ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF ENFORCEMENT

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# IMPACTS OF URANIUM MINING AND MILLING ON SURFACE AND POTABLE WATERS IN THE GRANTS MINERAL BELT, NEW MEXICO

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER

DENVER, COLORADO

REGION VI DALLAS, TEXAS

SEPTEMBER 1975

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and
REGION VI - Dallas, Texas

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## ABBREVIATIONS

| | |
|---|---|
| AEC | Atomic Energy Commission |
| gpm | gallons per minute |
| kg | kilograms |
| km | kilometers |
| l/min | liters per minute |
| $m^3$/day | cubic meters per day |
| mg/l | milligrams per liter |
| NEIC | National Enforcement Investigations Center |
| NMEIA | New Mexico Environmental Improvement Agency |
| NRC | Nuclear Regulatory Commission |
| ORP-LVF | Office of Radiation Programs-Las Vegas Facility |
| pCi/l | picocuries per liter |
| RIP | resin in pulp (ion-exchange process) |
| USPHS | United States Public Health Service |

# I. INTRODUCTION

## BACKGROUND

The United States experienced its first uranium "boom" in the early 1950's as a result of cold-war activities and the fabrication of large numbers of nuclear weapons. During that time, most of the currently-known uranium deposits were discovered by massive exploration by the U.S. government and private citizens. Many uranium mills were built at various sites throughout the west to treat the uranium ores to produce a uranium oxide called *yellow cake*.

This uranium milling was not without environmental damage. Among the first recognized water-pollution problems was in the Animas River Basin of Colorado and New Mexico. A mill at Durango, Colorado was contributing abnormally high concentrations of radium to the water supply of Aztec, New Mexico. To control radiochemical pollution resulting from uranium milling in this area, the Colorado River Basin Enforcement Conference was convened in 1960 by the states composing the Colorado River Basin. Federal, State, and industry cooperative efforts resulted in pollution control by which streams in the Colorado River Basin contained near background levels of pollutants resulting from uranium milling. Other uranium milling areas, most notably the Grants Mineral Belt, were not situated on interstate streams and thus not subject to Federal pollution control before the Federal Water Pollution Control Act Amendments were passed in 1972. Little pollution control effort was expended toward mine and mill discharges within this area.

The Grants Mineral Belt [Fig. 1], stretching west from just northwest of Albuquerque, New Mexico to the New Mexico-Arizona state line, contains almost half of the United States uranium reserves. A second uranium "boom" now underway promises to make the Grants Mineral Belt the

