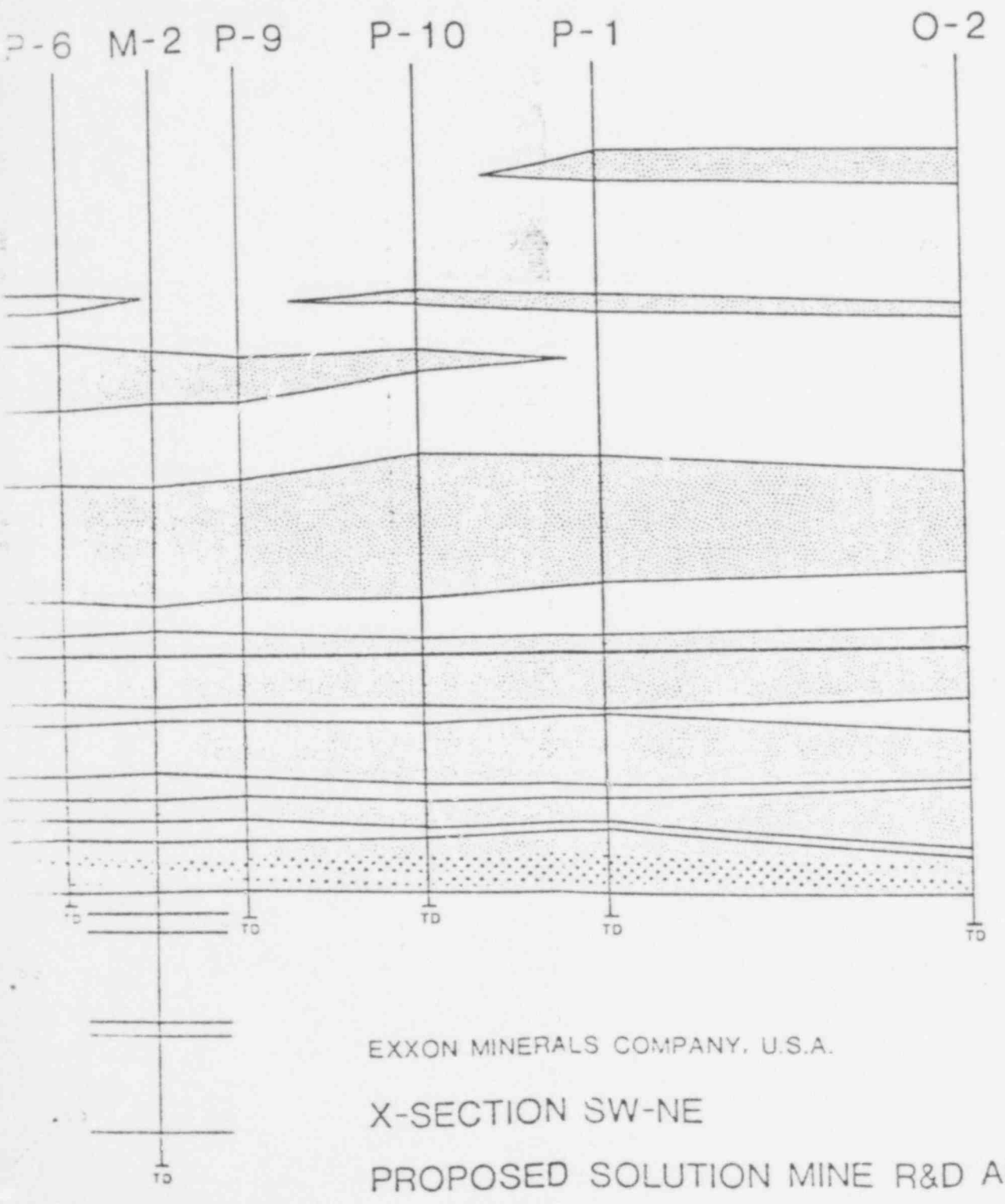
X-SECTION

PROPOSED

CONVERSE CO

649 038

FIGURE 1.8



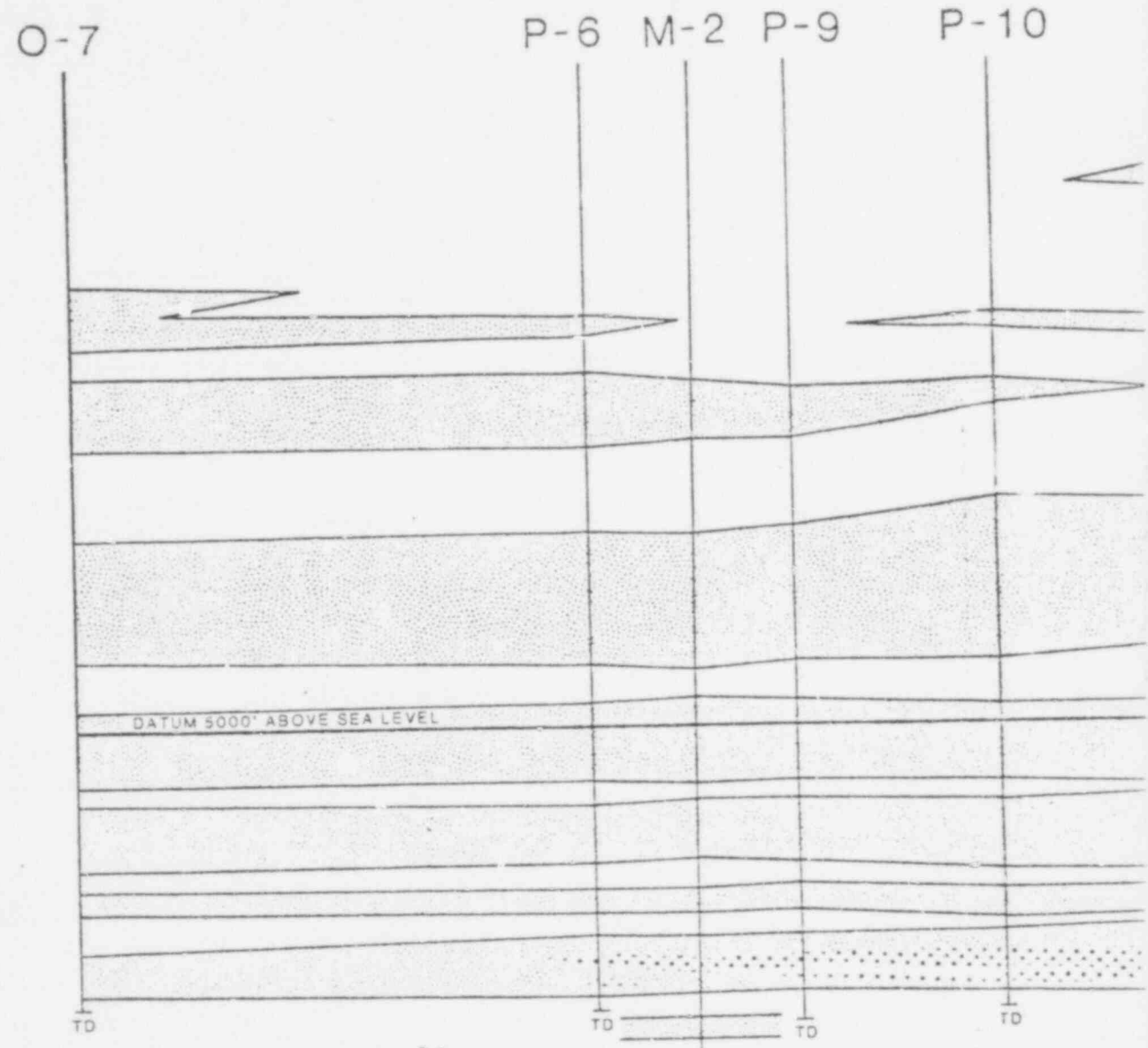
EXXON MINERALS COMPANY, U.S.A.

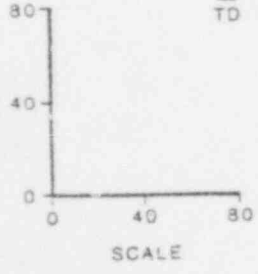
X-SECTION SW-NE

PROPOSED SOLUTION MINE R&D AREA

CONVERSE COUNTY, WYOMING

SW



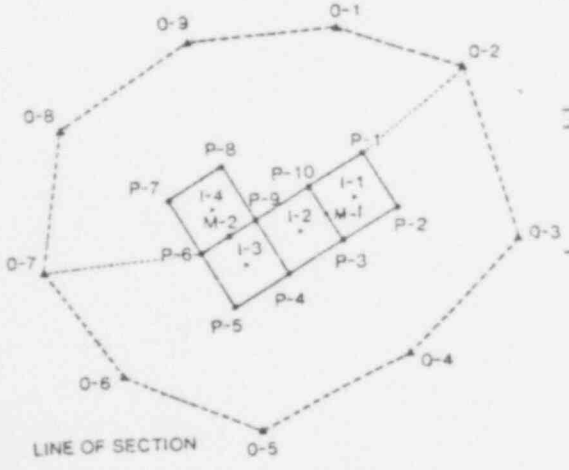


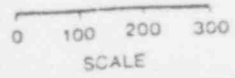
LEGEND

SANDSTONE

SHALE

URANIUM ORE





EXXON MINER

X-SECTIO

PROPOSE

CONVERSE C

649 040

FIGURE 1.9

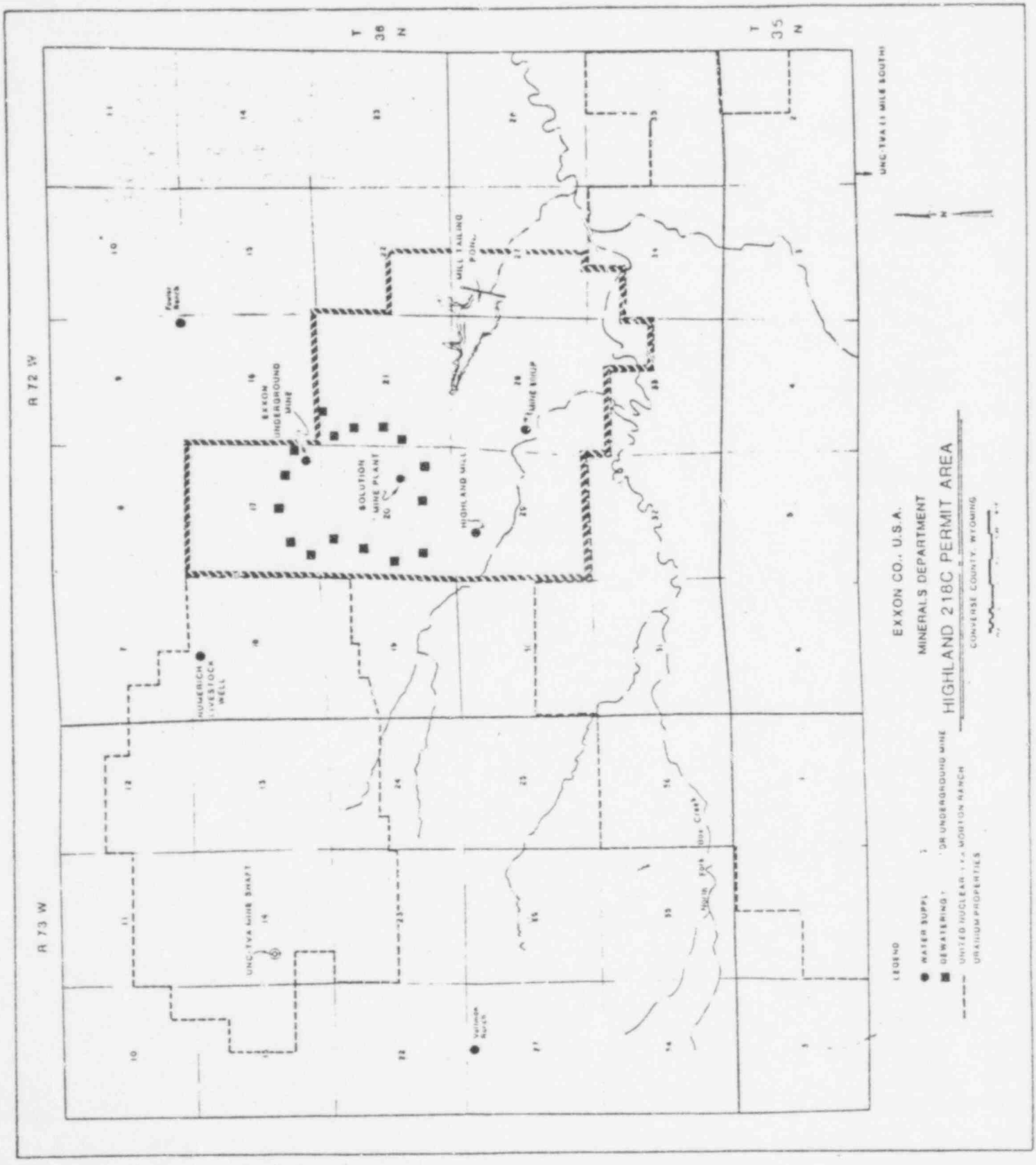
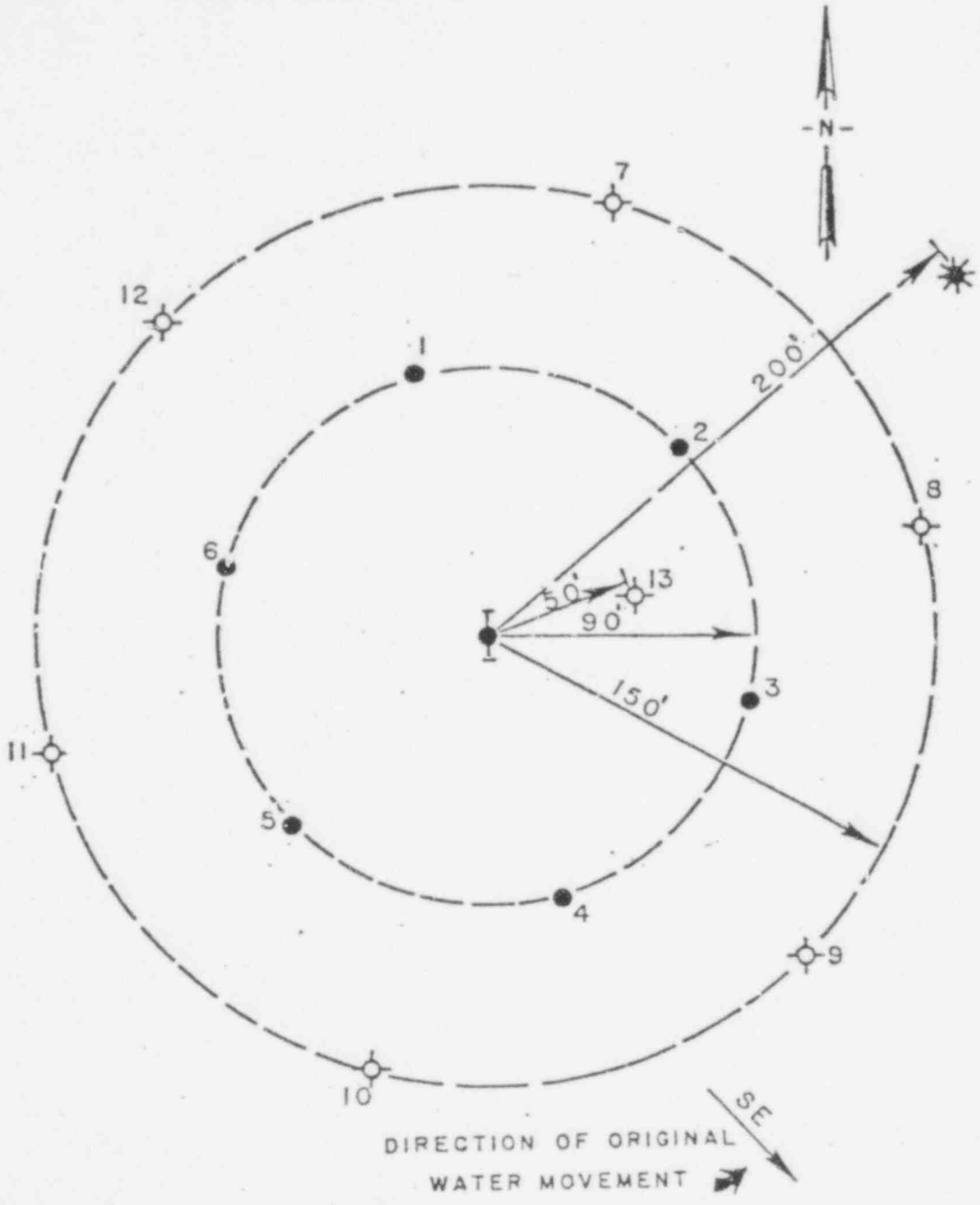


FIGURE 1.10

WELL PATTERN

SOLUTION MINING PILOT



INJECTOR

PRODUCER

OBSERVATION WELL

POTABLE WATER WELL (COMPLETED IN AQUIFER ABOVE THE ORE ZONE)

649 342

CROSS-SECTION THROUGH PILOT AREA

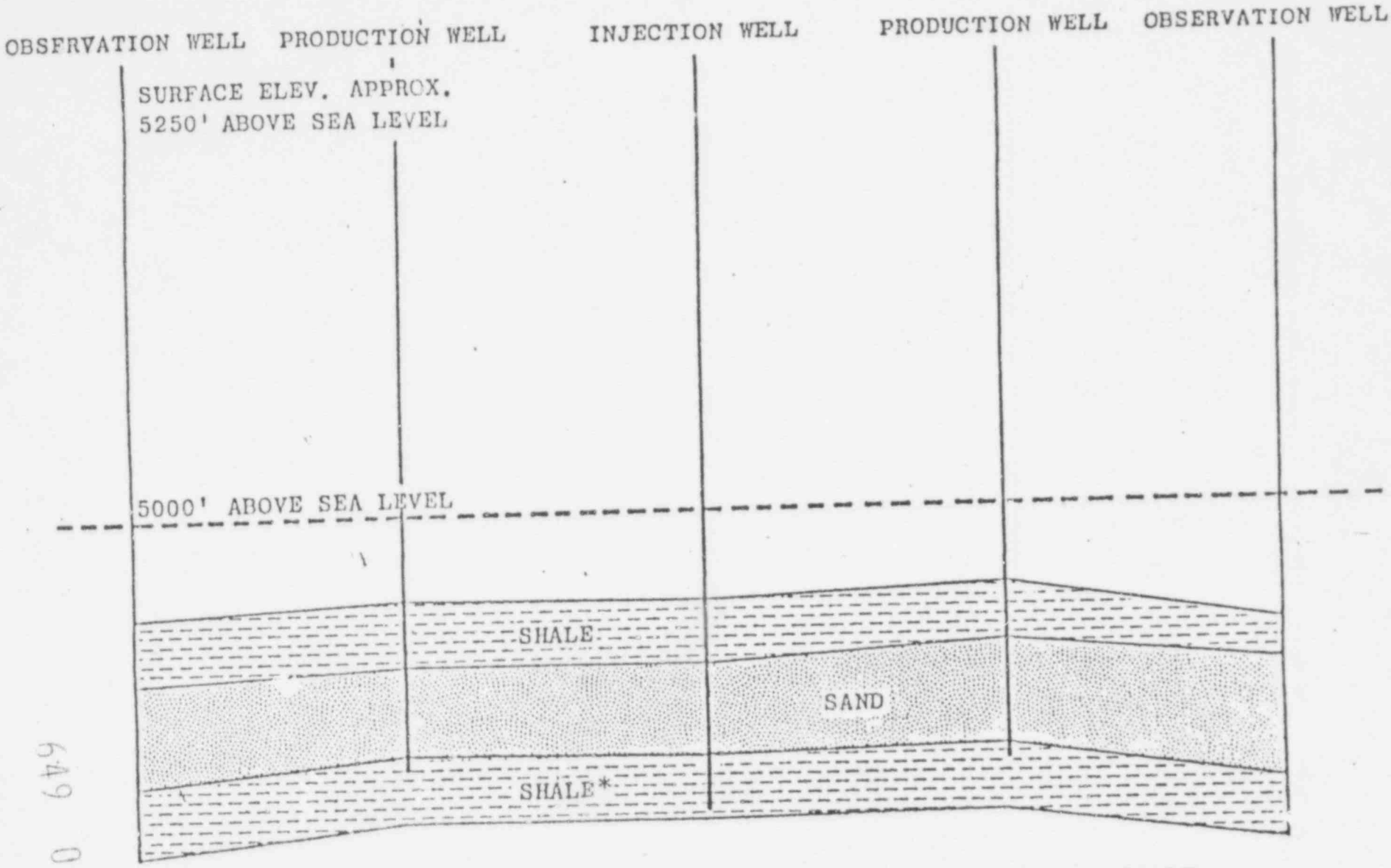


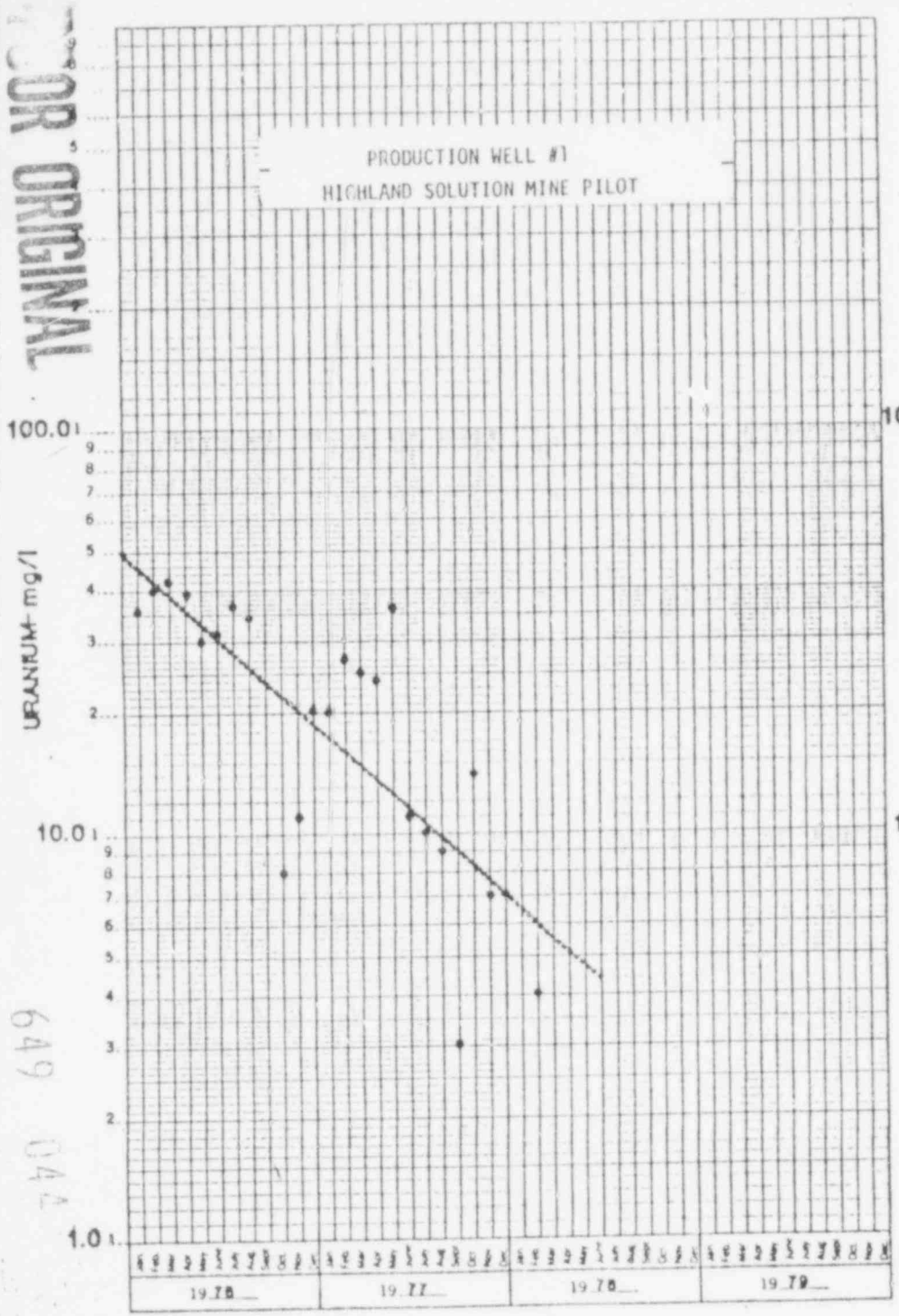
FIGURE 1.11

649 043

* ADDITIONAL THICKNESS CONTROL FROM 4 ABANDONED EXPLORATION HOLES.