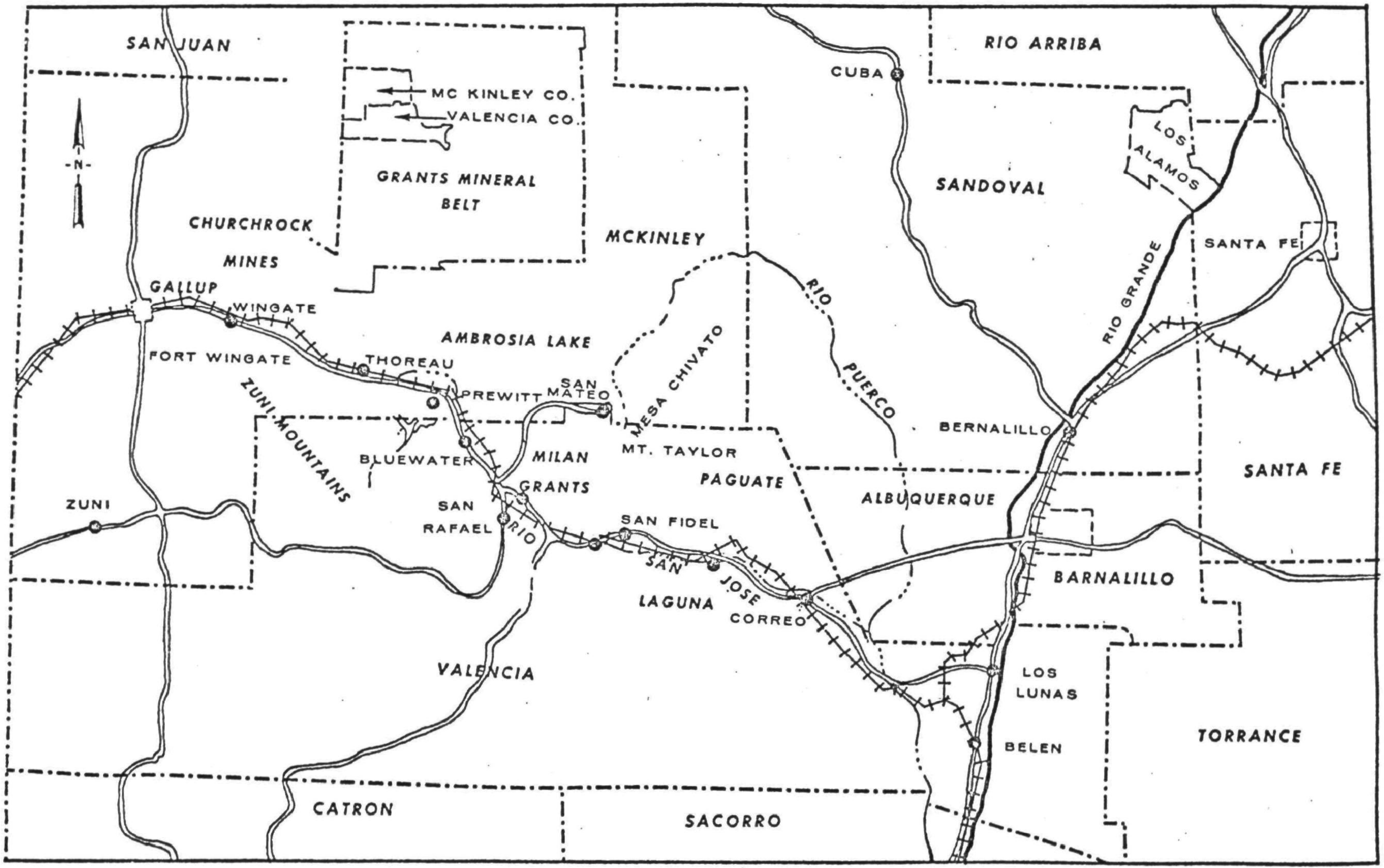

FIGURE 1. Location and General Features of the Grants Mineral Belt in Northwestern New MEXICO

foremost uranium mining and milling site in the United States. This "boom" results from the demand for nuclear fuel elements in nuclear power plants (Guccione, Aug. 1974).

## 1975 WATER QUALITY INVESTIGATION

The New Mexico Environmental Improvement Agency (NMEIA) realized that little information was available on the water discharges from mining and milling in the Grants Mineral Belt, and the subsequent effect on ground and surface water resources of the area. On September 25, 1974 NMEIA requested EPA Region VI to conduct a survey of water-pollution sources and surface and ground-water quality in the Grants Mineral Belt. The National Enforcement Investigations Center (NEIC) and the Office of Radiation Programs-Las Vegas Facility (ORP-LVF) were subsequently asked by Region VI to conduct a survey in cooperation with the NMEIA.

Studies conducted from February 24 to March 6, 1975 included industrial waste source evaluation, potable water sampling, and limited stream surveys by NEIC, and ground-water evaluations by ORP-LVF. NMEIA provided assistance to both NEIC and ORP-LVF during the survey. The three mining areas evaluated in the Grants Mineral Belt were [Fig. 1]:

| Area | Approximate Location |
|---|---|
| Ambrosia Lake | 32 km (20 mi) N of Milan, N. Mex. |
| Churchrock | 32 km (20 mi) NE of Gallup, N. Mex. |
| Paguate | 16 km (10 mi) N of Laguna, N. Mex. |

The mill sites are:

| | |
|---|---|
| Kerr-McGee | near Ambrosia Lake |
| United Nuclear-Homestake Partners | 8 km (5 mi) N of Milan |
| Anaconda | 11 km (7 mi) W of Milan |

United Nuclear Corporation operates an ion-exchange plant in the old "Phillips" mill near Ambrosia Lake. No conventional milling is currently done at this site.

As stated in a February 14, 1975 letter from the Director of NMEIA, the primary tasks of the study were to:

1. Assess the impacts of waste discharges from uranium mining and milling on surface and ground waters of the Grants Mineral Belt.
2. Determine if discharges comply with all applicable regulations, standards, permits and licenses.
3. Evaluate the adequacy of company water quality monitoring networks, self-monitoring data, analytical procedures and reporting requirements.
4. Determine the composition of potable waters at uranium mines and mills.
5. Develop priorities for subsequent monitoring and other follow-up studies.