SCALE
Horiz. 1"=40'
Vert. 1"=40'

FIGURE 1.12



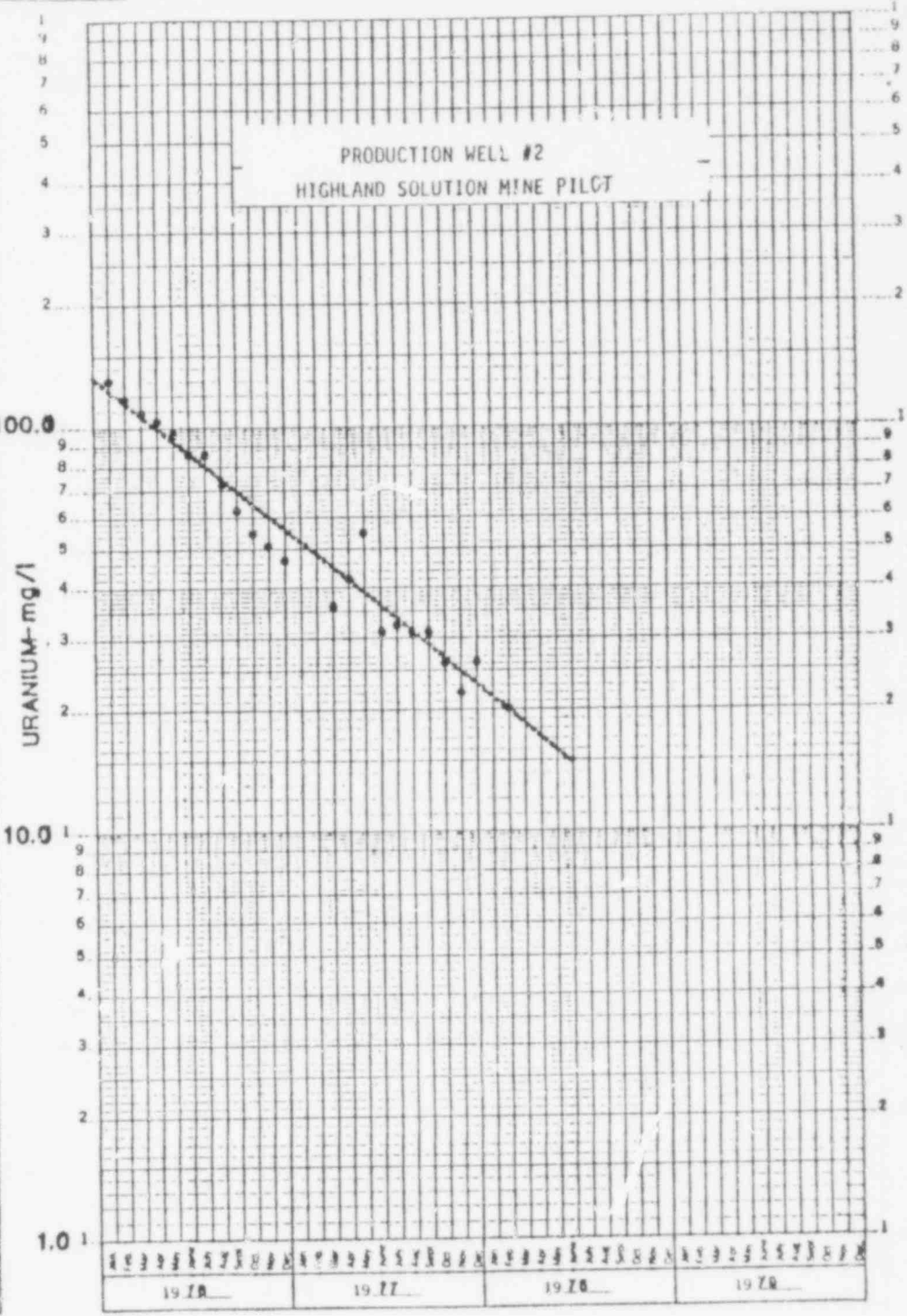
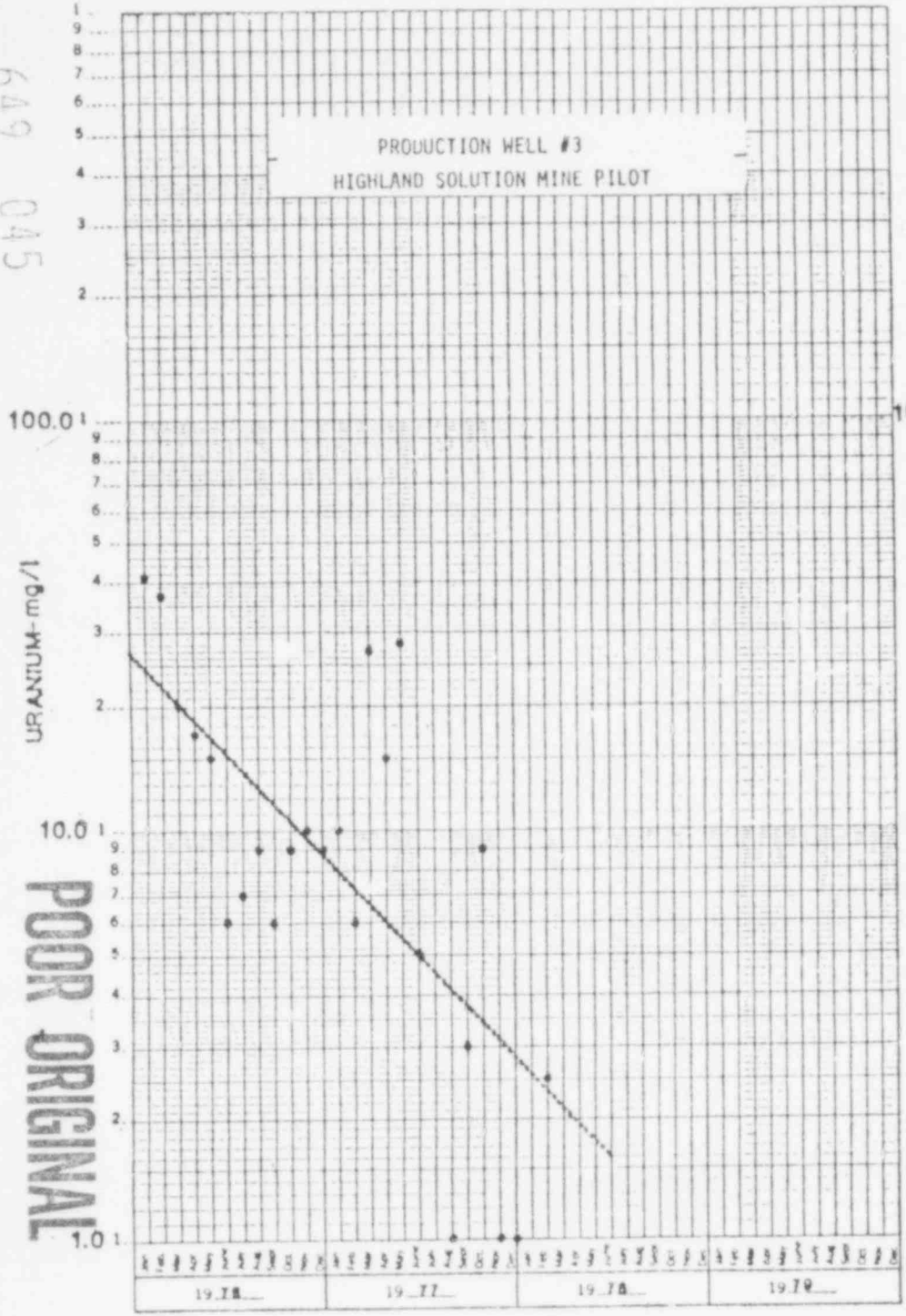
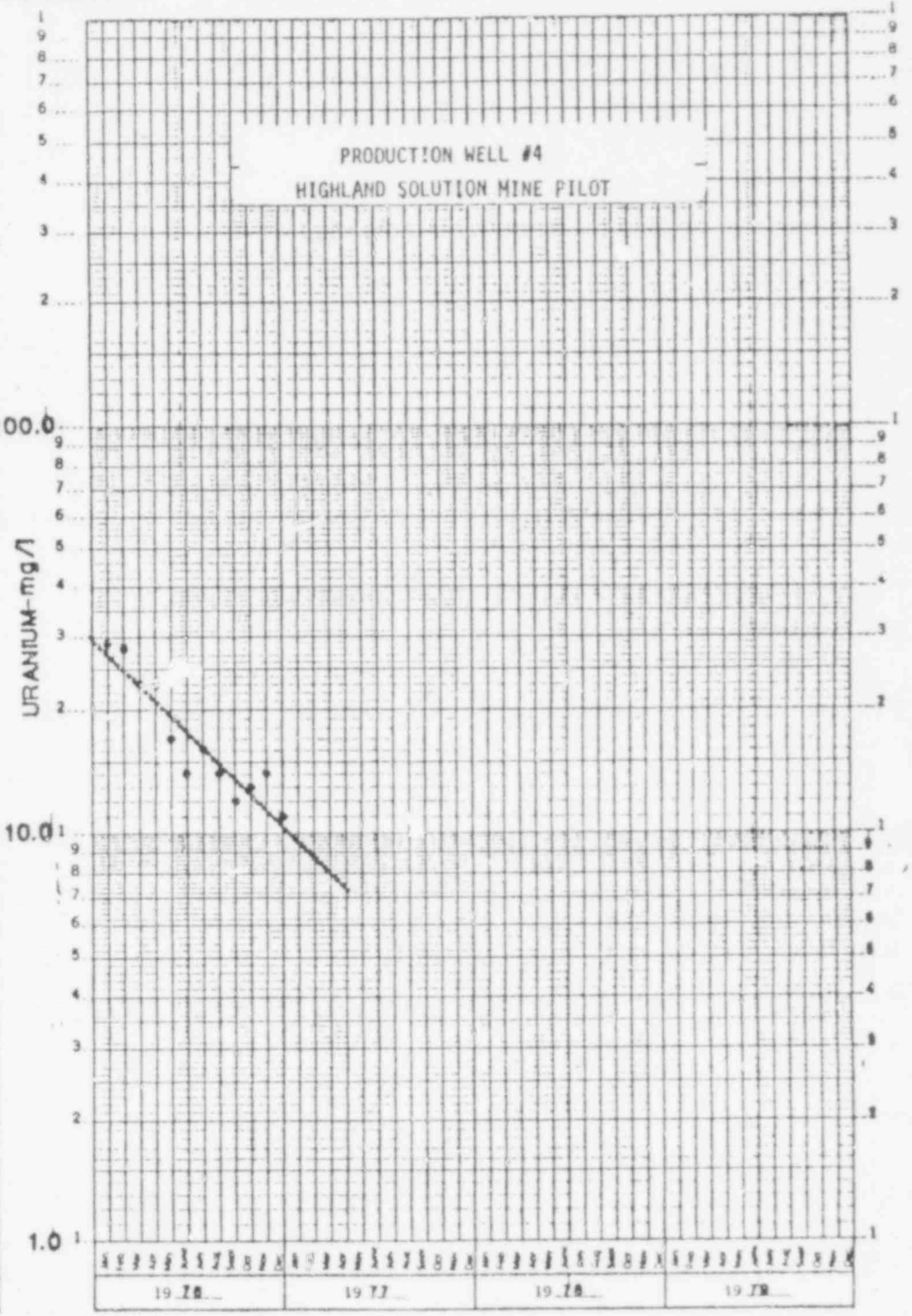
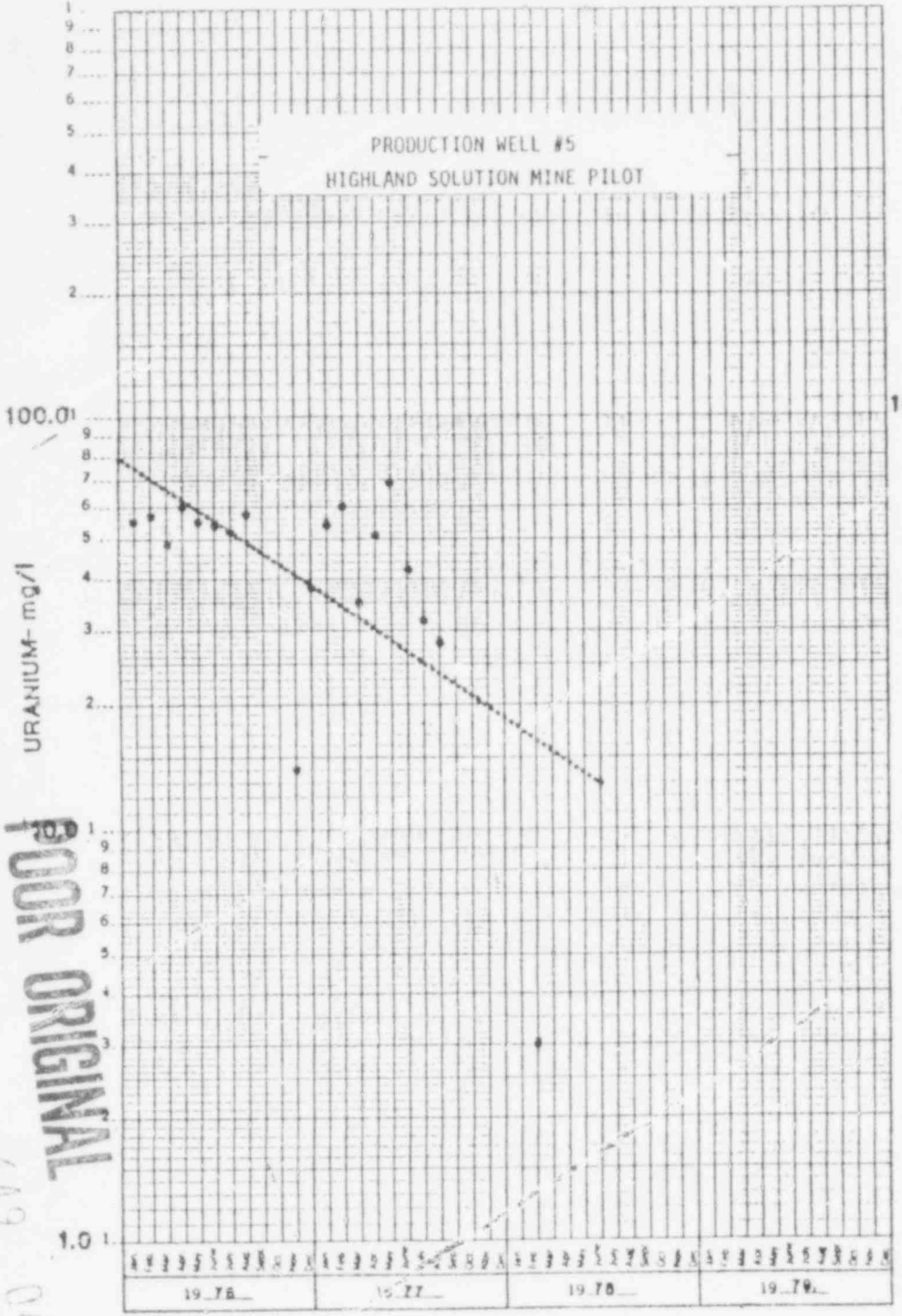


FIGURE 1.13





649 045



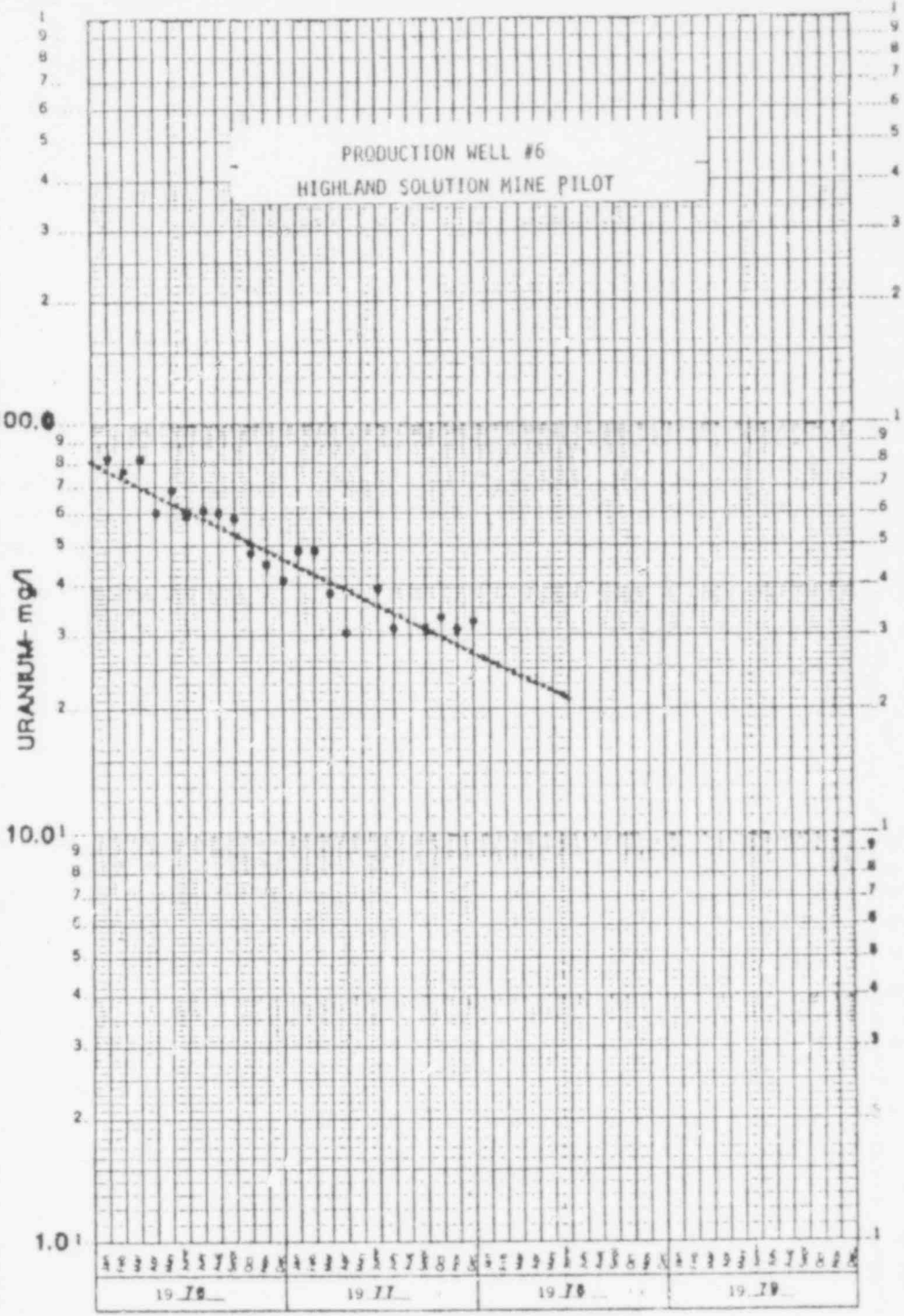
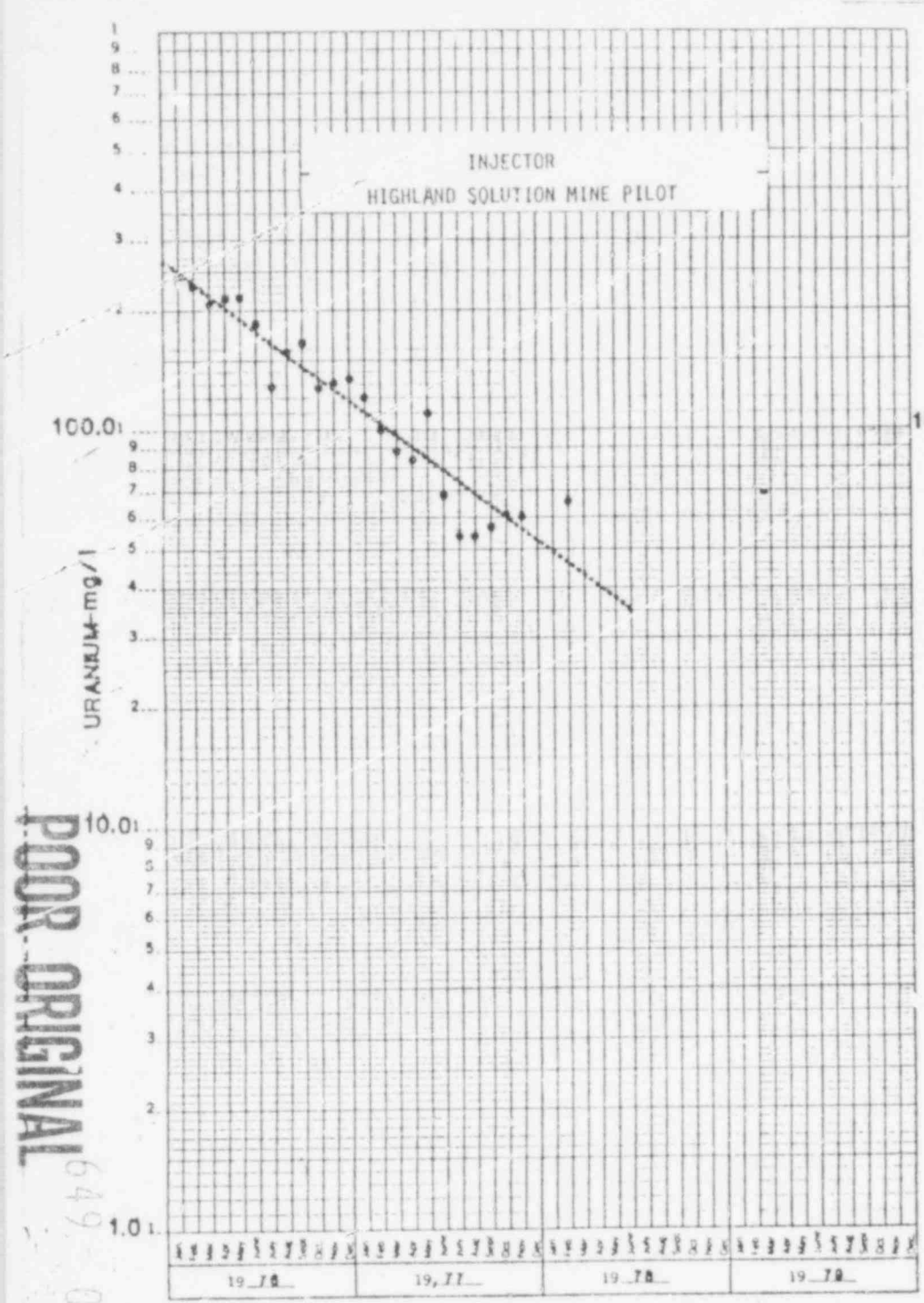