During the survey, samples were collected from wells, industrial discharges, drinking water supplies, and surface streams. The samples were appropriately preserved to determine the radiochemical, nutrient, and metals content and shipped to the NEIC and ORP-LVF laboratories for analyses (Appendix A). NEIC custody procedures were maintained during the collection and analyses of the samples (Appendix B).

This report presents the findings of analyses of surface water streams, potable water supplies, and industrial discharges. Appendix C contains raw data for all samples collected during the survey and analyzed by NEIC. The NEIC analysis, when combined with the ORP-LVF report, will present an overall study of water quality in the Grants Mineral Belt.

## II. SUMMARY AND CONCLUSIONS

*Task:* *Assess the impacts of waste discharges from uranium mining and milling on surface and ground waters of the Grants Mineral Belt.*

1. Radium concentrations in Arroyo del Puerto, a perennial stream, exceed New Mexico Water Quality Criteria as a result of discharges from the Kerr-McGee ion-exchange plant and Sections 30W and 35 mines and from the United Nuclear-Homestake Partners ion-exchange plant. Selenium and vanadium concentrations exceed EPA 1972 Water Quality Criteria for use of the water for irrigation and livestock watering, and render the stream unfit for use as a domestic water source.

2. Rainfall and runoff at the Anaconda Jackpile Mine erode uranium- and selenium-rich minerals into Rio Paguate. This erosion can be mitigated by waste stabilization and runoff control.

*Task:* *Determine if discharges comply with all applicable regulations, standards, permits, and licenses.*

1. At the time of sampling, the effluent from the Kerr-McGee ion-exchange plant contained dissolved-radium 226 at concentrations in excess of the applicable NPDES permit and New Mexico uranium-milling license conditions. This radium discharge was partly responsible for violations of New Mexico Water Quality Standards for Arroyo del Puerto, a perennial stream. The discharge also contained uranium at concentrations in excess of NPDES permit criteria. No treatment other than settling is currently in operation.

2. The Kerr-McGee Section 30W mine discharge contained dissolved radium-226 at concentrations in excess of the applicable NPDES permit condition. No treatment other than settling is currently in operation. This radium discharge also was partly responsible for violation of New Mexico Water Quality Standards in Arroyo del Puerto.

3. Kerr-McGee Nuclear Corporation has not applied for a discharge permit for their Section 35 mine, although the effluent reaches Arroyo del Puerto, a perennial stream. The discharge contains an average of 51 pCi/l of dissolved radium-226. No radium-removal treatment is currently in operation.

4. Sampling at the United Nuclear Corportion Churchrock mine was conducted when the operation was inactive due to a power failure and subsequent mine flooding. Indications are that the present treatment facility is inadequate to meet existing NPDES permit conditions.

5. Approximatley 15 percent of the total flow through the United Nuclear-Homestake Partners ion-exchange plant is discharged to Arroyo del Puerto, with the balance of the flow returning to the mines for in situ leaching. The discharge to Arroyo del Puerto is not regulated by an NPDES permit, and it contributes to the violation of New Mexico Water Quality Standards for radium-226 in this perennial stream. Uranium is lost from the ion-exchange facility. The facility is currently violating conditions of the applicable State license.

*Task: Determine the composition of potable waters at uranium mines and mills.*

1. Four industry potable water supply systems, obtained from mine waters, exceeded 1962 U. S. Public Health Service Drinking

Water Standards for selenium. Three such potable systems exceeded both the existing USPHS and proposed EPA Interim Primary Drinking Water Standards for radium. Such mine water is supplied as potable to families of miners at the United Nuclear Corporation Churchrock mine. These conditions are considered intolerable as they bear on the long-term health of those using the supplies. Non-potable systems at the Kerr-McGee mill and Churchrock mine have high radium and selenium concentrations, and are not adequately marked as non-potable.

## III. RECOMMENDATIONS

### ACTION REQUIRED

1. Procedures be initiated to require United Nuclear Corporation to immediately provide potable water which meets Federal Drinking Water Standards for their Ambrosia Lake and Churchrock operations.

2. Procedures be initiated to require Kerr-McGee Nuclear Corporation to immediately provide potable water supplies which meet Federal Drinking Water Standards at their mill and Sections 35 and 36 mines; the mill and Churchrock mine non-potable water supplies be clearly marked.

3. NMEIA initiate appropriate action to insure safe industrial potable water supplies at the United Nuclear Corporation's Ambrosia Lake and Churchrock operations and at the Kerr-McGee Nuclear Corporation's mill and Section 35 and 36 mines.