FIGURE 1.15



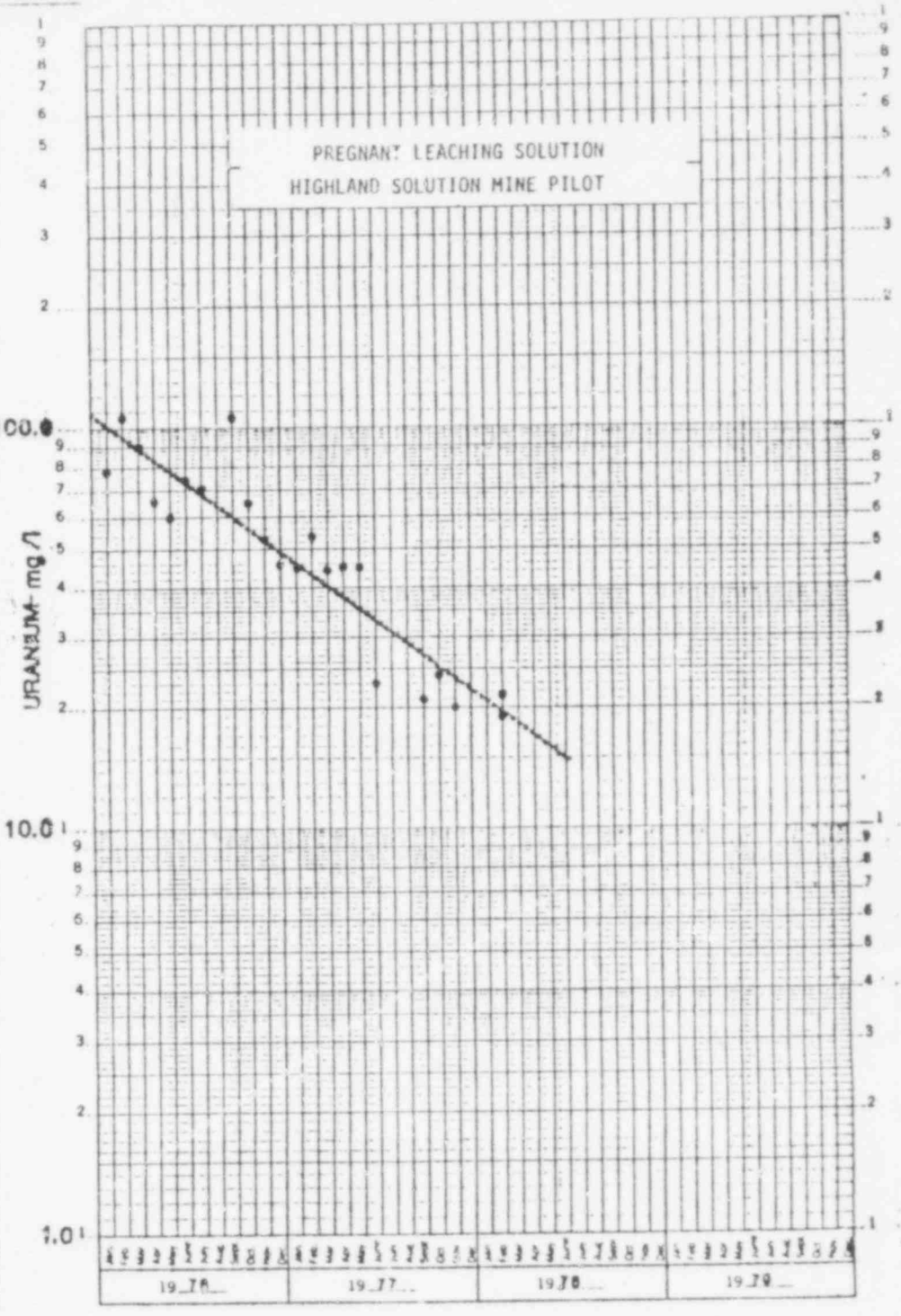
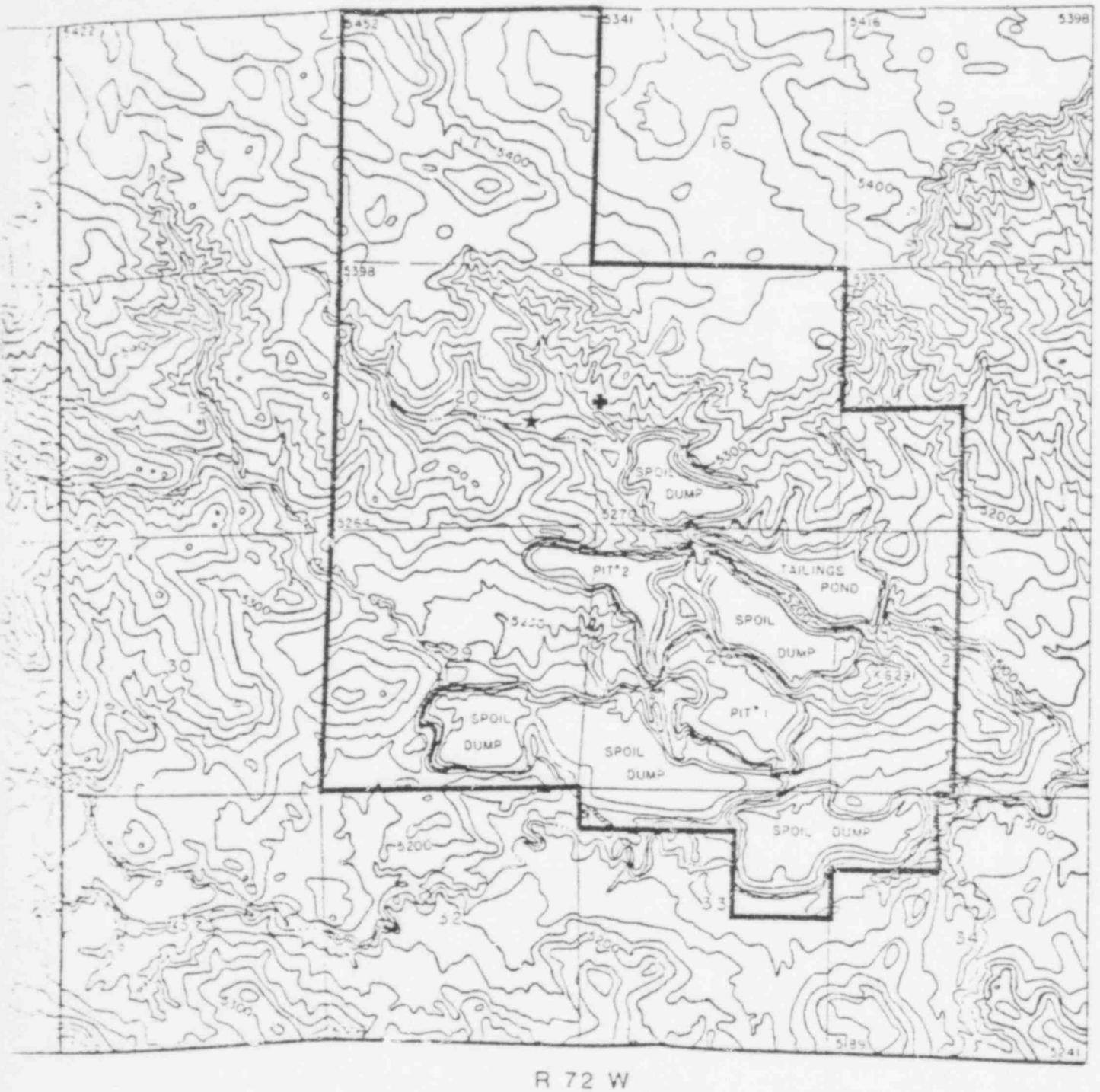


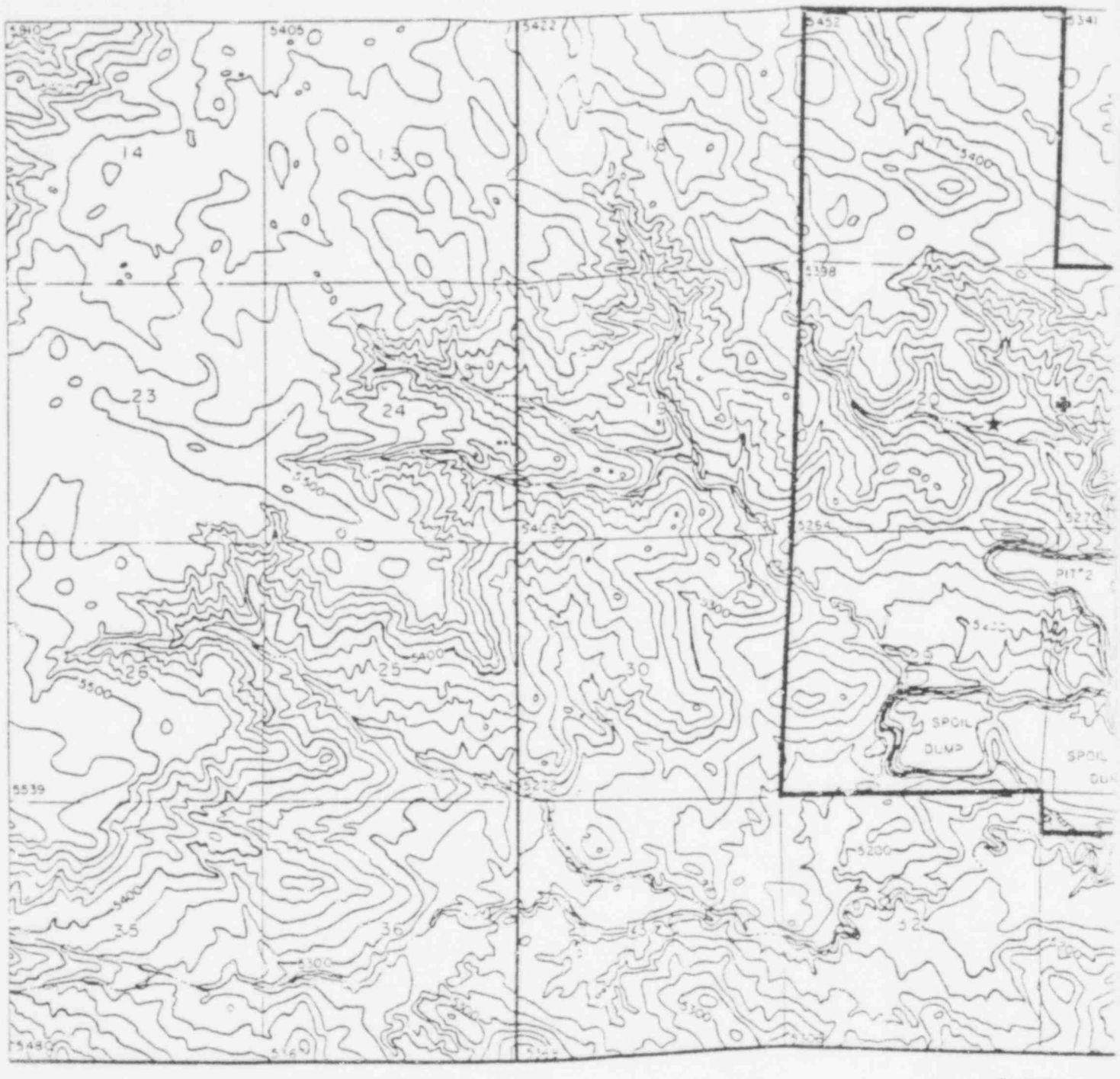
FIGURE 1.16



EXXON MINERALS CO., U.S.A.

HIGHLAND 218C PERMIT AREA

CONVERSE COUNTY, WYOMING



★ ORIGINAL PILOT

◆ PROPOSED TEST SITE

EXXON MINERALS CO., U.S.A.

HIGHLAND 218C PERMIT AREA

CONVERSE COUNTY, WYOMING

4000 0 1000 2000 3000 4000

TABLE 1.1

CORE ANALYSIS DATA

SOLUTION MINE PILOT

Well No.	Net Sand Thickness (Ft.)	Average Permeability To Water (md)	Porosity %
Injection	23	1234	28
1	22	1029	30
2	23	812	-
3	31	1362	30
4	25	805	-
5	15	1005	29
6	24	1269	-
Avg.	23	1038	29

TABLE 1.2

ORE ZONE WATER SAMPLE 'NALYSIS*

HIGHLAND SOLUTION MINE PILOT

Sodium	161 ppm
Calcium	77 ppm
Magnesium	13 ppm
Chloride	27 ppm
Sulfate	119 ppm
Bicarbonate	237 ppm
Selenium	<0.5 ppm
Uranium	212 ppb
Radium-226	1.2×10^{-7} uCi/ml
Thorium-230	8.6×10^{-8} uCi/ml

*Average of 3 samples taken from 3 production wells in original pilot area during May, 1970.

TABLE 1.3

URANIUM CONCENTRATIONS AT OBSERVATION WELLS

SOLUTION MINE PILOT

	Net* Production-1000 Bbls		Observed Uranium Concentration Milligrams per Liter by Well					
			#7	#8	#9	#10	#11	#12
02/02/73	-36		0	0	0	0	0	0
06/25/73	-40		23	0	7	0	0	0
07/05/73	-40		71	1	1	2	2	1
07/26/73	-34		101	0	36	0	0	0
08/02/73	-38		99	0	30	0	0	0
08/25/73	-36		71	0	19	0	0	0
09/04/73	-35		68	0	19	0	0	0
09/27/73	-34		78	0	15	0	0	0
10/10/73	-34		72	0	14	0	0	0
10/22/73	-34		79	3	10	0	0	0
11/10/73	-34		67	3	8	0	0	0
11/21/73	-33		54	0	10	0	0	0
02/15/74	-30		10	20	-	0	0	0
03/27/74	-31		2	0	-	0	-	0
05/13/74	-35		1	0	3	0	0	0
05/20/74	-35		92	1	4	2	1	2
05/31/74	-35		75	2	14	3	2	6
06/15/74	-35		84	0	3	0	0	3
07/04/74	-36		82	0	4	0	0	3
08/03/74	-36		74	0	2	0	1	2
09/16/74	-31		64	0	1	0	2	3
10/15/74	-29		57	0	2	0	-	2
10/28/74	-28		40	1	12	2	3	-
04/02/75	27		0	0	0	0	-	-
05/23/75	53		60	60	2	1	0	3
06/12/75	61		0	0	0	0	0	0
07/01/75	69		0	0	0	0	0	0
08/10/75	85		-	42	2	-	-	-
08/27/75	94	(See Note)	2	56	2	10	3	3
09/21/75	108		174	49	1	8	2	1
10/03/75	113		275	47	0	13	2	2
10/07/75	115		313	44	3	12	5	6
10/10/75	116		226	-	-	-	-	-
10/18/75	120		271	49	0	14	2	2
10/22/75	122		287	51	0	13	3	3
10/27/75	124		167	49	0	10	2	0
10/30/75	126		202	52	1	13	3	2
11/03/75	128		262	52	1	12	2	8
11/07/75	130		158	48	0	11	3	1
11/11/75	131		230	53	0	64	7	5
11/15/75	133		265	57	1	12	3	3
11/20/75	135		168	48	1	7	3	1
11/26/75	138		237	49	1	16	2	1
12/01/75	140		206	47	1	12	2	1
12/07/75	143		172	45	1	12	3	2
12/12/75	146		218	51	0	14	3	2
12/18/75	149		192	49	0	11	3	2
12/26/75	153		193	44	0	13	2	2

649 052

TABLE 1.3
(continued)

	Net*Production-1000 Bbls	Observed Uranium Concentration Milligrams per Liter by Well					
		#7	#8	#9	#10	#11	#12
01/04/76	156	176	45	0	9	-	-
01/15/76	162	168	43	0	13	-	-
01/24/76	170	128	42	0	12	-	-
02/09/76	172	124	43	0	10	2	-
02/22/76	177	116	24	0	10	2	-
03/01/76	180	94	-	-	-	-	-
03/04/76	181	88	-	-	-	-	-
03/16/76	186	77	-	-	-	-	-
03/19/76	188	74	26	0	9	-	1
03/24/76	193	79	36	1	8	2	2
04/04/76	199	63	36	0	9	3	2
04/10/76	202	54	26	0	7	2	2
04/20/76	208	64	33	0	8	3	3
05/02/76	213	60	27	1	9	3	3
05/11/76	220	59	34	2	10	3	3
05/20/76	226	55	31	1	6	3	3
06/03/76	232	-	27	0	4	2	2
06/10/76	236	-	25	4	10	3	4
06/22/76	244	45	23	3	8	3	4
06/30/76	250	48	17	0	5	2	2
07/09/76	260	48	20	1	5	2	2
07/22/76	269	43	18	2	4	2	3
08/19/76	288	-	20	0	4	2	2
09/25/76	308	-	13	0	4	0	1
10/11/76	312	35	8	0	5	1	3
10/20/76	317	48	11	1	2	-	1
10/29/76	324	42	13	0	3	2	0
11/04/76	327	43	20	1	7	7	2
11/15/76	335	26	11	2	2	1	1
11/24/76	341	22	1	1	3	3	0
12/07/76	350	9	29	3	3	3	2
12/13/76	354	-	18	0	2	0	0
12/20/76	358	24	19	1	6	2	3
12/30/76	364	-	15	2	3	1	1
01/06/77	368	-	20	1	4	2	-
01/23/77	377	-	19	0	4	2	2
02/06/77	385	-	25	0	4	1	1
02/14/77	389	-	24	0	4	2	2
02/18/77	391	42	24	0	3	0	0
02/27/77	395	53	23	-	4	3	1
03/12/77	404	-	4	5	7	6	7
03/25/77	413	-	21	1	-	3	2
04/26/77	428	20	20	1	3	-	2
05/31/77	434	-	19	1	4	3	2
06/14/77	448	6	20	1	3	3	2
07/03/77	456	10	15	1	1	1	1
08/02/77	469	4	15	1	3	2	1
09/25/77	496	1	1	2	3	1	1
10/26/77	510	-	14	1	4	1	1
02/10/78	545	-	1	1	1	1	1
02/15/78	547	-	3	1	3	1	1

*Net Production: (Total Fluid Produced)-
(Total Fluid Injected)

Note: In August 1975, observation wells were produced with airlift system.

649 053

TABLE 1.4

BICARBONATE CONCENTRATIONS AT OBSERVATION WELLS
HIGHLAND SOLUTION MINE PILOT

Date	OBSERVED BICARBONATE CONCENTRATIONS MILLIGRAMS PER LITER BY WELL					
	#7	#8	#9	#10	#11	#12
08/19/76	560*	237	203	220	193	232
09/25/76	-	187	257	141	48	118
10/11/76	17	207	519	228	187	228
10/20/76	622	228	145	187	-	228
11/04/76	517	282	222	176	212	23
11/24/76	477	187	187	207	52	166
12/07/76	207	249	145	124	145	145
12/20/76	604	338	290	290	243	290
01/30/77	-	270	166	207	124	124
02/14/77	-	293	116	212	93	187
02/27/77	519	290	207	414	332	414
03/12/77	317**	120	68	110	100	100
03/25/77	-	124	79	102	79	79
04/21/77	164	128	164	155	174	155
04/26/77	220	124	90	113	96	79

*No sample for this well on 8/19/76. Data reported is for 7/22/76 to indicate prior trend.

**No sample for this well on 3/12/77. Data reported is for 3/4/77 to indicate trend.

CARBONATE CONCENTRATIONS OF OBSERVATION WELLS
HIGHLAND SOLUTION MINE PILOT

Date	OBSERVED CARBONATE CONCENTRATIONS MILLIGRAMS PER LITER BY WELL					
	#7	#8	#9	#10	#11	#12
08/19/76	161*	10	5	15	5	10
09/25/76	-	0	11	47	47	11
10/11/76	-	11	146	2	2	5
10/20/76	49	6	0	15	-	6
11/04/76	139	0	0	23	16	8
11/24/76	226	11	0	11	10	0
12/07/76	5	11	16	32	5	5
12/20/76	167	24	24	24	24	24
01/30/77	-	11	0	23	23	23
02/14/77	-	11	0	11	23	11
02/27/77	23	23	0	47	70	47
03/12/77	43**	14	14	14	11	7
03/25/77	-	0	0	0	0	0
04/21/77	40	0	0	0	0	0
04/26/77	57	0	0	0	0	0

*No sample for this well on 8/19/76. Data reported is for 7/22/76 to indicate prior trend.

**No sample for this well on 3/12/77. Data reported is for 3/4/77 to indicate trend.

649 054

TABLE 1.5

URANIUM CONCENTRATION AT PRODUCTION WELLS
HIGHLAND SOLUTION MINE PILOT

Date	OBSERVED URANIUM CONCENTRATIONS MILLIGRAMS PER LITER BY WELL						
	#1	#2	#3	#4	#5	#6	INJ.
08/19/76	34	72	9	14	57	60	157
09/25/76	-	62	6	12	-	58	165
10/11/76	-	49	5	9	-	-	111
10/19/76	-	62	10	15	-	46	145
10/29/76	8	54	13	16	-	50	133
11/04/76	7	52	6	13	-	46	131
11/15/76	6	42	11	15	-	42	126
11/24/76	19	60	13	14	14	48	134
12/03/76	16	42	11	12	31	41	135
12/07/76	24	44	7	11	37	39	128
12/20/76	20	54	10	11	45	42	139
01/13/77	12	-	13	-	47	48	129
01/30/77	27	-	6	-	60	49	112
02/14/77	27	-	6	-	60	49	103
03/01/77	27	33	10	-	61	54	121
03/12/77	31	38	21	-	21	42	54
03/25/77	18	37	50	-	24	19	89
04/21/77	31	47	24	-	59	-	94
04/26/77	17	37	5	-	42	31	73
05/21/77	36	55	28	-	69	-	110
06/23/77	11	31	5	-	42	39	68
07/21/77	10	32	-	-	32	31	54
08/04/77	9	31	1	-	28	-	54
09/25/77	3	31	3	-	-	31	57
10/26/77	14	26	9	-	-	33	61
11/01/77	7	22	1	-	-	31	60
12/08/77	7	26	1	-	-	32	-
02/15/78	4	20	3	-	3	-	61

NOTE: Dash indicates well not producing, and no sample was taken on that date.

TABLE 1.6

CARBONATE CONCENTRATIONS AT PRODUCTION WELLS
HIGHLAND SOLUTION MINE PILOT

Date	Observed Carbonate Concentration Milligrams Per Liter By Well						
	#1	#2	#3	#4	#5	#6	INJ.
08/19/76	51	181	0	42	51	173	554
09/25/76	-	163	0	23	-	209	650
10/11/76	-	147	2	-	-	-	305
10/29/76	0	165	0	11	-	143	569
11/04/76	-	174	34	33	-	152	535
11/24/76	11	161	0	11	0	97	550
12/07/76	48	145	16	48	11	0	469
12/20/76	24	167	24	24	24	71	547
01/30/77	70	-	11	-	34	139	550
02/14/77	47	-	0	-	6	104	485
02/27/77	0	258	11	-	47	-	469
03/06/77	50	71	0	-	14	50	264
03/25/77	20	22	0	-	0	7	242
04/21/77	30	60	0	-	10	40	20
04/26/77	0	86	0	-	21	29	21

BICARBONATE CONCENTRATIONS AT PRODUCTION WELLS
HIGHLAND SOLUTION MINE PILOT

Date	Observed Bicarbonate Concentration Milligrams Per Liter By Well						
	#1	#2	#3	#4	#5	#6	INJ.
08/19/76	512	649	157	353	506	792	1503
09/25/76	-	495	142	355	-	520	1511
10/11/76	-	619	255	-	-	-	1233
10/29/76	236	418	259	351	-	489	1275
11/04/77	165	472	178	311	-	495	1145
12/07/76	220	477	145	187	207	477	1224
12/20/76	387	676	290	338	436	556	1718
01/30/77	311	-	228	-	456	519	14
02/14/77	328	-	234	-	517	434	774
02/27/77	332	519	199	-	519	477	12
03/06/77	181	226	113	-	266	226	447
03/25/77	147	194	68	-	158	136	520
04/21/77	119	201	174	-	174	146	137
04/26/77	90	271	102	-	254	226	243

649 056

TABLE 1.7

AIRBORNE RADIOACTIVE MATERIAL CONCENTRATIONS

HIGHLAND SOLUTION MINE PILOT

DATE	AIRBORNE URANIUM CONCENTRATION[2] - uCi/ml x 10^{-10}	
	PROCESS BUILDING	PUMP BUILDING
Restricted Area[1]	1.0	1.0
12/72	0.015	0.043
4/73	0.018	0.047
6/73	0.015	0.124
8/73	0.097	0.220
10/73	0.007	0.026
11/73	0.005	0.022
2/74	0.008	0.073
3/74	0.004	0.012
4/74	0.002	0.012
6/74	0.010	0.067
8/74	0.117	0.116
11/74	0.054	0.040
2/75	0.094	0.039
5/75	0.020	0.039
8/75	0.027	0.025
1/76	0.025	0.036
2/76	0.099	0.058
5/76	0.021	0.005
7/76	0.043	0.008
10/76	0.001	0.001
1/77	0.004	0.004
4/77	0.009	0.124
7/77	0.028	0.128
10/77	0.001	Nil

	RADON DAUGHTER CONCENTRATION - WORKING LEVELS	
	PROCESS BUILDING	PUMP BUILDING
Restricted Area[1]	0.33	0.33
11/75	0.10	0.03
1/76	0.03	0.016
3/76	0.00	0.03
5/76	0.10	0.003
7/76	0.02	Nil
9/76	0.08	1.03
11/76	0.13	0.10
1/77	Nil	0.04
2/77	0.21	0.09
3/77	0.21	0.05
4/77	0.11	1.15
5/77	0.09	Nil
6/77	0.08	0.38
7/77	0.03	Nil
8/77	0.03	0.54
10/77	0.18	Nil
11/77	Nil	0

(1)Restricted area limit of uniform concentration based on 40 hours per week - 10CFR20, Appendix B, Table I

(2)Specific activity of uranium = 6.77 x 10^{-7} Ci/g.

649 057

TABLE 1.8

ARSENIC AND SELENIUM CONCENTRATIONS
PREGNANT LEACHING SOLUTION
HIGHLAND SOLUTION MINE PILOT

Date	Arsenic Mg/Liter	Selenium Mg/Liter
May 1970[1]	-	<0.5
09/03/75	0.36	0.17
01/05/76	0.38	0.14
02/03/76	0.37	0.17
04/05/76	0.33	0.16
05/03/76	0.36	0.17
06/04/76	0.44	0.21
07/02/76	0.31	0.14
08/02/76	0.28	0.08
09/01/76	0.40	0.13
12/01/76	0.09	0.05
01/03/77	0.23	0.10
02/01/77	0.32	0.08
03/04/77	0.21	0.08
04/05/77	0.53	0.057
06/01/77	0.17	0.075
07/01/77	0.21	0.10
08/01/77	0.17	0.10
09/01/77	0.19	0.096
10/03/77	0.25	0.039
10/31/77	0.20	0.058
12/05/77	0.09	0.060
01/09/78	0.01	-
Wyoming DEQ[2] Guideline No. 4 (Livestock Impoundment)	0.2	0.05

(1) Sample taken in pilot area prior to initiating solution mining test.

(2) Wyoming Department of Environmental Quality, Division of Land Quality Guideline No. 4 (revised) November 9, 1976. Part II: Water Quality Criteria for Wildlife and Livestock Impoundments.

649 058

TABLE 1.9

WATER SAMPLE ANALYSIS

SOLUTION MINE PILOT AREA

	Wyoming DEQ[1] Guideline No. 4 (Livestock Impoundments)	Sample Well #13	Pilot Well #6	Pilot Well #3	Obsev Well #7	Obsev Well #9	Control[4] Well In Ore Zone	Control[5] Well Outside Ore Zone
Date of Sample		2/1/77, 2/15/77	4/21/77	4/21/77	4/21/77	4/21/77	2/1/77, 2/2/77	2/14/77, 2/15/77
Aluminum-mg/l	5.0	.46	.049	.03	.13	.17	.009	.123
Arsenic-mg/l	0.2	.30	.15	.065	.023	.014	.0015	<.001
Boron-mg/l	5.0	.1	.1	.1	<.1	.1	0.2	.2
Cadmium-mg/l	0.05	<.001	<.001	.001	<.001	.005	.002	.001
Chromium-mg/l	1.0	.002	.002	.004	.010	.003	<.001	.0345
Copper-mg/l	0.5	.016	.13	.004	.019	.069	<.001	<.001
Fluoride-mg/l	2.0	1.15	0.6	0.3	0.7	0.2	0.2	0.25
Lead-mg/l	0.1	.005	.013	.002	.037	.16	.002	.010
Mercury-mg/l	0.01	.0003	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Selenium-mg/l	0.05	.145	.30	.003	.004	<.001	<.001	.001
Zinc-mg/l	25	.010	.020	.029	15	16	.007	.016
Sulfate-mg/l	3000	189[6]	152	156	136	114	141[6]	132[6]
Chloride-mg/l	2000	18	9	12	27	10	6	17
Radium-226 pCi/l	30[2]	200	92	500	125	4.9	470	3.3
Thorium-230 pCi/l	2000[2]	160	113	48	230	3.8	0.55	0.2
Uranium-mg/l	44.3[2]	78	15	4.1	3.4	.15	.095	.045

[1]Wyoming Department of Environmental Quality, Division of Land Quality Guideline No. 4 (revised) November 9, 1976. Part II: Water Quality Criteria for Wildlife and Livestock Impoundments.