4. NMEIA should conduct periodic sampling of potable water supplies at operating uranium mines and mills throughout the State.

5. Improved mining practices should be adopted to reduce the amount of radium leached from ore solids by ground water present in operating mines.

6. Procedures should be initiated to require Anaconda Company to improve its present efforts at stabilizing waste and ore piles at the Jackpile Mine in order to prevent water erosion from transporting uranium and selenium into Rio Paguate.

7. Procedures be initiated to require Kerr-McGee Nuclear Corporation to immediately install necessary treatment systems to reduce the dissolved radium-226 concentration in the Section 30W mine discharge to applicable NPDES permit conditions.

8. Procedures be initiated to require Kerr-McGee Nuclear Corporation to file an application for discharge from their Section 35 mine. The permit should provide limits on total suspended solids, radium-226 and uranium, consistent with the permit conditions for the Section 30W mine.

9. Procedures be initiated to require Kerr-McGee Nuclear Corporation to immediately install necessary treatment systems to ensure that effluent from their ion-exchange plant meet applicable NPDES permit and State uranium milling license conditions. The Company should develop operating schedules to guard against undetected uranium breakthrough and subsequent discharge of uranium to Arroyo del Puerto.

10. United Nuclear-Homestake Partners should install pumps and pipelines necessary to achieve complete recycle of ion-exchange discharge. If unable to achieve complete recycle, it will be necessary to issue an NPDES permit. The Company should immediately install necessary treatment facilities to comply with the applicable State uranium milling license.

## ADDITIONAL STUDIES REQUIRED

Resampling should be scheduled at the United Nuclear Corporation Churchrock mine during periods of normal operation.

# IV. DESCRIPTION OF STUDY AREA

## LOCATION

The Grants Mineral Belt extends west from a point slightly northwest of Albuquerque, New Mexico, north of the towns of Grants and Gallup, almost to the New Mexico-Arizona state line [Fig. 1]. The Belt extends about 48 km (30 mi) north from the routes of U.S. 66 and the Atchison, Topeka and Santa Fe railroad. Some mining is conducted in Valencia County, but the bulk of the Grants Mineral Belt is in southern McKinley County.

The principal centers of population in the area are the towns of Grants and Gallup, and the villages of Churchrock, Wingate, Milan, and Laguna. Population in the area has increased rapidly since 1950, with the development of extensive uranium mining and milling operations.

With the exception of the volcanically formed Mt. Taylor area, most of the area is plateau topography underlain by sedimentary rocks. Streams have incised steep-walled valleys in the area, with broad valleys in those areas underlain by easily erodable sediments.

The eastern half of the Grants Mineral Belt, including the Ambrosia Lake district, is tributary to Rio San Jose. The western portion is in the valley of the Rio Puerco, a tributary to the Little Colorado River.

## CLIMATE

The Grants Mineral Belt area is semi-arid to arid, with an average annual temperature of about 10°C (50°F). Maximum summer temperatures rarely exceed 38°C (100°F) with minimum temperatures occasionally below -18°C (0°F). The humidity in the area is usually low, and moderate to strong winds are common during the spring. Precipitation is largely influenced by elevation, with a positive correlation between increasing elevation and increasing precipitation. Annual average precipitation at the Grants Airport is 21 cm (8.3 in), approximately 70% of which occurs May through September.

## INDUSTRY

Industry in the Grants Mineral Belt used to be largely centered around farming and ranching, with limited tourism. Since 1950, the economic base of the Grants Mineral Belt area has completely shifted to industry, based on the mining and milling of uranium ore to produce yellow cake.

Underground mining operations in the Grants Mineral Belt are by the room and pillar method, which consists of driving a number of parallel development drifts in the ore horizon. A series of parallel sluicer drifts are driven at right angles, leaving a grid of ore pillars to support the overlying rock, or "roof." As the pillars are mined (robbed), the roof is rock-bolted and supported by timbers as necessary to prevent subsidence. The mined area (stope) is then abandoned.

The ore horizon in underground mines in the Grants Mineral Belt is composed of the Westwater Canyon member of the Jurassic Morrison formation, which is the main aquifer of the Grants Mineral Belt area. Therefore, large quantities of ground water must be pumped from each mine to prevent mine flooding. Ore bodies are dewatered by drilling "long holes" from the development drifts into the ore horizon, and permitting ground water to flow from the long holes into the drifts and then be pumped to the surface for discharge. Water flow is by gravity to sumps near the mine shaft, with positive pumpage to the surface. This water passes through settling basins at each mine to remove solids and then is either pumped to an ion-exchange plant for removal of contained uranium, or is discharged directly to surface water courses. Some of the ion-exchange water is recycled to the mines for use in solution mining or is used as a potable water supply for workers in the mines and mills.