[2]MPC above background for release to an unrestricted area, 10CFR20, Appendix B, Table II.

[3]Average of two samples.

[4]Located 700 feet east of pilot injection well in the same sand.

[5]Located 1100 feet southeast of pilot injection well in the same sand.

[6]All sulphur calculated as $SO_4^=$.

Analyses are by mass spectrometry except for Ra-226 and Th-230.

TABLE 1.10

HIGHLAND WATER SUPPLY WELL NO. 3
SOLUTION MINE PILOT

WATER ANALYSES
(SAMPLE POINT NO. 8)

Mo/Yr	Carbonate mg/l	Bicarbonate mg/l	Uranium pCi/l	Ra-226 pCi/l	Th-230 pCi/l
6/72	-	-	<0.3	1.2	20
10/72	-	-	2.3	0.5	1
1/73	-	-	-	3.5	-
3/73	-	-	0.8	0.2	4
6/73	-	-	3.4	0	1.9
10/73	-	-	1.4	0.2	0.3
4/74	-	-	<0.5	0.1	0
6/74	0	146	<0.5	0.8	0
9/74	36	146	<1.0	0.4	1.9
12/74	0	146	5.4	0.4	1.7
3/75	0	146	<1.0	0.8	0.5
6/75	0	122	<1.0	0.2	0.9
9/75	7	166	<1.0	0.4	7.0
12/75	0	139	3.4	0.3	0.9
3/76	0	146	3.4	0.3	0.8
6/76	0	124	0.7	1.5	0.4
9/76	0	159	0.3	0.3	0.4
12/76	0	149	-	0.3	1.4
3/77	0	146	-	0.1	2.5

649 060

TABLE 1.11

RADIUM AND THORIUM CONCENTRATIONS
PREGNANT LEACHING SOLUTION
HIGHLAND SOLUTION MINE PILOT

Date	Radium-226 $\mu Ci/ml \times 10^{-8}$	Thorium-230 $\mu Ci/ml \times 10^{-7}$
05/01/70*	12.0	0.86
07/04/72	9.2	39.5
09/04/72	1.1	21.0
01/19/73	21.4	68.1
05/10/74	110.0	1040.0
08/05/74	-[1]	42.0
11/12/74	40.0	280.0
02/04/75	8.8	67.0
05/02/75	4.4	1.6
08/08/75	12.5	0.5
09/03/75	6.8	1.2
10/02/75	10.0	0.3
11/03/75	14.0	3.6
12/01/75	9.0	4.3
01/05/76	8.2	20.4
02/03/76	12.2	3.4
03/01/76	8.2	0.3
04/05/76	5.2	0.1
05/03/76	7.9	1.3
06/04/76	8.6	0.9
07/02/76	5.9	0.7
08/02/76	6.4	0.9
09/01/76	5.6	1.0
10/13/76	7.3	1.4
11/09/76	7.7	2.1
12/01/76	5.6	1.0
01/03/77	7.4	.7
02/01/77	7.6	1.2
03/04/77	9.2	1.4
04/01/77	17.0	1.6
05/01/77	11.0	0.4
06/01/77	9.7	0.2
07/01/77	5.3	0.2
08/01/77	12.0	0.8
09/01/77	18.0	2.3
10/03/77	4.8	0.2
10/31/77	7.2	3.5
12/05/77	3.6	0.4
01/09/78	13.2	1.6

*Average of 3 samples taken prior to solution mining operations.

649 061

TABLE 1.12

WATER WELL DATA

HIGHLAND OPERATIONS
CONVERSE CO., WYOMING

Description	Location	Completion Depth (ft)	Completion Interval (ft)
Highland Water Well #3 (Solution Mine Pilot)	SE/4 Sec 20 T36N; R72W	298'	180' - 298'
Highland Water Well #4 (Mine Dewatering)	NW/4 Sec 21 T36N; R72W	600'	455' - 590'
Highland Water Well #5 (Surface Mine Shop)	SW/4 Sec 28 T36N; R72W	270'	120' - 260'
Highland Water Well #6 (Highland Uranium Mill)	NE/4 Sec 21 T36N; R72W	395'	157' - 364'
Highland Water Well #11 (Mine Dewatering)	SW/4 Sec 20 T36N; R72W	710'	315' - 695'
Highland Water Well #12 (Underground Mine Shop)	SE/4 Sec 17 T36N; R72W	704'	440' - 651'
Highland Water Well #13 (Mine Dewatering)	SE/4 Sec 17 T36N; R72W	651'	414' - 601'
Highland Water Well #14 (Mine Dewatering)	NW/4 Sec 21 T36N; R72W	651'	405' - 601'
Highland Water Well #15 (Mine Dewatering)	NW/4 Sec 21 T36N; R72W	604'	343' - 554'
Highland Water Well #16 (Mine Dewatering)	NW/4 Sec 21 T36N; R72W	554'	289' - 504'
Highland Water Well #17 (Mine Dewatering)	SW/4 Sec 21 T36N; R72W	464'	229' - 414'
Highland Water Well #18 (Mine Dewatering)	SE/4 Sec 20 T36N; R72W	540'	259' - 490'
Highland Water Well #19 (Mine Dewatering)	SE/4 Sec 20 T36N; R72W	590'	333' - 537'
Highland Water Well #20 (Mine Dewatering)	SW/4 Sec 20 T36N; R72W	541'	345' - 485'
Highland Water Well #21 (Mine Dewatering)	SW/4 Sec 20 T36N; R72W	601'	379' - 518'
Highland Water Well #22 (Mine Dewatering)	NW/4 Sec 20 T36N; R72W	625'	379' - 575'
Highland Water Well #23 (Mine Dewatering)	NW/4 Sec 20 T36N; R72W	700'	450' - 650'
Highland Water Well #24 (Mine Dewatering)	SW/4 Sec 17 T36N; R72W	706'	453' - 653'
Highland Water Well #25 (Mine Dewatering)	SW/4 Sec 17 T36N; R72W	692'	448' - 639'
Highland Water Well #26 (Mine Dewatering)	SE/4 Sec 17 T36N; R72W	709'	490' - 656'
Rumerich Livestock Well	NW/4 Sec 18 T36N; R72W	40' (est.)	-
Fowler Ranch Well	SE/4 Sec 9 T36N; R72W	100' (est.)	-

TABLE 1.13

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE R&D PROGRAM
CONVERSE COUNTY, WYOMING

	LDL (1)	DEQ(2) LQD GL#4	WELL NO. I-1	WELL NO. I-3	WELL NO. P-3	WELL NO. P-5	WELL NO. P-7	WELL NO. P-9	WELL (6) NO. O-2	WELL NO. O-3	WELL NO. O-5	WELL NO. O-6	WELL NO. O-8	WELL NO. O-9	WELL NO. M-1	WELL NO. M-1
ALUMINUM mg/l	0.05	5.0	.05-1.75	.05-.15	.05-1.50	ND	ND	.05-.40	.05-.07	.05	.05	.05-.33	.05-.10	.05-.20	.05-.15	.05-1.70
ARSENIC mg/l	0.01	0.2	ND	ND	ND	.01-.02	.01	ND	.01	.01	.01	.01	.01	.01	ND	ND
BARIUM mg/l	0.05	-	ND	ND	ND	.05-.25	.05-.28	ND	.05	.05	.05	.05	.05	.05	ND	ND
BORON mg/l	1.0	5.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	1.0	[illegible]	ND	ND
BICARBONATE mg/l	1.0	-	195-208	183-220	171-207	122-159	73-122	146-195	159-195	73-122	122-171	183-207	195-232	[illegible]	171-207	122-170
CARBONATE mg/l	1.0	-	1.0-24	1.0-12	1.0-36	1.0-24	36-48	12-48	1.0	1.0-24	8-36	1.0-24	1.0-24	[illegible]	1.0-24	1.0-36
CADMIUM mg/l	0.002	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	.002	.002	.002	ND	ND
CALCIUM mg/l	1.0	-	41-43	41-45	15-43	19-21	5-7	27-36	58-59	21-35	45-60	41-49	48-51	4-12	43-52	8-33
CHLORIDE mg/l	1.0	2000	8-16	12-18	14-81	28-34	28-60	20-40	10-16	12-16	12-20	12-18	6-10	32-50	10-32	18-26
CHROMIUM mg/l	0.01	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	.01	.01	.01	ND	ND
COPPER mg/l	0.01	0.5	.01	ND	ND	.01	ND	ND	ND	ND	ND	.01	.01	.01	.01	ND
FLUORIDE mg/l	0.01	2.0	.08-.19	.07-.32	.11-.22	.15-.37	.11-.30	.07-.25	.06-0.3	.04-.15	.01-.15	.11-.30	.07-.30	.01-.28	.09-.11	.09-.70
IRON mg/l	0.01	-	.02-.81	.01-.16	.01-.16	.01-.02	ND	.01-.20	.01-.18	.01-.06	.01-.12	.01-.24		.01-.31	.01-.06	.06-.44
LEAD mg/l	0.05	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	.05	.05	.05	.05	ND
MANGANESE mg/l	0.01	-	.01	.01	.01-.08	.01-.19	.01-.36	ND	ND	ND	.01	.01	.01	.01	ND	ND
MAGNESIUM mg/l	1.0	-	9	6-7	7	3-6	3-4	6	12-14	2-6	2-9	9-12	6-7	4-6	12-13	2-3
MERCURY mg/l	0.001	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	.001	.001	.001	ND	ND
MOLYBDENUM mg/l	0.05	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	.05	.05	.05	ND	ND
NITRATES mg/l (as Nitrogen)	0.01	-	.01-.09	.01-.03	.01-.02	.01	.01-.04	.01-.10	.01-.06	.01-0.10	.01-.02	.01-.18	.01-.03	.01-.03	.01-.05	.01-.07
SELENIUM mg/l	0.01	.05	ND	ND	ND	.01	ND	ND	ND	ND	ND	.01	.01	.01	.01	ND
SILVER mg/l	0.02	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	.07	.02	.02	ND	ND
SODIUM mg/l	1.0	-	81	61-69	98-99	91-107	112-118	82-112	68-74	62-104	54-100	90-97	61-63	126-129	66-102	67-121
SULPHATE mg/l	1.0	3000	77-118	86-103	80-137	108-126	83-84	62-112	168-213	120-215	118-210	163-167	82-84	82-98	152-224	113-114
ZINC mg/l	0.01	25	.01-.14	.01-.6*	.01	.01-.04	.02	ND	ND	ND	ND		.01-.03		.01-.14	ND
URANIUM mg/l	0.001	-	.016-.170	.021-.120	.105-.450	.180-.940	.001-.050	.052-.160	.014-.230	.002-.030	.12-8.1(5)	.025-.084	.010-.050	.008-.030	.001-.068	.001-7.000(4)
RADIUM-226 pCi/l	-	-	101-159	152-320	36-48	171-296	3-10	104-110	7.2-9.3	1.2-4.8	207-318	12-16	1.1-3.1	0-4.5	1.6-17.1	.04-3.5
TOTAL DISSOLVED SOLIDS mg/l	-	5000	390-401	333-347	364-445	264-384	116-347	290-437	434-462	206-445	352-508	445-446	334-343	402-423	407-516	333-359
CONDUCTIVITY micromhos (Field)	-	-	400-430	420-465	390-460	420-460	350-460	410-500	430-500	330-440	440-575	450-520	370-400	430-490	445-520	345-450
pH (Field)	-	6.0-9.0	8.3-8.5	8.4-8.7	8.3-8.9	8.6-9.0	9.4-10.1	8.7-9.6	8.0-8.5	8.9-9.3	9.1-9.3	8.1-8.9	7.7-8.6	8.9-9.7	8.3-8.8	8.6-9.4

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.
(4) Single sample anomaly; second high value was 0.045.
(5) Single sample anomaly; second high value was 0.700.
(6) Well is in communication with the overlying aquifer. Additional samples will be taken after the well is reworked.

EXXON MINERALS COMPANY, U.S.A.
POST OFFICE BOX 2180 - HOUSTON, TEXAS 77001

GERALD D. ORTLOFF
REGULATORY AFFAIRS MANAGER

May 10, 1978

Mr. Walter C. Ackerman, Administrator
Land Quality Division
Department of Environmental Quality
State Office Building
Cheyenne, Wyoming 82002

Mining Permit 218C
Highland Solution Mining Operations
Converse County, Wyoming

Dear Mr. Ackerman:

Exxon Minerals Company hereby requests approval of a modification to Mining Permit 218C to allow continuation of the uranium solution mining (in-situ leaching) research and development program at a new location on the Highland Uranium Operations permit area in Converse County. Mineral rights and surface rights in this area are held by Exxon through claims and/or lease agreements. Approval of this modification will allow Exxon to continue the solution mining R&D program, in a new leach area of one acre or less, to evaluate important process variables and to obtain additional operating cost data. The program will utilize the existing plant facilities with minor modifications. The well field will be located approximately 1500 feet east of the existing test site. Supporting documents on the proposed program and on the status of the existing test program are attached.

The required amount of the reclamation bond for the Highland Operations is currently being reviewed with members of your staff. The proposed solution mining pilot area is included in the "area to be disturbed in 1978", as shown in the 1977 Annual Report for the Highland operations; therefore, the cost of reclamation of the surface disturbance will be included in the bonding estimate to cover the surface reclamation. An additional amount sufficient to cover the cost of groundwater reclamation, as presented in the enclosure, will be added to the bond coverage.

Your early consideration of this request will be appreciated. Exxon representatives will be available to discuss this application at your convenience.

Sincerely,

G. D. Ortloff

G. D. Ortloff

MDF:dd
Attachment

649 064

TABLE 1.13-1

EXCURSION PARAMETERS SENSITIVITY
Early Samples vs Stabilized Conductivity Samples
Highland Solution Mine R&D Program

	WELL O-2 4/27/78		WELL O-3 5/03/78		WELL O-5 5/0 /78		WELL O-6 4/25/78		WELL O-8 4/28/78	
	Special (1)	Standard (2)	Special	Standard	Special	tandard	Special	Standard	Special	Standard
BICARBONATE mg/l	146	159	61	98	110	159	171	195	207	220
CARBONATE mg/l	1	1	12	12	24	12	24	1	12	1
CHLORIDE mg/l	8	10	18	14	30	14	38	14	8	8
URANIUM mg/l	0.034	0.140	0.200	0.030	0.280	0.190	0.078	0.080	0.027	0.050
CONDUCTIVITY micromhos	500	500	350	330	430	440	490	480	370	370
pH	8.5	8.5	9.3	9.2	9.7	9.1	8.9	8.6	8.7	8.6

	WELL O-9 4/27/78		WELL M-1 4/25/78		WELL M-2 4/28/78	
	Special	Standard	Special	Standard	Special	Standard
BICARBONATE mg/l	207	134	183	207	146	159
CARBONATE mg/l	12	24	1	1	12	12
CHLORIDE mg/l	8	40	18	12	26	18
URANIUM mg/l	0.027	0.008	0.056	0.068	0.030	0.045
CONDUCTIVITY micromhos	2000	480	540	520	370	370
pH	12.3	9.4	8.9	8.6	9.2	8.9

The above special samples were taken on the fourth round of baseline sampling program for the R&D program. Although there are a number of variations on the various samples, the only major variation occurred at Well O-9. In this sample, it appears that the abnormal conductivity reading indicates the sample is not a representative sample as it is approximately four times the stabilized values. Additional special samples were not taken during the baseline sampling program; however, another round of special samples will be taken if needed by DBQ for the evaluation.

(1) Special sample taken after approximately 2 casing volumes of water was produced.
(2) Standard sample taken after conductivity of produced water had stabilized.

649 090

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-2

WELL NO. PILOT I-1 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/22/78	SAMPLE NO. 2 3/23/78	SAMPLE NO. 3 4/10/78	SAMPLE NO. 4 4/25/78	SAMPLE NO. 5 5/12/78
ALUMINUM mg/l	0.05	5.0	0.25	1.75	.05	.06	-
ARSENIC mg/l	0.01	0.2	ND(3)	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	195	268	207	207	231
CARBONATE mg/l	1.0	-	24	ND	12	12	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	47	45	-	-	-
CHLORIDE mg/l	1.0	2000	16	10	8	10	10
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	0.01	ND	ND	-	-
FLUORIDE mg/l	0.01	2.0	0.08	0.15	0.11	0.16	0.19
IRON mg/l	0.01	-	0.36	0.83	0.02	0.02	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	.01	.01	-	-	-
MAGNESIUM mg/l	1.0	-	9	9	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.05	ND	0.01	0.09
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	83	83	-	-	-
SULPHATE mg/l	1.0	3000	118	103	77	77	-
ZINC mg/l	0.01	25	0.14	0.01	ND	ND	-
URANIUM mg/l	0.001	-	0.170	0.066	0.026	0.054	0.016
RADIUM-226 pCi/l	-	-	101	101	150	-	153
TOTAL DISSOLVED SOLIDS mg/l	-	5000	401	390	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	430	410	400	420	400
pH (Field)	-	6.0-9.0	8.3	8.3	8.3	8.5	8.4

649 066

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 1.13-3

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

WELL NO. PILOT I-3 SEC. 21 T 36N R 72W

	LDL (1)	DEQ (2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/30/78	SAMPLE NO. 3 4/14/78	SAMPLE NO. 4 4/27/78	SAMPLE NO. 5 5/11/78
ALUMINUM mg/l	0.05	5.0	0.15	ND	ND	-	-
ARSENIC mg/l	0.01	0.2	ND(3)	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	183	220	207	220	195
CARBONATE mg/l	1.0	-	12	ND	ND	ND	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	45	41	-	-	-
CHLORIDE mg/l	1.0	2000	14	16	14	12	18
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.32	0.07	0.15	0.16	-
IRON mg/l	0.01	-	0.03	0.16	0.06	ND	ND
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	0.01	ND	ND	-	-
MAGNESIUM mg/l	1.0	-	6	7	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.03	0.02	-	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	67	69	-	-	-
SULPHATE mg/l	1.0	3000	103	86	102	94	-
ZINC mg/l	0.01	25	0.02	ND	ND	-	-
URANIUM mg/l	0.001	-	0.11	0.054	0.074	0.120	0.021
RADIUM-226 pCi/l	-	-	173	296	157	240	320
TOTAL DISSOLVED SOLIDS mg/l	-	5000	347	335	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	465	435	420	425	450
pH (Field)	-	6.0-9.0	8.4	8.5	8.7	8.7	8.6

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-4

WELL NO. PILOT P-3 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/29/78	SAMPLE NO. 3 4/12/78	SAMPLE NO. 4 4/26/78	SAMPLE NO. 5 5/12/78
ALUMINUM mg/1	0.05	5.0	1.50	ND(3)	0.23	0.20	ND
ARSENIC mg/1	0.01	0.2	ND	ND	-	-	-
BARIUM mg/1	0.05	-	ND	ND	-	-	-
BORON mg/1	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/1	1.0	-	183	183	207	171	207
CARBONATE mg/1	1.0	-	36	24	12	12	ND
CADMIUM mg/1	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/1	1.0	-	47	27	36	27	15
CHLORIDE mg/1	1.0	2000	81	28	18	20	14
CHROMIUM mg/1	0.01	1.0	ND	ND	-	-	-
COPPER mg/1	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/1	0.01	2.0	0.22	0.11	0.15	0.17	0.20
IRON mg/1	0.01	-	0.03	0.16	0.15	-	-
LEAD mg/1	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/1	0.01	-	0.01	0.08	ND	ND	-
MAGNESIUM mg/1	1.0	-	7	7	-	-	-
MERCURY mg/1	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/1	0.05	-	ND	ND	-	-	-
NITRATES mg/1 (as Nitrogen)	0.01	-	0.01	0.02	-	-	-
SELENIUM mg/1	0.01	.05	ND	ND	-	-	-
SILVER mg/1	0.02	-	ND	ND	-	-	-
SODIUM mg/1	1.0	-	98	99	-	-	-
SULPHATE mg/1	1.0	3000	137	96	85	80	-
ZINC mg/1	0.01	25	ND	0.01	ND	-	-
URANIUM mg/1	0.001	-	0.250	0.130	0.150	0.450	0.105
RADIUM-226 pCi/1	-	-	48	36	43	-	-
TOTAL DISSOLVED SOLIDS mg/1	-	5000	445	384	364	382	-
CONDUCTIVITY micromhos (Field)	-	-	460	455	400	400	390
pH (Field)	-	6.0-9.0	8.7	8.9	8.9	8.7	8.3

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-5

WELL NO. PILOT P-5 SEC. 21 T 36N R 72W

	LDL (1)	DEQ (2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/29/78	SAMPLE NO. 3 4/12/78	SAMPLE NO. 4 4/26/78	SAMPLE NO. 5 5/12/78
ALUMINUM mg/l	0.05	5.0	ND (3)	ND	-	-	-
ARSENIC mg/l	0.01	0.2	0.01	0.02	ND	0.02	ND
BARIUM mg/l	0.05	-	ND	0.25	ND	ND	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	122	132	159	146	146
CARBONATE mg/l	1.0	-	24	12	ND	12	12
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	21	19	-	-	-
CHLORIDE mg/l	1.0	2000	30	32	26	32	34
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	0.01	ND	ND	-
FLUORIDE mg/l	0.01	2.0	0.37	0.15	0.17	-	-
IRON mg/l	0.01	-	0.02	ND	ND	-	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	0.39	ND	ND	-
MAGNESIUM mg/l	1.0	-	3	6	6	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.01	ND	-	-
SELENIUM mg/l	0.01	.05	0.01	ND	ND	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	107	91	91	-	-
SULPHATE mg/l	1.0	3000	126	108	110	-	-
ZINC mg/l	0.01	25	0.04	0.02	ND	ND	-
URANIUM mg/l	0.001	-	0.180	0.860	0.940	0.620	0.765
RADIUM-226 pCi/l	-	-	171	296	291	-	-
TOTAL DISSOLVED SOLIDS mg/l	-	5000	384	347	264	382	379
CONDUCTIVITY micromhos (Field)	-	-	460	455	420	430	440
pH (Field)	-	6.0-9.0	9.0	8.6	8.8	8.9	8.6

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 1.13-6

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

WELL NO. PILOT P-7 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/29/78	SAMPLE NO. 3 4/12/78	SAMPLE NO. 4 4/26/78	SAMPLE NO. 5 5/11/78
ALUMINUM mg/l	0.05	5.0	ND(3)	ND	-	-	-
ARSENIC mg/l	0.01	0.2	0.01	ND	ND	-	-
BARIUM mg/l	0.05	-	ND	0.28	ND	ND	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	73	73	85	98	122
CARBONATE mg/l	1.0	-	48	48	36	36	36
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	7	5	7	-	-
CHLORIDE mg/l	1.0	2000	60	44	32	28	28
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.30	0.11	0.18	0.17	-
IRON mg/l	0.01	-	ND	ND	-	-	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	0.38	ND	ND	-
MAGNESIUM mg/l	1.0	-	4	3	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.04	0.03	-	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	118	112	-	-	-
SULPHATE mg/l	1.0	3000	84	83	-	-	-
ZINC mg/l	0.01	25	0.02	0.02	-	-	-
URANIUM mg/l	0.001	-	ND	0.022	0.050	0.024	0.006
RADIUM-226 pCi/l	-	-	3.0	8.8	14	10	8.3
TOTAL DISSOLVED SOLIDS mg/l	-	5000	347	346	116	337	315
CONDUCTIVITY micromhos (Field)	-	-	460	420	380	390	350
pH (Field)	-	6.0-9.0	10.1	9.9	10.1	9.4	9.7

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 1.13-7

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

WELL NO. PILOT P-9 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/24/78	SAMPLE NO. 2 3/30/78	SAMPLE NO. 3 4/14/78	SAMPLE NO. 4 4/27/78	SAMPLE NO. 5 5/11/78
ALUMINUM mg/l	0.05	5.0	ND(3)	0.01	0.40	0.05	0.05
ARSENIC mg/l	0.01	0.2	ND	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	146	159	183	159	195
CARBONATE mg/l	1.0	-	48	36	12	24	12
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	36	27	30	-	-
CHLORIDE mg/l	1.0	2000	40	22	20	22	20
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.25	0.07	0.20	0.20	-
IRON mg/l	0.01	-	0.14	ND	0.20	ND	ND
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	6	6	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	0.02	0.10	0.01	ND	0.05
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	112	82	83	-	-
SULPHATE mg/l	1.0	3000	112	62	95	89	-
ZINC mg/l	0.01	25	ND	ND	-	-	-
URANIUM mg/l	0.001	-	0.120	0.052	0.152	0.160	0.090
RADIUM-226 pCi/l	-	-	110	106	104	-	-
TOTAL DISSOLVED SOLIDS mg/l	-	5000	437	326	290	364	352
CONDUCTIVITY micromhos (Field)	-	-	500	430	420	430	410
pH (Field)	-	6.0-9.0	9.0	9.0	9.6	9.0	8.7