Where the physical and economic situations permit, most mining companies now collect underground mine water in a single location for ion-exchange treatment to recover uranium which is dissolved in the mine water. Recovery is accomplished by using specific resins which are extremely selective in the removal of dissolved uranium. The mine water is passed through the resin column where the resin becomes *loaded* until it reaches its capacity for uranium (*breakthrough*). Flow is then diverted to another barren resin column and the loaded resin is *stripped* or eluted with a sodium chloride brine. The pregnant sodium chloride brine is then treated in one of the uranium mills to precipitate yellow cake. The barren solution is returned and reused for subsequent elution steps.

Experience has shown that a carefully operated ion-exchange plant will yield an effluent containing less than 1 mg/l uranium in solution (USEPA, April 1975). The greatest operating difficulty has been in monitoring for breakthrough of the uranium, or the loading of ion-exchange resins. Both United Nuclear Corporation and United Nuclear-Homestake Partners return a portion of the ion-exchange effluent, or *tailings,* to abandoned mines in the Ambrosia Lake area. This barren water is used to leach the ore which remained behind in ore pillars and rock which was not of ore grade. By this practice, uranium resources are recovered which would otherwise be lost.

The Anaconda Company operates its Jackpile-Paguate mine mostly as an open-pit operation. From 1953 to the present, the operation has yielded approximately 10 million tons of uranium ore with an average grade of 0.25% uranium oxide (Graves, Aug. 1974). Mining is accomplished with power shovels loading off-highway trucks. Ore is transported from the mine to Anaconda's mill by rail.

No surface discharge of water is reported from the Jackpile mine. Rainfall collects in pits and seeps or evaporates. However, intense summer thunderstorms erode piles of waste and ore.

Three uranium mills are currently operating in the Grants Mineral Belt, and several other mills are in the design or construction phase. The three operating mills practice different techniques for uranium recovery. All three operate on the basis of zero discharge of waste to surface waters by utilizing evaporation, seepage and, in one case, subsurface injection. To solubilize the uranium, two of the mills acid leach the ore while the third uses an alkaline leach circuit. Uranium is concentrated by solvent extraction at two of the mills. In all three mills, uranium is precipitated as yellow cake, a complex uranium oxide. Ammonia is used in precipitating or purifying the yellow cake at all three mills. Details on milling techniques at the three facilities are provided in the August 1974 issue of *Mining Engineering* (Vol. 26, no. 8).

# V. REGULATIONS

The discharge of wastes to surface or ground waters from uranium mining and milling operations are subject to a number of regulations. Applicable portions of each regulation are discussed below.

## NEW MEXICO WATER QUALITY STANDARDS

Water Quality Standards were adopted by the New Mexico Water Quality Control Commission under the authority of Paragraph C, Section 75-39-4 of the New Mexico Water Quality Act (Chapter 326, Laws of 1973, as amended). The NMEIA has held that general standards do apply to receiving waters in the Grants Mineral Belt. The general standard that governs these radioactive discharges follows:

> Radioactivity - The radioactivity of surface waters shall be maintained at the lowest practical level and shall in no case exceed the standards set forth in Part 4 of New Mexico Environmental Inprovement Board Radiation Protection Regulations, adopted June 16, 1973.

These regulations set a maximum concentration of 30 pCi/l of dissolved radium-226.

## NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMITS

Congress, with the passage of the *Federal Water Pollution Control Act Amendments of 1972* (PL92-500, Oct. 18, 1972) established the requirement for NPDES permits for discharge of pollutants to waters of the United States. Discharge of pollutants without a valid NPDES permit is illegal.

To date, three permits have been written covering four sources in the area studied.

| Permit No. | Outfall No. | Source |
|---|---|---|
| NM0020532 | 001 | Kerr-McGee Nuclear Corp. Sec. 30W Mine |
| NM0020532 | 002 | Kerr-McGee Nuclear Corp. Ion Exchange Facility |
| NM0020524 | 001 | Kerr-McGee Nuclear Corp. Churchrock Mine |
| NM0020401 | 001 | United Nuclear Corp. Churchrock Mine |

The first three sources are currently pending adjudication with respect to the need for an NPDES permit to discharge to Puertecito Creek or Rio Puerco.