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 1.13-8

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

WELL NO. PILOT O-2 (4) SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/30/78	SAMPLE NO. 3 4/13/78	SAMPLE NO. 4 4/27/78	SAMPLE NO. 5 5/31/78
ALUMINUM mg/l	0.05	5.0	0.07	ND	ND	-	-
ARSENIC mg/l	0.01	0.2	ND(3)	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	159	171	183	159	195
CARBONATE mg/l	1.0	-	ND	ND	ND	ND	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	58	59	-	-	-
CHLORIDE mg/l	1.0	2000	16	10	12	10	12
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.30	0.06	0.15	0.16	-
IRON mg/l	0.01	-	0.18	ND	ND	-	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	12	14	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.06	ND	-	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	68	74	-	-	-
SULPHATE mg/l	1.0	3000	193	213	168	182	-
ZINC mg/l	0.01	25	ND	ND	-	-	-
URANIUM mg/l	0.001	-	0.055	0.035	0.014	0.140	0.230
RADIUM-226 pCi/l	-	-	9.3	8.8	7.2	-	-
TOTAL DISSOLVED SOLIDS mg/l	-	5000	434	462	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	495	500	500	500	430
pH (Field)	-	6.0-9.0	8.0	8.3	8.4	8.5	8.1

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-9

WELL NO. PILOT 0-3 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 3/28/78	SAMPLE NO. 2 4/03/78	SAMPLE NO. 3 4/17/78	SAMPLE NO. 4 5/03/78	SAMPLE NO. 5 7/06/78
ALUMINUM mg/l	0.05	5.0	ND(3)	ND	-	-	-
ARSENIC mg/l	0.01	0.2	ND	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	98	73	73	98	122
CARBONATE mg/l	1.0	-	12	24	12	12	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	33	24	21	22	35
CHLORIDE mg/l	1.0	2000	16	14	12	14	12
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.15	0.04	0.02	0.10	0.14
IRON mg/l	0.01	-	0.06	ND	ND	-	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	6	2	5	6	2
MERCURY mg/l	0.001	0.01	ND	ND	-	-	ND
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	0.02	ND	0.02	0.06	0.10
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	104	74	66	73	62
SULPHATE mg/l	1.0	3000	215	124	128	-	120
ZINC mg/l	0.01	25	ND	ND	-	-	-
URANIUM mg/l	0.002	-	0.002	0.030	0.010	0.030	0.016
RADIUM-226 pCi/l	-	-	4.8	1.5	1.2	1.3	-
TOTAL DISSOLVED SOLIDS mg/l	-	5000	445	313	206	295	300
CONDUCTIVITY micromhos (Field)	-	-	440	340	350	330	
pH (Field)	-	6.0-9.0	8.9	9.2	9.3	9.2	

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 1.13-10

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

WELL NO. PILOT O-5 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 3/28/78	SAMPLE NO. 2 4/03/78	SAMPLE NO. 3 4/18/78	SAMPLE NO. 4 5/03/78	SAMPLE NO. 5 7/06/78
ALUMINUM mg/l	0.05	5.0	ND(3)	ND	-	-	-
ARSENIC mg/l	0.01	0.2	ND	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	171	122	146	159	171
CARBONATE mg/l	1.0	-	24	36	24	12	9
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	60	55	45	52	50
CHLORIDE mg/l	1.0	2000	12	20	12	14	14
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.15	0.07	0.01	0.04	0.09
IRON mg/l	0.01	-	0.12	ND	-	ND	0.03
LEAD mg/l	0.05	0.1	ND	ND	ND	-	-
MANGANESE mg/l	0.01	-	0.01	ND	-	-	-
MAGNESIUM mg/l	1.0	-	9	2	8	6	7
MERCURY mg/l	0.001	0.01	ND	ND	ND	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	0.02	ND	-	ND	0.01
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	100	83	71	85	54
SULPHATE mg/l	1.0	3000	210	150	157	-	118
ZINC mg/l	0.01	25	ND	ND	-	-	-
URANIUM mg/l	0.001	-	0.058	0.120	0.200	0.190	8.10
RADIUM-226 pCi/l	-	-	318	207	260	260	-
TOTAL DISSOLVED SOLIDS mg/l	-	5000	508	420	352	405	336
CONDUCTIVITY micromhos (Field)	-	-	575	475	450	440	
pH (Field)	-	6.0-9.0	9.2	9.2	9.3	9.1	

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-11

WELL NO. PILOT 0-6 SEC. 20 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/28/78	SAMPLE NO. 2 3/28/78	SAMPLE NO. 3 4/11/78	SAMPLE NO. 4 4/25/78	SAMPLE NO. 5 5/12/78
ALUMINUM mg/l	0.05	5.0	0.22	ND	0.35	0.05	ND
ARSENIC mg/l	0.01	0.2	ND(3)	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	188	183	207	195	195
CARBONATE mg/l	1.0	-	24	12	ND	ND	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	49	43	41	-	-
CHLORIDE mg/l	1.0	2000	16	18	14	14	12
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.30	0.15	0.11	0.14	0.19
IRON mg/l	0.01	-	0.24	0.01	0.24	ND	ND
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	12	9	9	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.18	0.03	0.02	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	90	97	-	-	-
SULPHATE mg/l	1.0	3000	163	167	-	-	-
ZINC mg/l	0.01	25	0.01	ND	ND	-	-
URANIUM mg/l	0.001	-	0.084	0.025	0.042	0.080	0.027
RADIUM-226 pCi/l	-	-	15	12	14	-	16
TOTAL DISSOLVED SOLIDS mg/l	-	5000	445	446	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	510	520	450	480	450
pH (Field)	-	6.0-9.0	8.1	8.8	8.6	8.6	8.6

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-12

WELL NO. PILOT O-8 SEC. 20 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/31/78	SAMPLE NO. 3 4/14/78	SAMPLE NO. 4 4/27/78	SAMPLE NO. 5 5/11/78
ALUMINUM mg/l	0.05	5.0	0.05	0.10	ND	ND	-
ARSENIC mg/l	0.01	0.2	ND(3)	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	195	195	232	220	231
CARBONATE mg/l	1.0	-	24	24	ND	ND	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	51	48	-	-	-
CHLORIDE mg/l	1.0	2000	10	6	6	8	10
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.30	0.07	0.17	0.17	-
IRON mg/l	0.01	-	ND	ND	-	-	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	0.01	ND	ND	-	-
MAGNESIUM mg/l	1.0	-	7	6	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.03	ND	-	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	61	63	-	-	-
SULPHATE mg/l	1.0	3000	84	82	-	-	-
ZINC mg/l	0.01	25	0.03	ND	ND	-	-
URANIUM mg/l	0.001	-	0.010	0.028	0.035	0.050	0.018
RADIUM-226 pCi/l	-	-	1.1	2.2	3.1	-	2.7
TOTAL DISSOLVED SOLIDS mg/l	-	5000	343	334	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	400	375	380	370	375
pH (Field)	-	6.0-9.0	7.7	8.4	8.5	8.6	8.5

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-13

WELL NO. PILOT O-9 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 3/02/78	SAMPLE NO. 2 3/30/78	SAMPLE NO. 3 4/14/78	SAMPLE NO. 4 4/27/78	SAMPLE NO. 5 5/16/78
ALUMINUM mg/l	0.05	5.0	0.20	ND	0.05	0.06	-
ARSENIC mg/l	0.01	0.2	ND(3)	nd	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	122	122	134	134	148
CARBONATE mg/l	1.0	-	48	48	36	24	36
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	12	6	4	6	-
CHLORIDE mg/l	1.0	2000	50	50	44	40	32
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.25	0.01	0.20	0.17	0.28
IRON mg/l	0.01	-	0.31	ND	ND	-	-
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	6	4	6	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.03	ND	-	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	126	129	-	-	-
SULPHATE mg/l	1.0	3000	96	84	82	-	-
ZINC mg/l	0.01	25	ND	ND	-	-	-
URANIUM mg/l	0.001	-	0.030	0.013	0.018	0.008	0.025
RADIUM-226 pCi/l	-	-	0	4.5	1.4	1.0	3.6
TOTAL DISSOLVED SOLIDS mg/l	-	5000	415	402	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	485	485	490	480	430
pH (Field)	-	6.0-9.0	9.6	9.7	8.9	9.4	9.3

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 1.13-14

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

WELL NO. PILOT M-1 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/22/78	SAMPLE NO. 2 3/23/78	SAMPLE NO. 3 4/10/78	SAMPLE NO. 4 4/25/78	SAMPLE NO. 5 5/12/78
ALUMINUM mg/l	0.05	5.0	0.15	ND	ND	-	-
ARSENIC mg/l	0.01	0.2	ND(3)	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	171	171	195	207	171
CARBONATE mg/l	1.0	-	24	ND	ND	ND	ND
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	43	52	51	-	-
CHLORIDE mg/l	1.0	2000	10	12	10	12	12
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	0.01	ND	ND	-	-
FLUORIDE mg/l	0.01	2.0	0.09	0.11	0.09	-	-
IRON mg/l	0.01	-	0.06	0.04	ND	ND	-
LEAD mg/l	0.05	0.1	0.05	ND	ND	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	12	13	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	ND	0.05	0.01	0.02	-
SELENIUM mg/l	0.01	.05	0.01	ND	ND	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	91	103	69	66	-
SULPHATE mg/l	1.0	3000	168	224	152	155	-
ZINC mg/l	0.01	25	0.14	ND	ND	-	-
URANIUM mg/l	0.001	-	0.035	0.001	0.010	0.068	ND
RADIUM-226 pCi/l	-	-	17.1	1.6	3.7	2.4	2.1
TOTAL DISSOLVED SOLIDS mg/l	-	5000	442	516	407	414	-
CONDUCTIVITY micromhos (Field)	-	-	445	520	460	520	500
pH (Field)	-	6.0-9.0	8.3	8.8	8.4	8.6	8.4

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE PROGRAM
CONVERSE COUNTY, WYOMING

TABLE 1.13-15

WELL NO. PILOT M-2 SEC. 21 T 36N R 72W

	LDL (1)	DEQ(2) LQD G1#4	SAMPLE NO. 1 2/27/78	SAMPLE NO. 2 3/31/78	SAMPLE NO. 3 4/14/78	SAMPLE NO. 4 4/28/78	SAMPLE NO. 5 5/11/78
ALUMINUM mg/l	0.05	5.0	ND(3)	1.70	0.19	0.25	0.10
ARSENIC mg/l	0.01	0.2	ND	ND	-	-	-
BARIUM mg/l	0.05	-	ND	ND	-	-	-
BORON mg/l	1.0	5.0	ND	ND	-	-	-
BICARBONATE mg/l	1.0	-	122	122	146	159	170
CARBONATE mg/l	1.0	-	24	36	ND	12	12
CADMIUM mg/l	0.002	0.05	ND	ND	-	-	-
CALCIUM mg/l	1.0	-	19	8	11	33	10
CHLORIDE mg/l	1.0	2000	26	26	20	18	18
CHROMIUM mg/l	0.01	1.0	ND	ND	-	-	-
COPPER mg/l	0.01	0.5	ND	ND	-	-	-
FLUORIDE mg/l	0.01	2.0	0.20	0.09	0.14	0.13	-
IRON mg/l	0.01	-	0.24	0.44	0.12	0.06	0.06
LEAD mg/l	0.05	0.1	ND	ND	-	-	-
MANGANESE mg/l	0.01	-	ND	ND	-	-	-
MAGNESIUM mg/l	1.0	-	3	2	-	-	-
MERCURY mg/l	0.001	0.01	ND	ND	-	-	-
MOLYBDENUM mg/l	0.05	-	ND	ND	-	-	-
NITRATES mg/l (as Nitrogen)	0.01	-	0.03	0.70	0.01	0.01	-
SELENIUM mg/l	0.01	.05	ND	ND	-	-	-
SILVER mg/l	0.02	-	ND	ND	-	-	-
SODIUM mg/l	1.0	-	101	121	89	67	79
SULPHATE mg/l	1.0	3000	114	113	-	-	-
ZINC mg/l	0.01	25	ND	ND	-	-	-
URANIUM mg/l	0.001	-	7.000	0.015	0.015	0.045	ND
RADIUM-226 pCi/l	-	-	2.5	2.2	0.4		3.5
TOTAL DISSOLVED SOLIDS mg/l	-	5000	359	333	-	-	-
CONDUCTIVITY micromhos (Field)	-	-	450	450	400	370	345
pH (Field)	-	6.0-9.0	8.6	9.4	8.9	8.9	9.2

(1) LDL - Lower Detection Limit
(2) Wyoming Department of Environmental Quality, Land Quality Division Guideline No. 4 (Revised) November 9, 1976. Part II, Water Quality Criteria for Wildlife and Livestock Impoundments.
(3) ND - Not detected at level specified in Lower Detection Limit column.

TABLE 7.4-4

BASELINE WATER QUALITY PARAMETERS
HIGHLAND SOLUTION MINE R&D PROGRAM
CONVERSE COUNTY, WYOMING

ARSENIC	MAGNESIUM
BARIUM	MERCURY
BORON	MOLYBDENUM
BICARBONATE	NITRATES(as Nitrogen)
CARBONATE	SELENIUM
CADMIUM	SODIUM
CALCIUM	SULPHATE
CHLORIDE	ZINC
CHROMIUM	URANIUM
COPPER	RADIUM-226
IRON	TOTAL DISSOLVED SOLIDS
LEAD	CONDUCTIVITY
MANGANESE	pH

649 078

TABLE 1.15

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
LAND QUALITY DIVISION
GUIDELINE NO. 4 (REVISED)
NOVEMBER 9, 1976

PART II: Water Quality Criteria for Wildlife and Livestock Impoundments

In order to approve a wildlife or livestock watering impoundment as part of a final reclamation plan, the applicant must technically substantiate that the quality of water will not exceed the criteria listed below. This same criteria will be used in the post mining monitoring program to determine if the impoundment is acceptable for wildlife and livestock watering (refer to Wyoming Land Quality Rules and Regulations, 1975, Chapter III, Section 6). The indicated criteria are based on total concentrations.

Parameter	Maximum Concentration (mg/l except for pH)
Aluminum	5.0
Arsenic	0.2
Boron	5.0
Cadmium	0.05
Chromium	1.0
Copper	0.5
Fluoride	2.0
Lead	0.1
Mercury	0.01
Selenium	0.05
Zinc	25
Total Dissolved Solids	5000
Sulfate	3000
Chloride	2000
pH	6.0 to 9.0

TABLE 1.16

WELL COMPLETION DATA
HIGHLAND SOLUTION MINE R&D PROGRAM

Well No.	Collar Elevation Feet above MSL	Well Depth Feet	Completion Interval Depth-Feet
O-1	5301.0	434	414-434
O-2	5299.9	428	408-428
O-3	5278.6	406	382-406
O-4	5264.8	395	369-395
O-5	5266.7	393	372-393
O-6	5265.9	385	360-385
O-7	5268.1	399	369-399
O-8	5274.1	408	375-408
O-9	5282.9	410	374-410
M-1	5280.8	350	320-350
M-2	5271.4	430	415-430
P-1	5288.7	417	402-417
P-2	5280.6	398	380-398
P-3	5275.7	405	379-405
P-4	5271.5	397	380-397
P-5	5268.3	407	382-407
P-6	5268.6	399	377-399
P-7	5269.6	393	367-393
P-8	5276.0	404	385-404
P-9	5271.5	399	377-399
P-10	5283.1	420	399-420
I-1	5283.5	412	389-412
I-2	5277.6	389	376-389
I-3	5271.1	404	385-404
I-4	5269.6	400	376-400

TABLE 1.17

EXCURSION PARAMETERS FOR MONITOR WELLS
HIGHLAND SOLUTION MINE R&D PROGRAM

Well #	Bicarbonate-mg/l Range	Bicarbonate-mg/l UCL	Carbonate-mg/l Range	Carbonate-mg/l UCL	Chloride-mg/l Range	Chloride-mg/l UCL	Uranium-mg/l Range	Uranium-mg/l UCL
O-1	183-201	221	18-24	44	6-14	24	.009-.028	5
O-2(3)	195-220	240	1-12	32	8-30	40	.006-.024	5
O-3	73-204(4)	224	1-24	44	12-16	26	.002-.030	5
O-4	195-201	221	6-18	38	8	18	.006-.008	5
O-5	122-171	191	9-36	56	12-20	30	.058-8.10(5)	5
O-6	183-207	227	1-24	44	12-18	28	.025-.084	5
O-7	165-220	240	12-24	44	18-80	90	.001-.017	5
O-8	195-232	252	1-24	44	6-10	20	.010-.050	5
O-9	122-218(4)	238	24-48	68	32-118(4)	128	.008-.030	5
M-1	171-207	227	1-24	44	10-12	22	.001-.068	5
M-2	122-170	190	1-36	56	18-26	36	.001-7.00(5)	5

The conductivity and pH data have been dropped from this table as they are recorded for information purposes but are not excursion parameters.

(1) Upper Control Limit to be used to identify potential excursions.

(2) If not detected, the detection limit value of .001 is used.

(3) This data based on tests conducted after the old well was plugged and the new monitor well O-2 was completed.

(4) Based on the average March 1979 values as discussed in the report for the 1st Quarter 1979.

(5) The single high value reported appears to be an anomaly and was not used.

TABLE 1.18

TARGET RESTORATION VALUES (1)
WELL FIELD PRODUCTION AREA
HIGHLAND SOLUTION MINE R&D PROGRAM

ALUMINUM, mg/l	5.0
ARSENIC, mg/l	0.2
BORON, mg/l	5.0
CADMIUM, mg/l	0.05
CHLORIDE, mg/l	2000
CHROMIUM, mg/l	1.0
COPPER, mg/l	0.5
FLUORIDE, mg/l	2.0
LEAD, mg/l	0.1
MERCURY, mg/l	0.01
SELENIUM, mg/l	0.05
SULPHATE, mg/l	3000
ZINC, mg/l	25
URANIUM, mg/l	5-22 (2)
RADIUM-226, pCi/l	314 (3)
TOTAL DISSOLVED SOLIDS, mg/l	500-2000 (2)
pH (Field), mg/l	6.0-9.9 (4)

(1) The values are defined as the arithmatic average of the values for each parameter determined by analyses of samples from each of the ten producers and four injectors.

(2) The values for uranium and TDS shall be the values achieved in the R&D site after the production of 65 acre-feet of water from the leach area. This is equivalent to the withdrawal of approximately six pore volumes of ground water from the leach area including a 20-foot buffer zone.

The restoration program may be terminated before the withdrawal of a total of 65 acre-feet of water if the average uranium and average TDS values do not exceed 5 mg/l and 500 mg/l, respectively, and if all other restoration criteria have been met. In any event, Exxon will continue aquifer reclamation until the uranium and TDS in all wells are reduced to no more than 22 mg/l and 2,000 mg/l, respectively.

(3) Based on 1.2 times average value in Well 0-5

(4) Based on 1.2 times average value in Well P-7

649 082

Revised 10/13/78

APPENDIX I

TO

REQUEST FOR MODIFICATION

TO MINING PERMIT 218C

URANIUM SOLUTION MINE TEST PROGRAM

HYDROLOGICAL TEST DATA

The hydrological test program for the new solution Mine R&D site consisted of conducting a long-term pump test from production well No. P-9 while monitoring fluid levels in selected offsetting wells, including all observation and monitor wells. The objectives of the test were to verify communication between the production area and each of the observation wells, test for hydraulic communication between the ore zone and the overlying and underlying aquifers, and obtain data on formation characteristics of the ore zone.

Static fluid levels were taken on September 1, 1978, and again on September 7, 1978, prior to starting the pump test. The September 1 data, Figure I-1, show a hydraulic gradient of approximately 2.5 feet of head per 100 linear feet in a northwesterly direction with the average hydrostatic level at about 4,980 feet above mean sea level. The direction of the gradient is toward Exxon's underground mine workings which are located about 4,000 feet to the northwest in Section 17.

With the exception of Well O-2, this data shows good continuity of the data across the area. After review of the well completion data on Well O-2, it was concluded that the well casing was set too high, thereby allowing communication with the overlying aquifer. Well O-2 has since been plugged and redrilled. The results of another pump test conducted to verify its communication with the production area is compared to the September 7 pump test in Table I-2.

The September 1 fluid level data indicate good isolation of the ore zone from the aquifers above and below it. Well M-1, which is completed in the overlying aquifer had a hydrostatic pressure of about 35 feet of head greater than ore zone wells located only 50 feet away. Well M-2, which is completed in the underlying aquifer, had a fluid level of 4974.9 feet above MSL which is about 4 feet below that of the ore zone wells only 50 feet away.

On September 7, the fluid levels were again taken prior to initiating the pump test. This data, plotted on Figure I-2, again show a gradient of about the same magnitude in a northwesterly direction; however, the fluid levels for all the ore zone wells had dropped 2 to 4 feet. Fluid level variations of this nature are expected to continue during the operating life of the project due to changing pumping characteristics associated with the starting and stopping of the underground mine dewatering wells and from the mining operations themselves, which are being conducted in the same aquifer. The overlying and underlying aquifers showed fluid level changes of less than one-half foot, again indicating separation of the aquifers.

The pump test to determine communication with the observation wells was initiated at 10:20 AM on September 7, by pumping Well P-9 in the R&D pattern at a rate of 4.8 gpm. Fluid level measurements were then taken for all observation and monitor wells and other selected wells at 3:00 PM that afternoon and at 11:00 AM the next morning. The results of these measurements, tabulated in Table I-1, show drawdowns of 3.4 to 5.7 feet at all observation wells except Well O-2 which has been reworked and retested. During this same period, the overlying aquifer, Well M-1, showed a slight increase in fluid level (0.3 feet) and the underlying aquifer, Well M-2, showed a slight decrease in fluid level (0.1 feet). The changes in fluid levels were insignificant at the monitor wells located only 40 to 110 feet from the pumped well, (Figure I-12 and I-13), while the observation wells located 300 to 400 feet away showed drawdowns of 3.4 to 5.7 feet, demonstrating that there is no significant communication between the ore zone and the overlying or underlying aquifers in the test site area. The test further demonstrated that all observation wells, with the exception of Well O-2 are in communication with the area to be leached. Communication between the leach area and the redrilled Well O-2 has been demonstrated by a pump test conducted October 9, 1978 (Table I-2).

The transmissivity values determined from analyses of fluid level drawdown in all the observation wells, except Well O-2, are summarized in Figure I-3. Transmissivity values ranging form 259 gallons per day per foot to 517 gallons per day per foot were calculated. The highest transmissivity values were to the northeast of the center of the R&D site, and the lowest were calculated to be to the southwest of the site. The individual drawdown plots for the observation wells are attached as Figures I-4 through I-11. Although the actual transmissivity values calculated from this test should be used with some caution as the aquifer in this area is highly influenced by the other mining operations, the relative values are believed representative of the aquifer in this area. The potential influence of other operations on the actual values is reflected in most of the drawdown plots which show the aquifer hydrostatic head recovering after about two days although pumping from the test area continued at a constant rate for a period of five days.

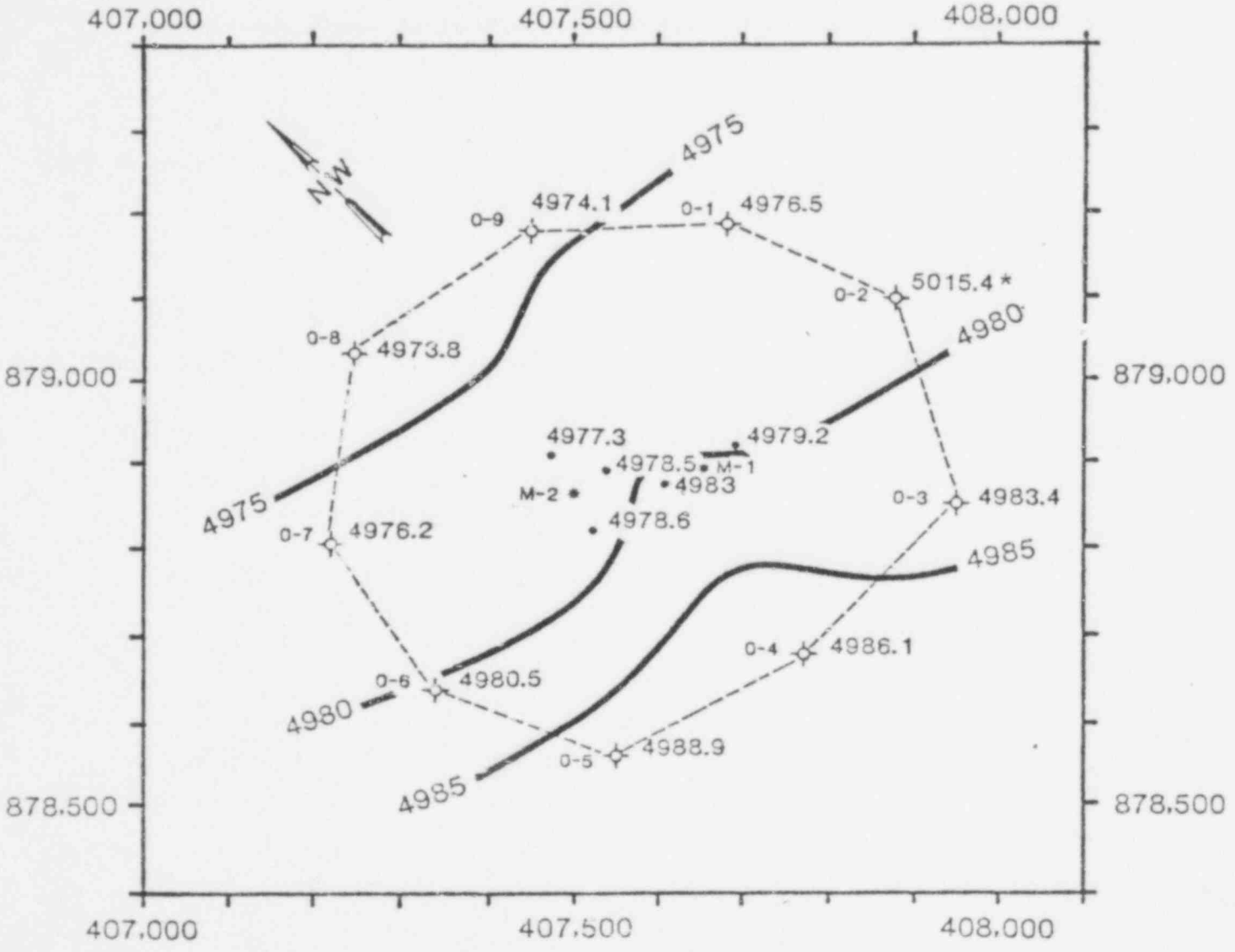
From analyses of these data, we have concluded that the leach solutions can be effectively contained in the leach area and this will be ensured by the approved monitoring program.

649 086

FIGURE I-1

STATIC FLUID LEVEL DATA, SEPT. 1, 1978

HIGHLAND SOLUTION MINE R & D PROGRAM



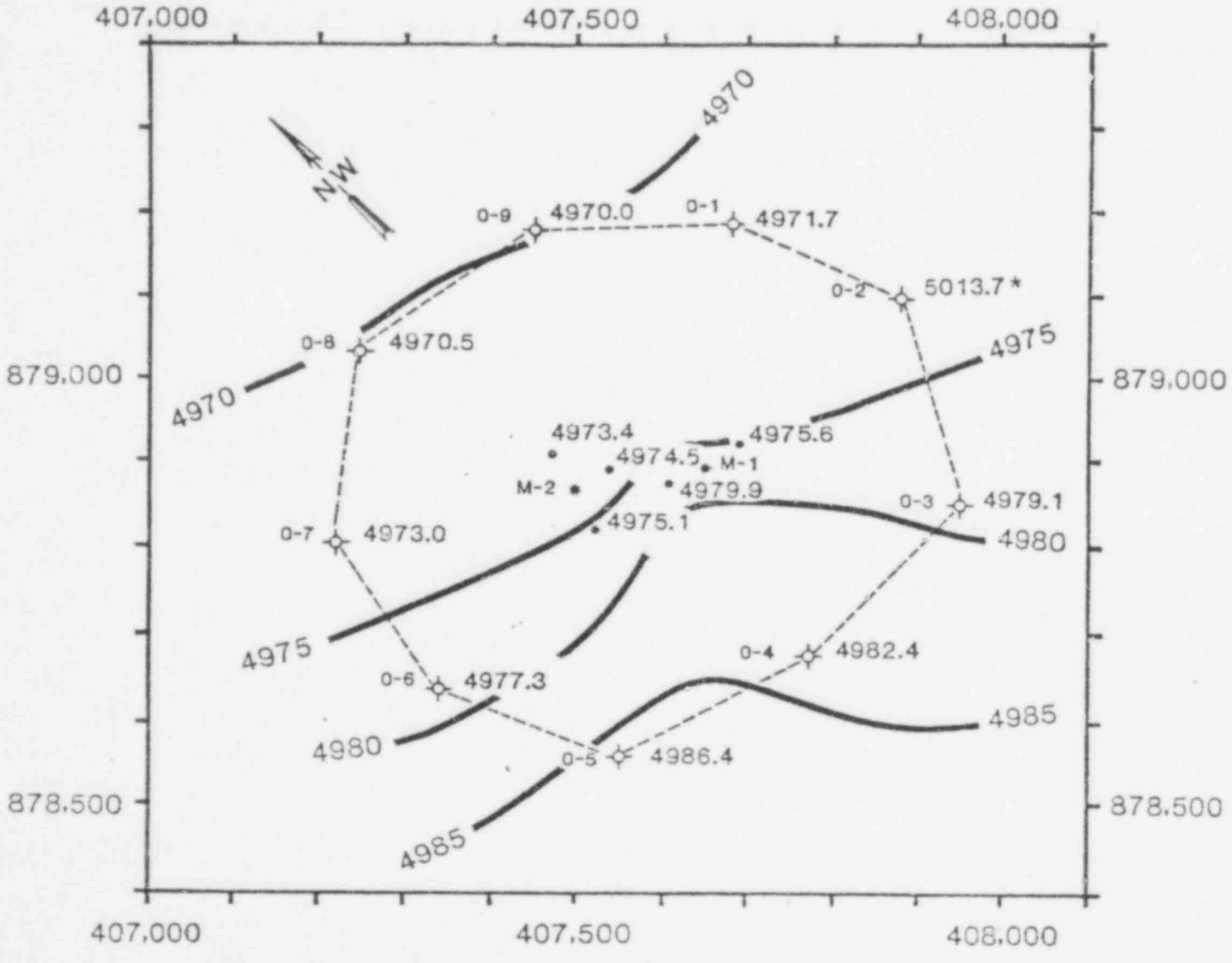
Fluid Level Data of September 1, 1978 show a hydraulic gradient in a northwesterly direction toward Exxon's underground mine workings. The upper aquifer fluid level (Well M-1) of 5016.5 feet above MSL shows a static fluid level approximately 35 feet above that in the ore zone. The lower aquifer static fluid level (Well M-2) of 4974.9 is only about 4 feet below that in the ore zone.

* Well 0-2 completion is apparently in communication with the overlying zone. The well will be reworked; therefore, it is not included in the contours.

FIGURE I-2

STATIC FLUID LEVEL DATA, SEPT. 7, 1978

HIGHLAND SOLUTION MINE R & D PROGRAM



The fluid level data shown above was taken at 9 AM on September 7, 1978, prior to starting the hydraulic pump test to verify communication between the production area and the observation wells. The overlying aquifer (Well M-1) and underlying aquifer (Well M-2) fluid levels were 5016.9 and 4975.1 respectively.

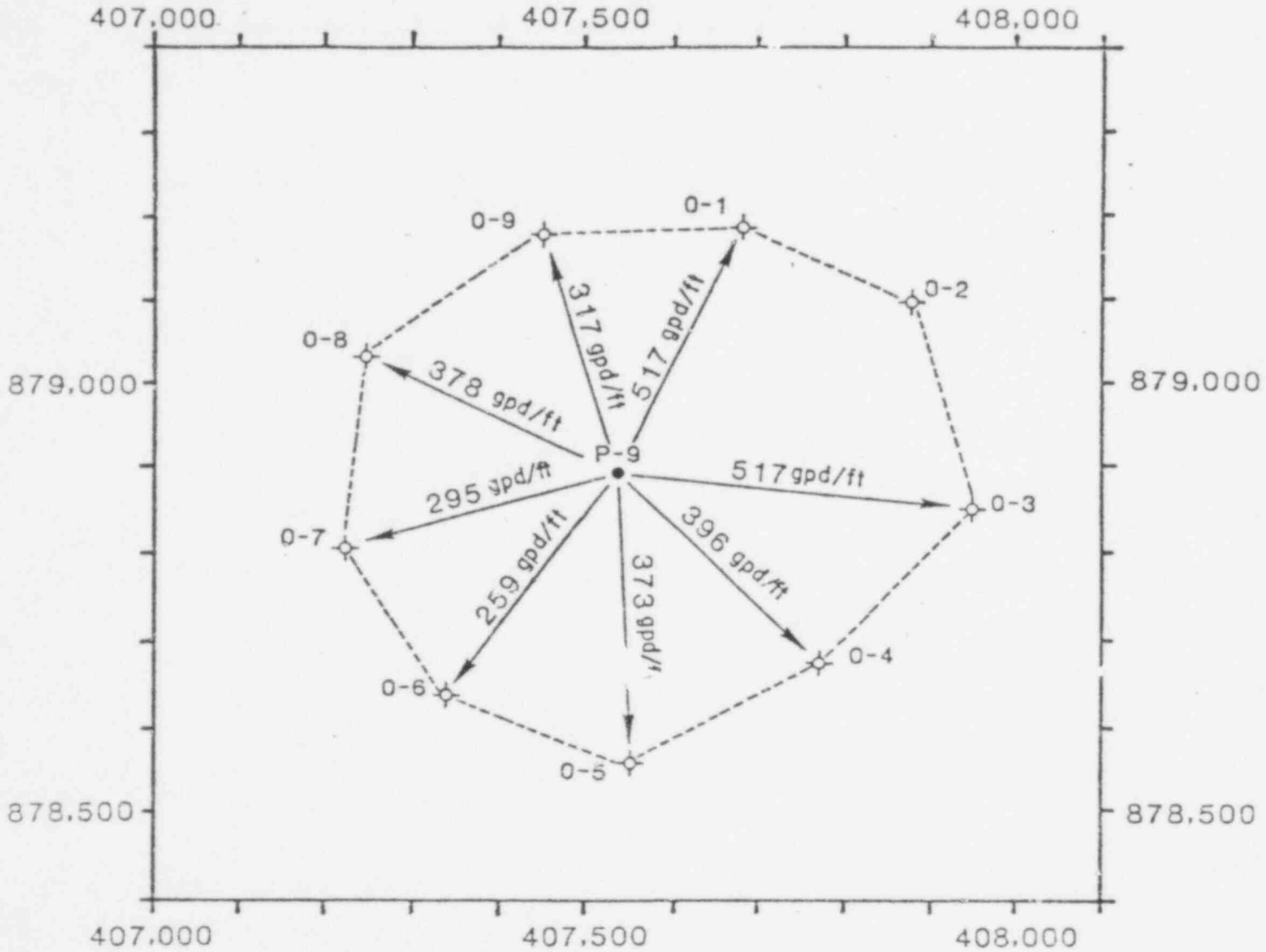
* Well 0-2 completion is apparently in communication with the overlying zone. The well will be reworked; therefore, it is not included in the contours.

649 088

FIGURE I-3

ORE ZONE TRANSMISSIVITY DATA

HIGHLAND SOLUTION MINE R & D PROGRAM

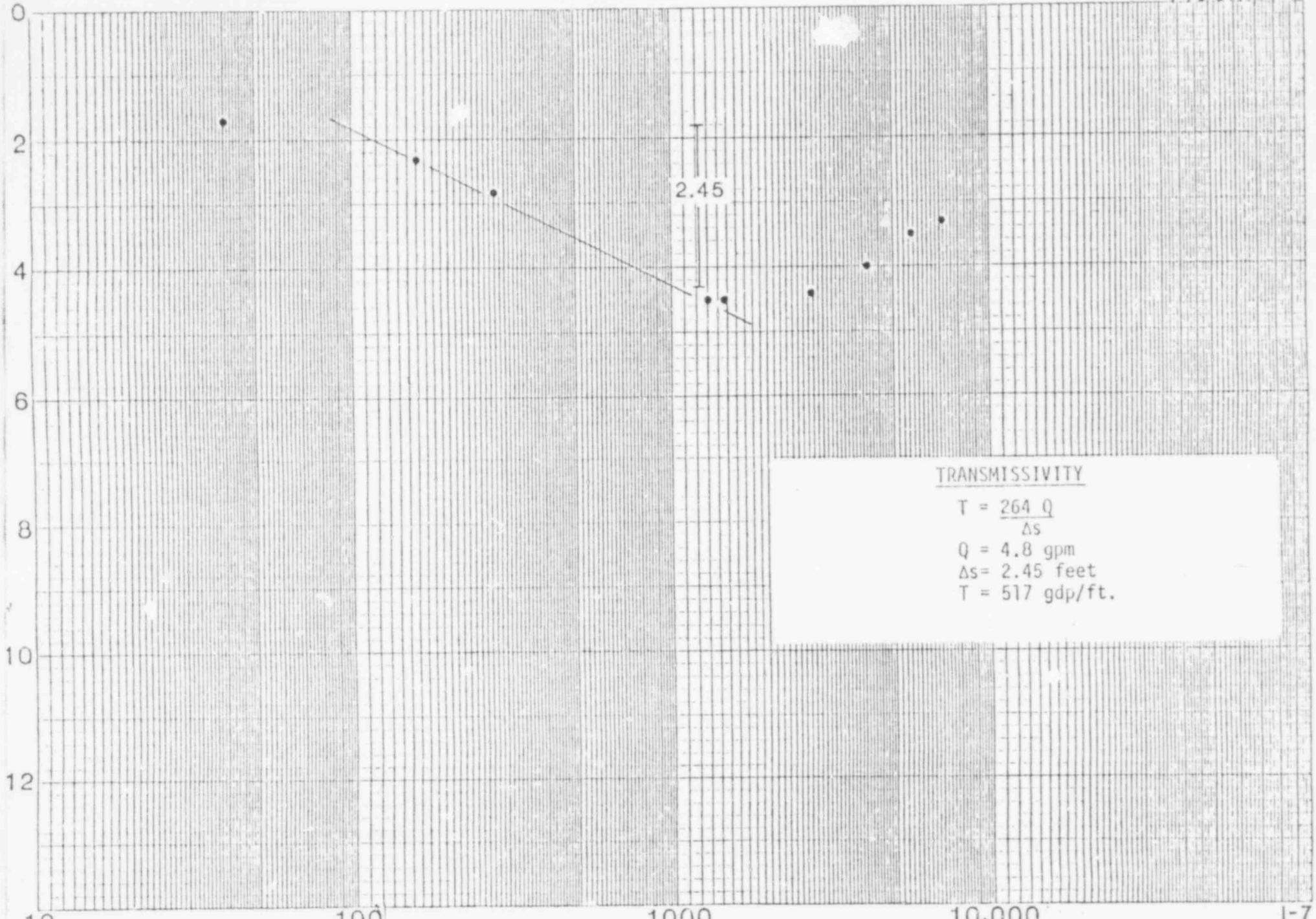


Transmissivity was calculated using field data and the equation $T = \frac{264\ Q}{\Delta s}$, where T = Transmissivity in gpd/ft., Q = pumping rate in gpm, and Δs = the change in fluid level in feet per log cycle where the drawdown is plotted against time on semilog paper. The semilog plots for the individual wells are provided in Figures I-4 through I-11.

649 089

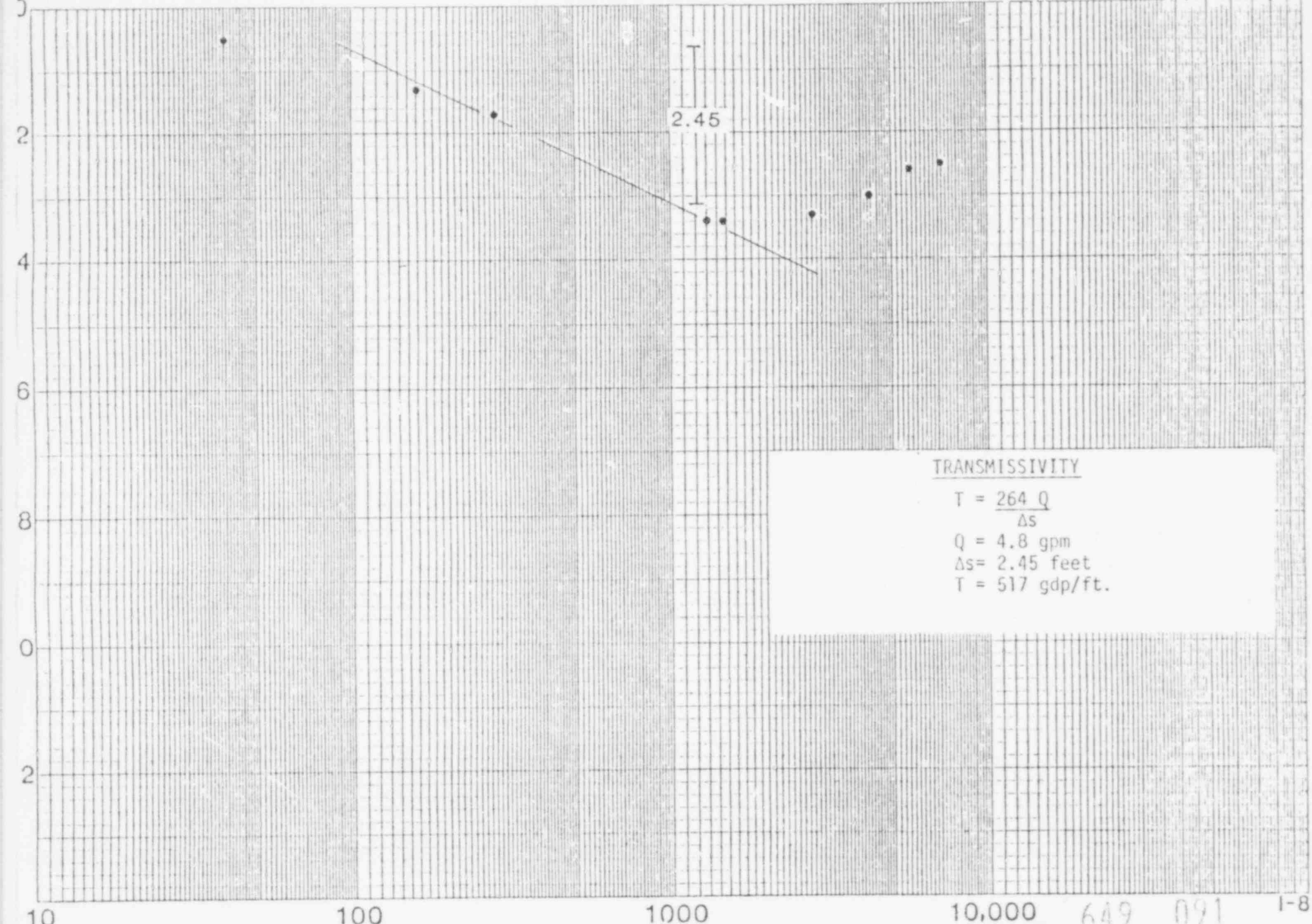
WELL O-1

FIGURE I-4



WELL 0-3

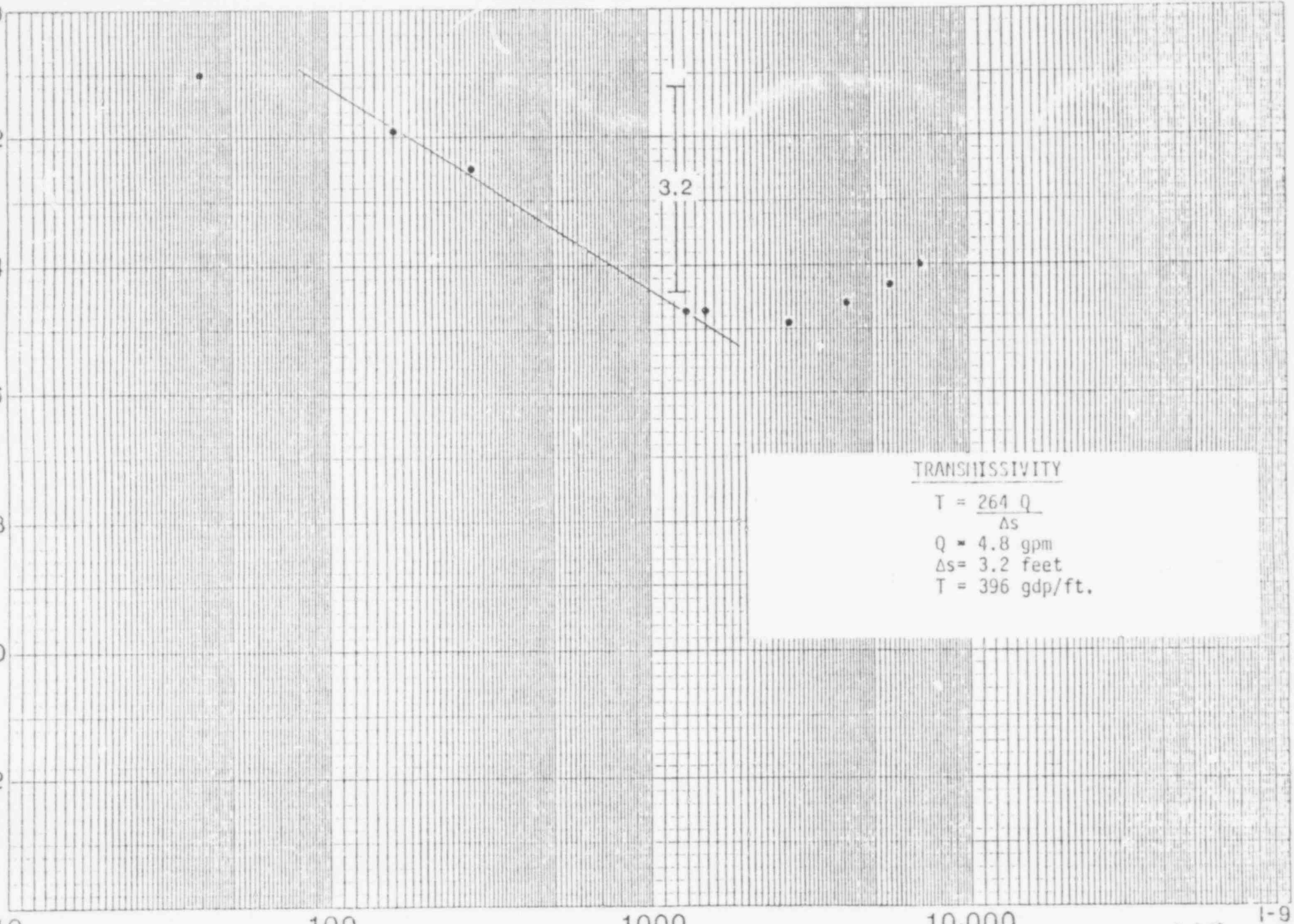
FIGURE I-5



649 091

WELL O-4

FIGURE I-6



TRANSMISSIVITY

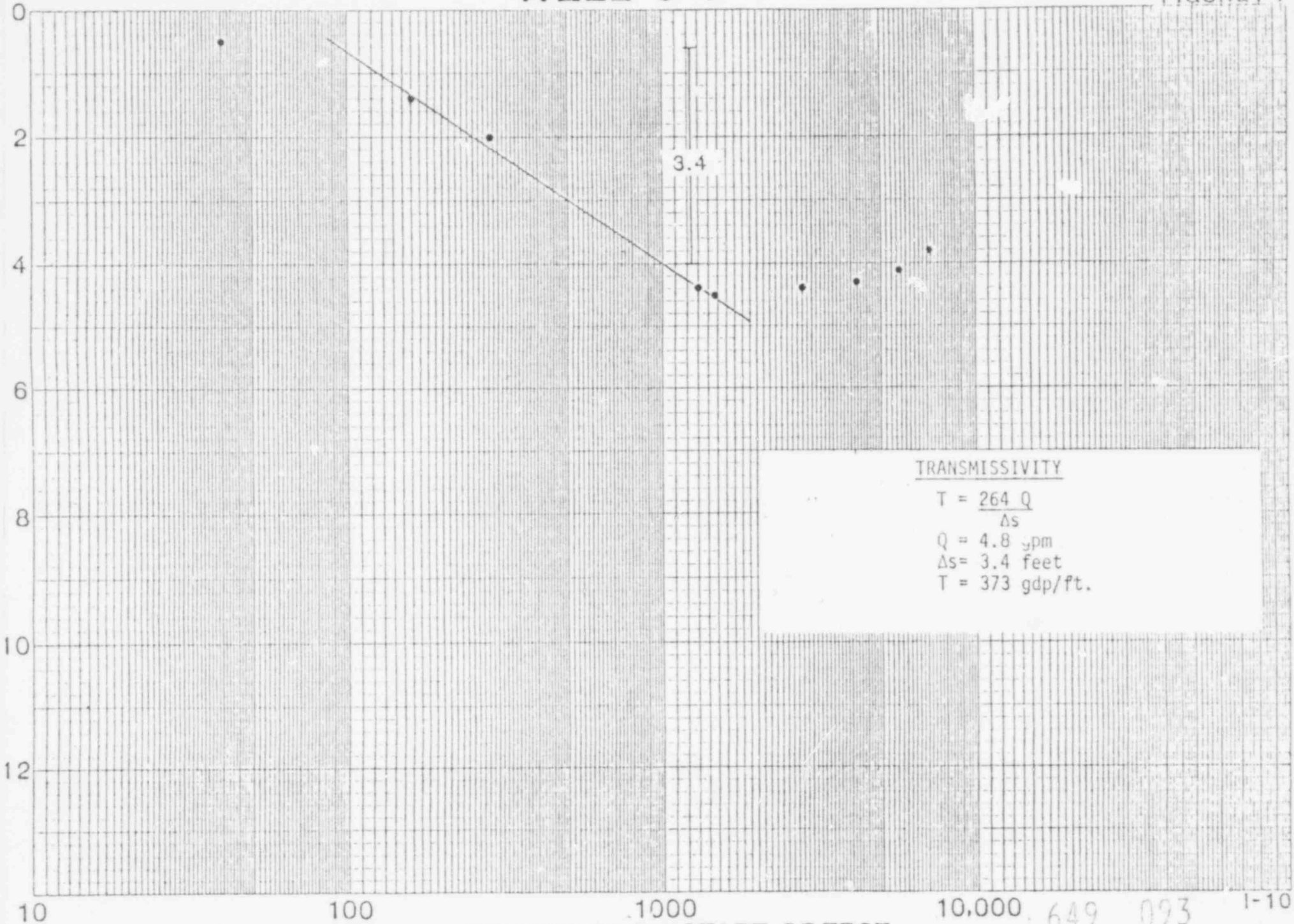
$$T = \frac{264\ Q}{\Delta s}$$

Q = 4.8 gpm
Δs = 3.2 feet
T = 396 gdp/ft.

649 092

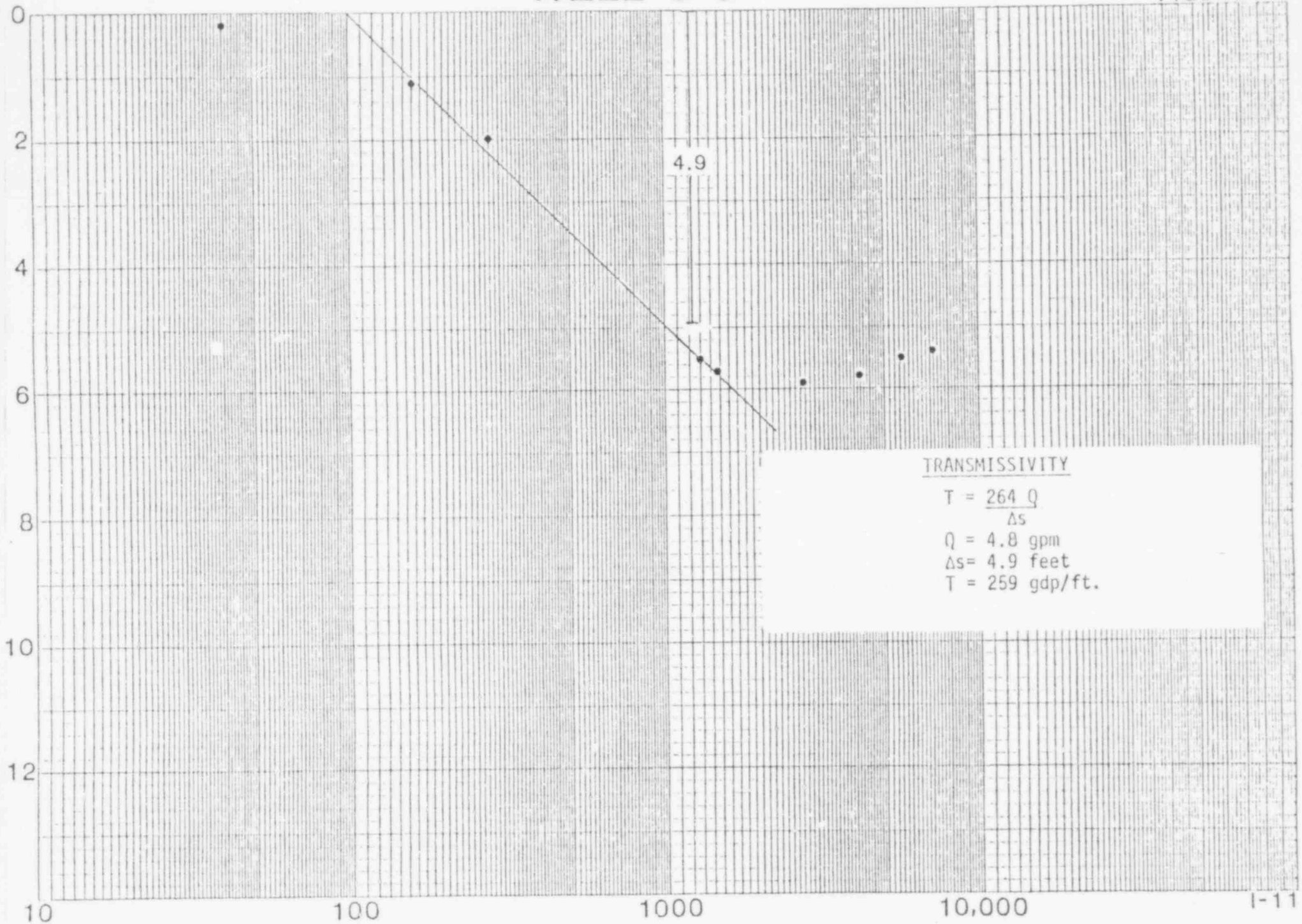
WELL 0-5

FIGURE I-7



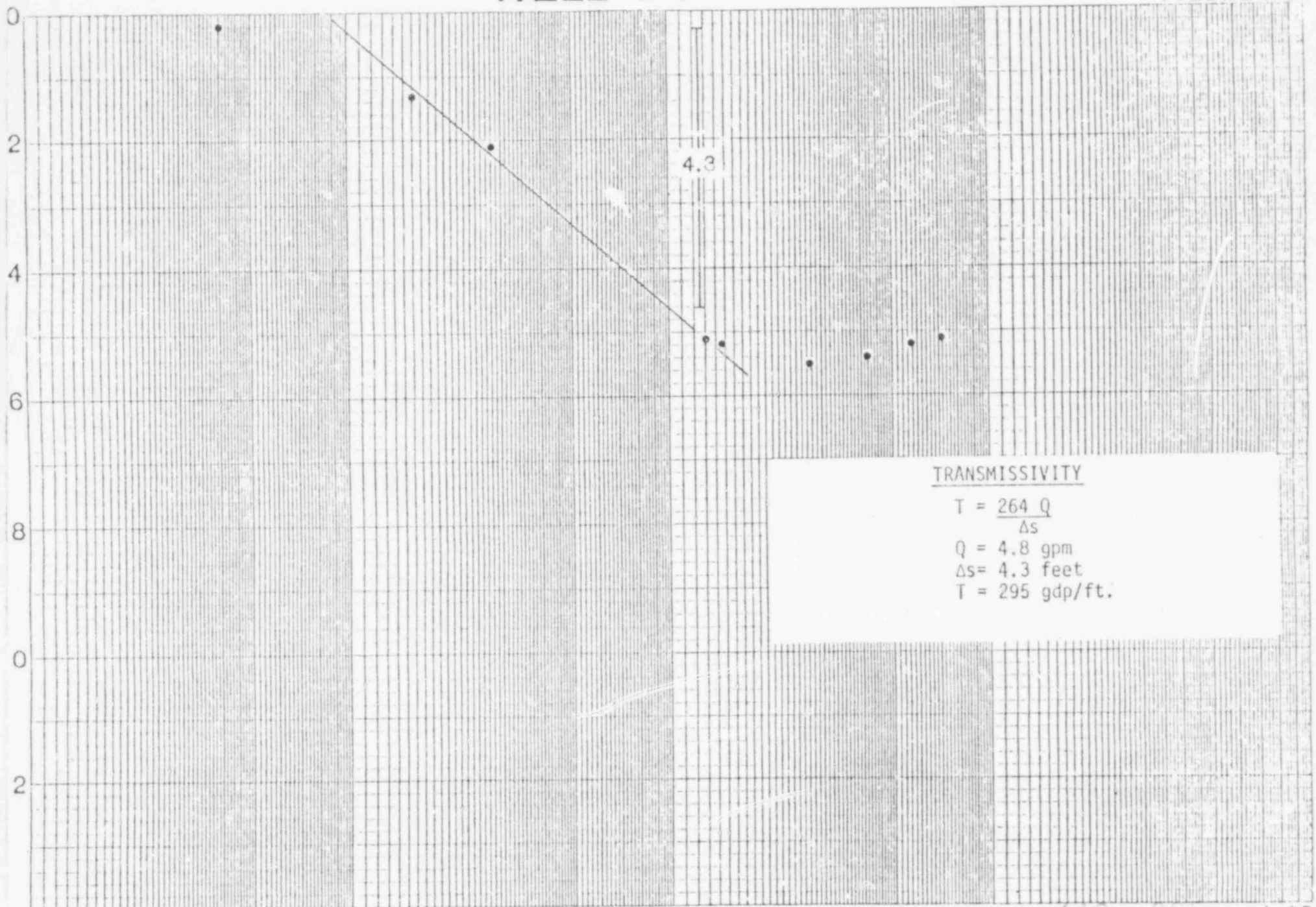
WELL 0-6

FIGURE I-8



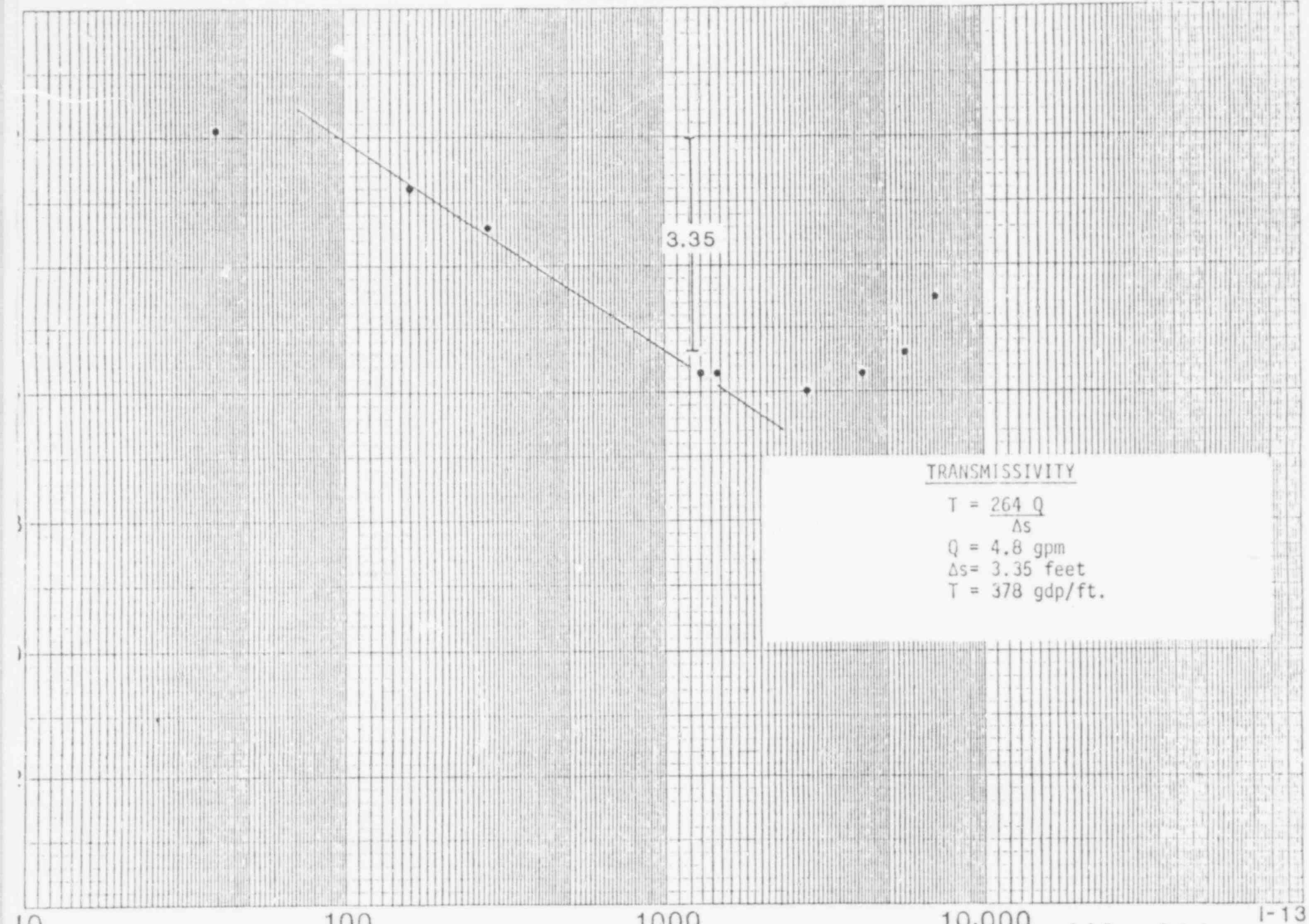
WELL 0-7

FIGURE I-9



WELL 0-8

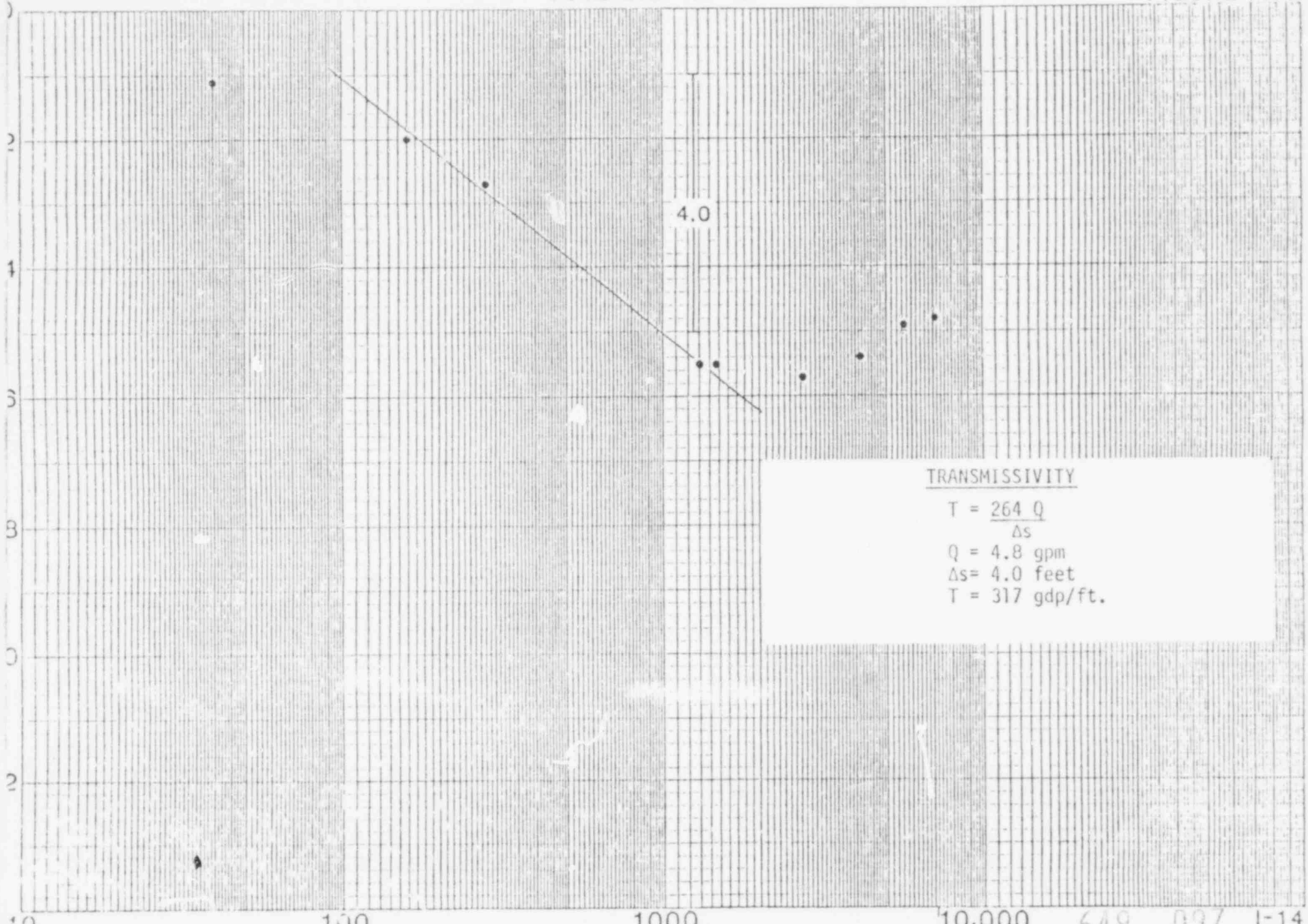
FIGURE I-10



649 096

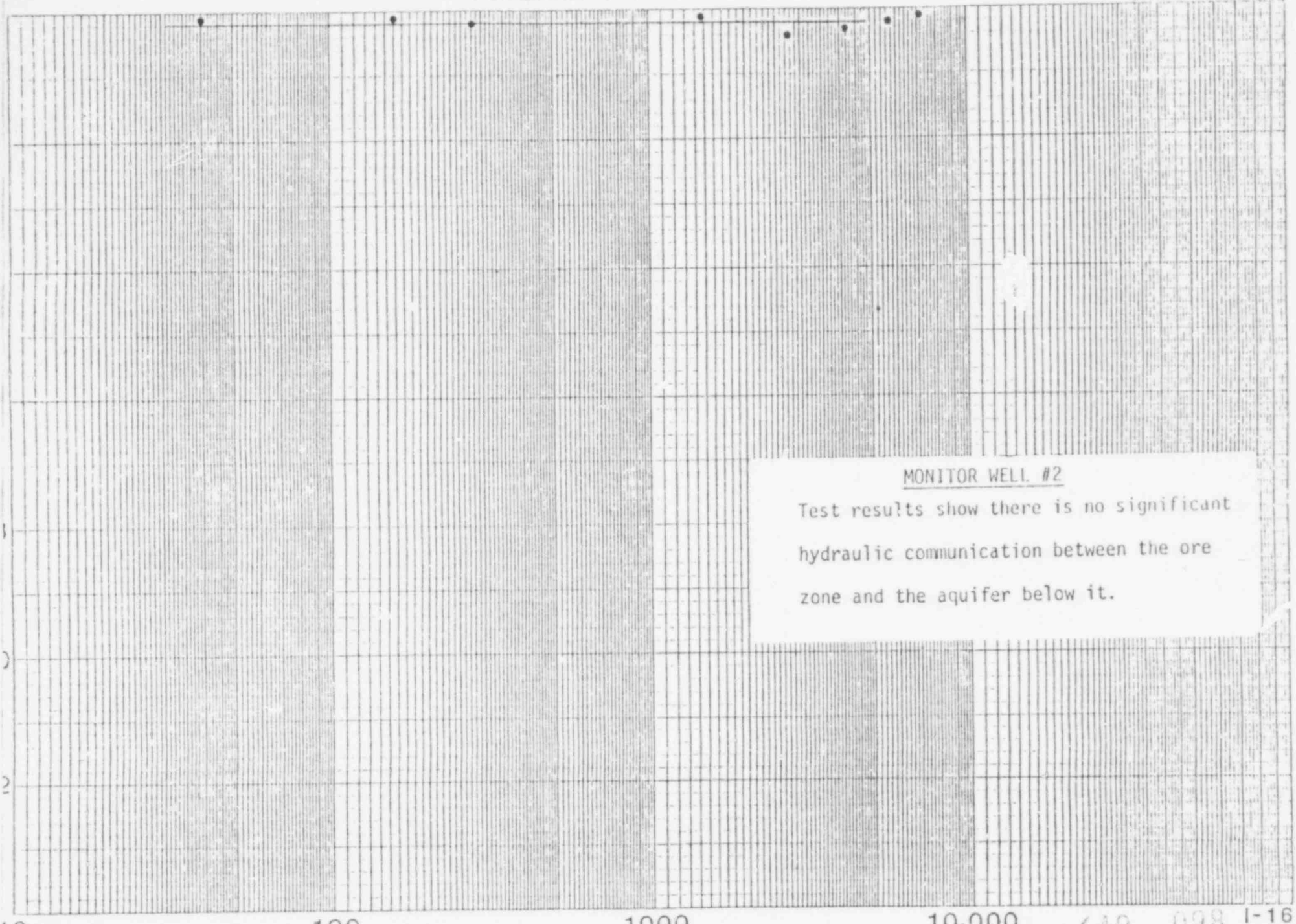
WELL 0-9

FIGURE I-11



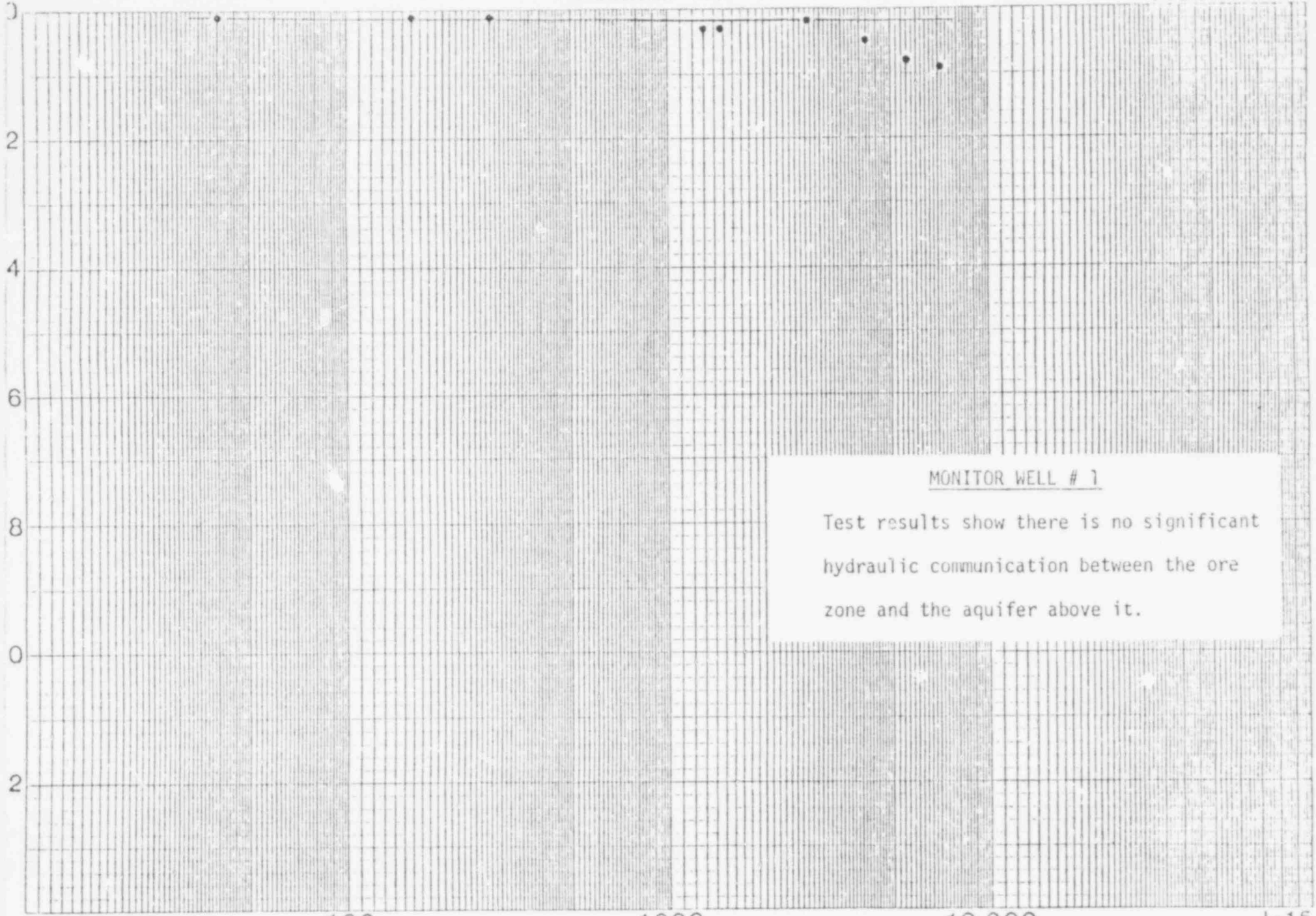
WELL M-2

FIGURE I-13



WELL M-1

FIGURE I-12



MONITOR WELL # 1

Test results show there is no significant hydraulic communication between the ore zone and the aquifer above it.

649 099

TABLE I-1

FLUID LEVEL DATA
HIGHLAND SOLUTION MINE R&D PROGRAM
CONVERSE COUNTY, WYOMING

	FLUID LEVEL ELEVATIONS - FEET ABOVE MSL					
WELL #	SEPT 1, 1978	SEPT 7, 1978[1] 9AM	SEPT 7, 1978 3PM	SEPT 8, 1978 11AM	CHANGE(2) IN FLUID LEVEL-FEET	APPROXIMATE DISTANCE FROM WELL P-9-FEET
P-9	4978.5	4974.5	4930.8	4926.7	-47.8	-
I-1	4979.2	4975.6	4967.6	4965.9	- 9.7	160
I-2	4983.0	4979.9	4975.0	4973.8	- 6.1	70
I-3	4978.6	4975.1	4963.8	4961.6	-13.5	70
I-4	4977.3	4973.4	4968.5	4965.8	- 7.6	70
O-1	4976.5	4971.7	4968.9	4967.2	- 4.5	330
O-2[3]	5015.4	5013.0	5013.9	5014.0	+ 0.3	410
O-3	4983.4	4979.1	4977.4	4975.7	- 3.4	410
O-4	4986.1	4982.4	4979.9	4977.7	- 4.7	320
O-5	4988.9	4986.3	4984.3	4981.8	- 4.5	320
O-6	4980.5	4977.3	4975.3	4971.6	- 5.7	320
O-7	4976.2	4973.0	4970.9	4967.8	- 5.2	320
O-8	4973.8	4970.5	4967.1	4964.8	- 5.7	330
O-9	4974.1	4970.0	4967.3	4964.5	- 5.5	300
M-1	5016.5	5016.9	5016.8	5017.2	+ 0.3	110
M-2	4974.9	4975.1	4974.9	4975.0	- 0.1	40

(1) Fluid level taken prior to start of pump test Well P-9 pumped at rate of 5gpm starting about 10 AM Sept. 7, 1978.
(2) Fluid level change from 9AM Sept. 7 to 11AM Sept. 8
(3) The casing in this well was set too high allowing communication with the overlying aquifer. The well will be recompleted lower or plugged and redrilled. After the rework, tests to verify communication with the production area and isolation from the overlying aquifer will be conducted.

TABLE I-2

FLUID LEVEL DATA
WELL O-2 HYDRAULIC COMMUNICATION TEST
CONVERSE COUNTY, WYOMING

Pump test results prior to redrilling Well O-2

	Fluid Level Elevations - Feet Above MSL			
Well #	Sept. 7, 1978 9AM	Sept. 7, 1978 3PM	Drawdown Feet (1)	Sept. 8, 1978 11AM (2)
O-1	4971.7	4968.9	2.8	4967.2
O-2	5013.0	5013.9	(0.9)	5014.0
O-3	4979.1	4977.4	1.7	4975.7
M-1	5016.9	5016.8	0.1	5017.2

Pump test results after redrilling Well O-2

	Fluid Level Elevations - Feet Above MSL			
Well #	Oct. 9, 1978 8AM	Oct. 9, 1978 2:45PM	Drawdown Feet (3)	Oct. 10, 1978 8AM (4)
O-1	4972.7	4960.1	12.6	4973.2
O-2	4976.9	4964.4	12.5	4976.1
O-3	4980.9	4967.2	13.7	4980.9
M-1	5017.3	5017.4	(0.1)	5017.1

(1) Drawdown after 4.7 nours of pumping Well P-9 at 4.8 gpm

(2) Pump test continuing at 4.8 gpm

(3) Drawdown after about 6 hours at pump rate of 20+ gpm

(4) Levels taken after wells were shut-in over night

649 101

TABLE I-3

MONITOR WELL FLUID LEVEL DATA
HYDRAULIC COMMUNICATION PUMP TEST(1)
HIGHLAND SOLUTION MINE R&D PROGRAM

Well No.	FLUID LEVEL ELEVATIONS - FEET ABOVE MEAN SEA LEVEL									
	9/07/78				9/08/78		9/09/78	9/10/78	9/11/78	9/12/78
	9AM	11AM	1PM	3PM	8AM	11AM	8AM	8AM	8AM	8AM
P-9	4974.5	4937.3	4934.5	4930.8	4926.7	4926.7	4929.7	4930.0	4930.9	4931.4
I-1	4975.6	4969.7	4968.5	4967.6	4965.8	4965.9	4965.7	4966.0	4966.7	4967.2
I-2	4979.9	4977.3	4975.5	4975.0	4974.3	4973.8	4972.7	4972.0	4971.4	4970.9
I-3	4975.1	4969.3	-	4963.8	4961.7	4961.6	4961.5	4961.8	4962.4	4962.5
I-4	4973.4	4971.0	4969.3	4968.5	4965.9	4965.8	4962.0	4962.0	4965.4	4965.6
O-1	4971.7	4970.0	4969.4	4968.9	4967.2	4967.2	4967.3	4967.7	4968.2	4968.4
O-2	5013.7	5014.0	5013.9	5013.9	5013.8	5014.0	5014.1	5014.4	5014.9	5015.2
O-3	4979.1	4978.6	4977.8	4977.4	4975.7	4975.7	4975.8	4976.1	4976.5	4976.6
O-4	4982.4	4981.4	4980.5	4979.9	4977.7	4977.7	4977.5	4977.8	4978.1	4978.4
O-5	4986.3	4985.8	4984.9	4984.3	4981.9	4981.8	4981.9	4982.0	4982.2	4982.5
O-6	4977.3	4977.1	4976.2	4975.3	4971.8	4971.6	4971.4	4971.5	4971.8	4971.9
O-7	4973.0	4972.8	4971.7	4970.9	4967.9	4967.8	4967.5	4967.6	4967.8	4967.9
O-8	4970.5	4968.6	4967.7	4967.1	4964.8	4964.8	4964.5	4964.8	4965.1	4966.0
O-9	4970.0	4968.9	4968.0	4967.3	4964.5	4964.5	4964.3	4964.6	4965.1	4965.2
M-1	5016.9	5016.8	5016.8	5016.8	5017.2	5017.2	5017.1	5017.4	5017.7	5017.8
M-2	4975.1	4975.0	4975.0	4974.9	4975.1	4975.0	4974.7	4974.8	4974.9	4975.0

(1) Pump test initiated at 10:20 AM 9/07/78. Well P-9 pumped at rate of 4.8 gpm for duration of test.

649 102

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Department of Environmental Quality

LAND QUALITY DIVISION

STATE OFFICE BUILDING TELEPHONE 307-777-7756 CHEYENNE, WYOMING 82002

October 26, 1978

RECEIVED
NOV 01 1978
MINERALS DEPT.

Mr. Marvin D. Freeman
Minerals Department
Exxon Company, U.S.A.
PO Box 2180
Houston, TX 77001

RE: Permit No. 218C, Solution Mining Test No. 2

Dear Mr. Freeman:

The second solution mining pilot test in Exxon's permit area in Converse County, Wyoming has been approved by this division. The test and reclamation will be conducted as detailed in the Request for Modification for Mining Permit 218C received May 12, 1978 and changes received September 28, 1978 and October 23, 1978, with the exception that a full suite of parameters as listed in the Land Quality Division Guideline No. 4 (revised 12/12/77) shall be analyzed after reclamation rather than the list of parameters in Table 1.18 (p. 63) of the Modification.

It should be stressed that if the uranium concentration in the mined aquifer is not returned to 5 ppm or less or if the TDS concentration is not returned to an average of 500 ppm or less, then aquifer restoration may not be considered successful. The approval of proposed production scale solution mines will be contingent upon the successful groundwater restoration or a positive trend towards restoration of the previous tests.

Sincerely,

Rebecca L. Mathisen

Rebecca L. Mathisen
District I Engineer

RLM:sh
cc: Jim Shannon
Ray Cooperstein
W.C. Ackerman
Roger Shaffer

649 103

EXXON MINERALS COMPANY, U.S.A.
POST OFFICE BOX 2180 · HOUSTON, TEXAS 77001

OPERATIONS DEPARTMENT

April 19, 1979

Ms. Rebecca Mathisen
District 1 Engineer
Wyoming Department of Environmental Quality
Land Quality Division
State Office Building
Cheyenne, Wyoming 82002

Dear Ms. Mathisen:

Re: Report of the First Quarter 1979
New Solution Mine Pilot Site
Converse County, Wyoming
Permit 218C

Operations at the new solution mine pilot site continued as scheduled through the 1st Quarter of 1979 with the only significant change being the initiation in February of a bleed stream equivalent to about 20 percent of the produced volume. This large bleed stream was implemented as a precautionary measure during the evaluation of a potential excursion to monitor well O-9. Fluid production and injection during the first quarter were 5.75 million gallons and 4.84 million gallons respectively. Fluid routed to the mill tailings pond during this period totaled 1.84 million gallons, about half of which was cleanup fluid produced from the old R&D site.

On January 25, indications of a potential excursion of leach fluids to monitor well O-9 was reported to your office. Analyses of samples taken from well O-9 contained bicarbonate and chloride levels above the upper control limits (UCL) for the well. As stated in the report, the cause of the elevated chloride was believed to be the result of the chloride used in the well cementing procedure and not due to the leaching operation. This high bicarbonate level, although above the UCL, was also questionable as it was below the UCL values of both offsetting monitor wells. It was expected that the data was not an indication of leach solution movement but the result of local variability in water quality due to a natural variations and/or well completion procedures. This position has been confirmed by samples taken from a well drilled approximately halfway between monitor well O-9 and the well field. If leach solution had moved out to well O-9, the new well (see Figure 1 attached) would have encountered elevated excursion parameters; however, two samples from this well had excursion parameter values characteristic of the native aquifer waters (bicarbonate: 191 and 211 mg/l; chloride: 23 and 24 mg/l; uranium: <1 mg/l). Based on this data, it has been concluded that we did not have an excursion of leach solution out to monitor well O-9 and that the UCL values for bicarbonate and chloride should be adjusted.

649 104

The new bicarbonate and chloride UCL values which will be used for monitor well O-9 are 238 mg/l and 128 mg/l respectively. These values are based on the average of the sample values recorded during March plus 20 mg/l for bicarbonate and 10 mg/l for chloride. The bicarbonate UCL value of 238 mg/l determined by this method is essentially the same as calculated by averaging the UCL values of the offsetting monitor wells (O-1 = 221 mg/l and O-8 = 252 mg/l).

In March, well O-3 analyses were indicating bicarbonate levels above the UCL value for the well similar to what had occurred in monitor well O-9. A review of the baseline data for monitor well O-3 indicated an abnormally low bicarbonate level compared to the offsetting monitor wells and production area wells. Based on the data gained from drilling the sample well between monitor well O-9 and the leach area and the similarity of the conditions, it is believed that the bicarbonate UCL value for monitor well O-3 should also be increased. The new bicarbonate UCL value which will be used for well O-3 is 224 mg/l. This value which is based on the average of the March values plus 20 mg/l compares favorably with the UCL values in the offsetting monitor wells (O-2 = 215 mg/l and O-4 = 221 mg/l).

Since we believe that the new well between well O-9 and the leach field has confirmed that there is not an excursion, the pilot injection-to-production ratio will be increased to about 0.98 and the monitor well sampling will go back to the normal frequency. This quarterly report will be the final report on the excursion evaluations previously reported on monitor well O-9 unless DEQ requests otherwise.

A plot plan of the R&D site well field, summaries of the monitor wells and sample well analyses, and an updated Table 1.17 on the UCL values are attached. If you have any questions on the attached data or require additonal data on the pilot operations, please call me at 713/656-1504.

Sincerely,

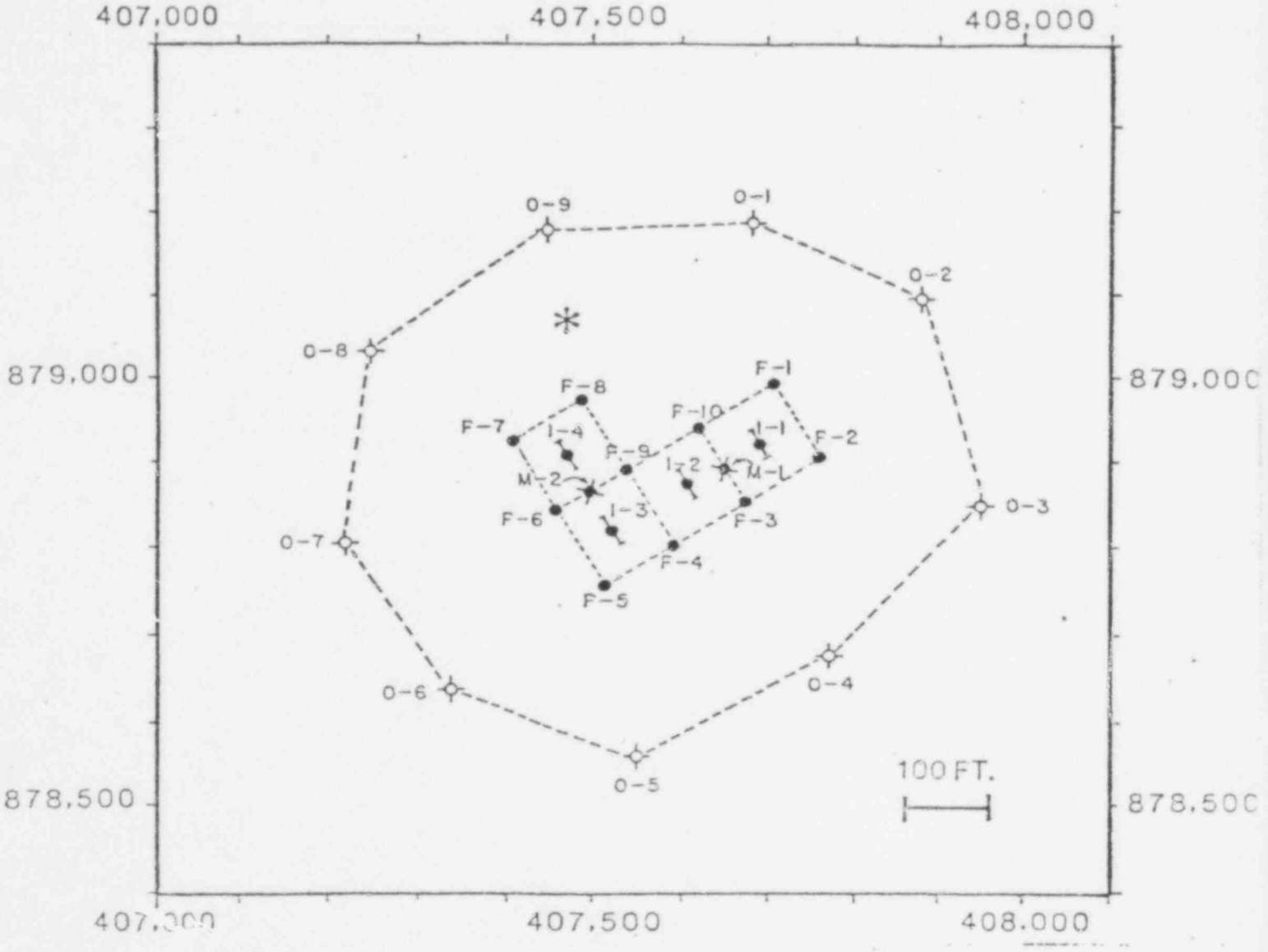
Marvin D. Freeman

MDF:dh
Attachments

cc: Mr. R. L. Bullock
Mr. R. T. Hornsby
Mr. J. D. Patton
Mr. D. M. Ringe
Mr. J. D. Shannon

FIGURE I

SOLUTION MINE WELL PATTERN
HIGHLAND R&D PROGRAM
CONVERSE COUNTY, WYOMING
(NEW PILOT AREA)



LEGEND

- PRODUCTION WELL
- INJECTION WELL
- MONITOR WELL
- NEW SAMPLE WELL LOCATION

649 106

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well O-1

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	44	221	5	24	-	-
1/12/79	<1	181	<1	8	400	8.0
1/24/79	<1	237*	<1	7	490	8.2
1/31/79	<1	204	<1	8	500	8.1
2/06/79	<1	198	1	6	500	7.8
2/15/79	<1	118	<1	6	-	7.9
2/21/79	<1	69	<1	6	240	8.3
2/28/79	<1	214	<1	6	445	7.1
3/10/79	<1	204	<1	11	355	7.5
3/13/79	6	152	<1	7	360	7.7
3/27/79	<1	204	1	7	400	8.0

All arsenic and selenium values have been <0.01 mg/l

* Over UCL

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well 0-2

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL** Value	22	240	5	40	-	-
1/16/79	<1	194	<1	9	380	7.9
1/25/79	<1	243*	<1	6	570	8.0
2/03/79	1	158	<1	21	500	7.6
2/06/79	<1	217	2	7	500	7.8
2/08/79	<1	250*	<1	7	500	7.6
2/09/79	<1	171	1	9	500	8.2
2/10/79	<1	217	<1	6	495	7.9
2/11/79	<1	283*	<1	8	510	8.2
2/12/79	<1	283*	<1	7	450	8.2
2/13/79	<1	231	<1	7	505	8.1
2/14/79	<1	198	<1	6	-	7.7
2/21/79	<1	224	<1	7	400	8.1
2/28/79	<1	228	<1	6	440	6.9
3/09/79	<1	211	<1	7	375	7.9
3/13/79	6	217	<1	6	420	7.9
3/27/79	<1	227	<1	5	400	7.9

All arsenic and selenium values have been <0.01 mg/l

* Over UCL
** Based on analyses conducted after new well was drilled.

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well O-3

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	44	224**	5	26	-	-
1/15/79	<1	119	<1	8	280	7.9
1/25/79	<1	158	<1	8	630	7.9
2/03/79	<1	158	<1	64*	450	7.7
2/06/79	<1	158	<1	10	450	7.9
2/08/79	<1	171	<1	11	450	7.8
2/09/79	<1	165	<1	10	450	8.5
2/10/79	3	184	<1	7	450	8.4
2/11/79	13	165	<1	10	475	8.6
2/12/79	3	211	<1	6	460	8.3
2/13/79	<1	185	<1	6	470	8.3
2/14/79	<1	145	<1	7	-	7.7
2/21/79	<1	184	<1	13	425	8.4
2/28/79	<1	188	<1	6	445	7.8
3/09/79	<1	211	<1	8	380	8.2
3/13/79	3	194	<1	8	395	8.1
3/27/79	<1	207	<1	5	400	8.1

All arsenic and selenium values have been <0.01 mg/l

* Over UCL

** New UCL value

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well 0-4

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	38	221	5	18	-	-
1/15/79	<1	175	<1	12	360	8.2
1/25/79	<1	217	<1	9	600	7.6
2/06/79	<1	244*	<1	10	500	8.2
2/15/79	<1	191	<1	8	-	8.3
2/16/79	<1	244*	<1	-	425	7.6
2/17/79	<1	217	<1	39*	405	7.9
2/18/79	<1	231*	<1	12	440	8.0
2/19/79	6	224*	<1	7	430	8.3
2/20/79	<1	204	<1	8	410	8.2
2/21/79	<1	211	<1	8	415	8.2
2/27/79	<1	228*	<1	8	500	8.0
3/07/79	<1	198	<1	16	448	8.5
3/13/79	3	208	<1	8	390	7.6
3/20/79	<1	211	<1	7	410	7.9
3/21/79	<1	221	<1	7	400	8.0
3/22/79	<1	228*	<1	7	390	8.0
3/23/79	<1	217	<1	7	390	7.9
3/24/79	<1	217	<1	7	390	7.9
3/25/79	<1	217	1	7	390	7.8
3/26/79	<1	228*	<1	7	390	7.9
3/27/79	<1	217	<1	7	390	7.9

All arsenic and selenium values have been <0.01 mg/l

649 110

* Over UCL

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well 0-5

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	56	[illegible]	5	30	-	-
1/15/79	<1	119	1	10	340	7.9
1/26/79	<1	152	2	11	640	7.9
2/06/79	<1	125	1	13	600	7.7
2/08/79	<1	165	1	18	610	7.7
2/09/79	<1	165	2	12	610	8.1
2/10/79	<1	171	2	10	610	8.2
2/11/79	<1	165	1	14	625	8.4
2/12/79	3	165	1	9	560	8.3
2/13/79	<1	178	1	8	520	8.1
2/14/79	<1	158	<1	8	-	7.8
2/20/79	<1	165	<1	9	510	8.1
2/27/79	<1	148	1	11	550	7.5
3/10/79	<1	132	<1	24	350	8.0
3/14/79	3	190	<1	8	510	7.7
3/27/79	<1	171	<1	8	500	7.7

All arsenic and selenium values have been <0.01 mg/l

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS REPORT
Well 0-7

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	44	240	5	90	-	-
1/14/79	13	143	<1	78	610	8.4
1/24/79	<1	119	<1	25	550	8.1
2/07/79	6	138	<1	29	450	8.4
2/15/79	<1	138	<1	12	360	9.1
2/20/79	<1	152	<1	15	395	8.5
2/27/79	<1	158	<1	16	480	7.9
3/08/79	<1	105	<1	58	380	8.4
3/13/79	10	136	<1	18	355	8.6
3/27/79	<1	145	<1	22	370	8.3

All arsenic and selenium values have been <0.01 mg/l

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well 0-8

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	44	252	5	20	-	-
1/15/79	<1	231	<1	1	410	7.8
1/24/79	<1	224	<1	7	580	7.9
1/31/79	<1	152	<1	8	500	8.0
2/06/79	<1	217	<1	10	500	7.8
2/08/79	<1	224	<1	8	510	7.9
2/09/79	<1	217	<1	6	495	8.2
2/10/79	<1	184	1	6	490	8.2
2/11/79	<1	224	<1	10	520	8.3
2/12/79	<1	224	<1	11	505	8.2
2/13/79	<1	185	<1	8	510	8.3
2/14/79	<1	217	<1	6	-	7.2
2/20/79	<1	224	<1	7	415	7.8
2/27/79	<1	237	<1	8	450	7.5
3/07/79	<1	217	<1	7	425	8.5
3/14/79	3	217	<1	5	410	7.9
3/20/79	<1	225	<1	5	400	7.5
3/27/79	<1	224	<1	5	390	8.2

All arsenic and selenium values have been <0.01 mg/l

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well 0-9

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	68	238**	5	128**	-	-
1/11/79	76*	344*	<1	190*	1500	-
1/14/79	13	283*	<1	114	1050	8.5
1/23/79	26	448*	<1	173*	-	-
1/25/79	6	237	<1	129*	1010	8.8
1/26/79	<1	200	<1	93	630	--
1/27/79	<1	100	<1	97	630	-
1/28/79	<1	200	<1	85	650	-
1/29/79	<1	200	<1	81	610	-
1/31/79	<1	171	<1	78	750	-
2/01/79	<1	171	<1	62	640	8.1
2/06/79	6	211	<1	115	850	8.5
2/15/79	<1	244*	<1	60	800	9.1
2/20/79	13	204	<1	122	840	8.7
2/28/79	<1	220	<1	138*	855	8.6
3/10/79	<1	158	<1	65	400	8.2
3/13/79	13	283*	<1	155*	780	8.4
3/20/79	19	228	<1	129*	730	8.2
3/27/79	13	201	<1	124	700	8.8

All arsenic and selenium values have been <0.01 mg/l

* Over UCL

** New UCL value

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well M-1

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	44	227	5	22	-	-
1/16/79	<1	201	<1	4	-	8.0
1/26/79	<1	165	<1	9	740	7.9
2/07/79	<1	250*	<1	12	710	7.4
2/08/79	<1	257*	<1	12	720	7.6
2/09/79	<1	191	1	13	730	8.3
2/10/79	<1	198	<1	9	720	8.3
2/11/79	<1	198	<1	10	715	8.2
2/12/79	<1	198	<1	9	715	8.2
2/13/79	<1	191	<1	29*	700	7.8
2/14/79	<1	185	<1	14	-	8.2
2/20/79	<1	198	1	8	565	8.0
2/28/79	<1	191	<1	8	660	7.3
3/09/79	<1	185	<1	10	565	8.2
3/13/79	<1	158	<1	7	500	7.9
3/27/79	<1	184	<1	9	590	8.0

All arsenic and selenium values have been <0.01 mg/l

* Over UCL

649 115

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS RESULTS
Well M-2

Sample Date	Carbonate (mg/l)	Bicarbonate (mg/l)	Uranium (mg/l)	Chloride (mg/l)	Conductivity (µmhos)	pH (Units)
DEQ UCL Value	56	190	5	36	-	-
1/16/79	7	97	<1	11	-	8.4
1/26/79	<1	132	<1	10	430	8.1
2/07/79	<1	178	<1	11	410	7.5
2/09/79	<1	178	1	12	450	7.5
2/20/79	<1	178	<1	8	390	8.3
2/28/79	<1	171	<1	10	445	8.0
3/09/79	<1	178	<1	9	370	8.2
3/13/79	13	171	<1	5	395	8.1
3/27/79	<1	178	<1	6	375	8.1

All arsenic and selenium values have been <0.01 mg/l

HIGHLAND SOLUTION MINE R&D SITE
SAMPLE ANALYSIS REPORT

Sample well between monitor well 0-9
and the leach area

	Sample Date	
	April 4, 1979	April 10, 1979
Carbonate - mg/l	6	<1
Bicarbonate - mg/l	211	191
Uranium - mg/l	<1	<1
pH	8.7	8.8
Chloride - mg/l	23	24
Conductivity - micromhos	455	470

TABLE 1.17

EXCURSION PARAMETERS FOR MONITOR WELLS
HIGHLAND SOLUTION MINE R&D PROGRAM

Well #	Bicarbonate-mg/l Range	Bicarbonate-mg/l UCL	Carbonate-mg/l Range	Carbonate-mg/l UCL	Chloride-mg/l Range	Chloride-mg/l UCL	Uranium-mg/l Range	Uranium-mg/l UCL
0-1	183-201	221	18-24	44	6-14	24	.009-.028	5
0-2(3)	195-220	240	1-12	32	8-30	40	.006-.024	5
0-3	73-204(4)	224	1-24	44	12-16	26	.002-.030	5
0-4	195-201	221	6-18	38	8	18	.006-.008	5
0-5	122-171	191	9-36	56	12-20	30	.058-8.10(5)	5
0-6	183-207	227	1-24	44	12-18	28	.025-.084	5
0-7	165-220	240	12-24	44	18-80	90	.001-.017	5
0-8	195-232	252	1-24	44	6-10	20	.010-.050	5
0-9	122-218(4)	238	24-48	68	32-118(4)	128	.008-.030	5
M-1	171-207	227	1-24	44	10-12	22	.001-.068	5
M-2	122-170	190	1-36	56	18-26	36	.001-7.00(5)	5

The conductivity and pH data have been dropped from this table as they are recorded for information purposes but are not excursion parameters.

(1) Upper Control Limit to be used to identify potential excursions.

(2) If not detected, the detection limit value of .001 is used.

(3) This data based on tests conducted after the old well was plugged and the new monitor well 0-2 was completed.

(4) Based on the average March 1979 values as discussed in the report for the 1st Quarter 1979.

(5) The single high value reported appears to be an anomaly and was not used.