Specific numerical limits are set for the concentration of total suspended solids (TSS), total uranium, and dissolved radium-226 [Table 1]. In addition, each permit contains the following statement:

> Provision shall be made to assure the elimination of all seepage, overflow or other sources which may result in any direct or indirect discharge to surface waters other than that authorized by this permit.

## URANIUM-MILLING LICENSES

U.S. Regulation 10CFR20 provides that all persons "who receive, possess, use or transfer ... source material" shall be controlled by general or specific license issued by the U.S. Atomic Energy Commission (now called the Nuclear Regulatory Commission) or any state conducting a licensing program. Source materials are defined as ores which contain more than 0.05% of combined uranium and thorium. Under the regulation, all ion-exchange plants and uranium mills are licensed by the New Mexico Environmental Improvement Agency.

The regulations set forth the maximum concentration of various radionuclides which are permitted in effluents to "unrestricted areas." An unrestricted area is defined as any area to which access is not

*Table 1*

*SUMMARY OF NPDES PERMIT CRITERIA*

| Company/Discharge | Period of Limitation | Parameter† | | | | | | pH Range |
|---|---|---|---|---|---|---|---|---|
| | | TSS (mg/l) | | Total Uranium (mg/l) | | Dissolved Radium-226 (pCi/l) | | |
| | | Daily | | Daily | | Daily | | |
| | | Avg. | Max. | Avg. | Max. | Avg. | Max. | |
| **Kerr-McGee Corporation** | | | | | | | | |
| Churchrock Mine | 1/28/75-6/30/77 | 20 | 30 | - | 2 | - | 30 | 6.0-9.5 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 2 | - | 3.3 | 6.0-9.0 |
| Section 30W Mine (Ambrosia Lake) | 1/28/75-12/31/75 | 20 | 30 | - | 2 | - | 150 | 6.0-9.0 |
| | 1/1/76-6/30/77 | 20 | 30 | - | 2 | - | 30 | 6.0-9.0 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 2 | - | 3.3 | 6.0-9.0 |
| Ion-Exchange Plant (Ambrosia Lake) | 1/28/75-12/31/75 | 20 | 30 | - | 1 | - | 100 | 6.0-9.0 |
| | 1/1/76-6/30/77 | 20 | 30 | - | 1 | - | 30 | 6.0-9.0 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 1 | - | 3.3 | 6.0-9.0 |
| **United Nuclear Corporation** | | | | | | | | |
| Churchrock Mine | 1/28/75-12/31/75 | 100 | 200 | - | 2 | - | 30 | 6.0-9.5 |
| | 1/1/76-6/30/77 | 20 | 30 | - | 2 | - | 30 | 6.0-9.5 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 2 | - | 3.3 | 6.0-9.0 |

† *In addition to these parameters, the companies are required to monitor flow, temperature, total molybdenum, total selenium and total vanadium.*

controlled by the licensee to protect individuals from exposure to radiation and radioactive materials. Personnel badge monitoring is not required in unrestricted areas. The maximum allowable concentration of radium-226 in a water effluent to an unrestricted area is 30 pCi/l. All uranium mills and ion-exchange plants are controlled by this regulation from the initial start-up of the facility.

## POTABLE WATER REQUIREMENTS

Congress, with the passage of the *Safe Drinking Water Act* (PL93-523, Dec. 16, 1974) extended Federal control over many potable water supply systems. Previously, only those systems used in interstate commerce were required to meet USPHS Drinking Water Standards. The latest issue of the USPHS Standards set a limit of 3 pCi/l for radium-226, and 0.01 mg/l for selenium.

The Safe Drinking Water Act applies to all public systems supplying water to fifteen service connections or at least 25 individuals unless the system is exempted by four specific criteria. The industrial potable water supply systems in the Grants Mineral Belt are thus covered by the Safe Drinking Water Act.

As required by Sections 1412, 1414, 1415, and 1450 of the Safe Drinking Water Act, the EPA Administrator, on March 14, 1975, proposed *Interim Primary Drinking Water Standards*. These proposed regulations include a limit of 0.01 mg/l selenium. The Interim Primary Drinking Water Standards are to be promulgated within 180 days of the enactment of the Act, and they become effective 18 months after their promulgation, or Dec. 1977. The EPA has proposed standards of 5 pCi/l radium (226 and 228) and 15 pCi/l gross alpha (exclusive of uranium) under the Act (Appendix D quotes the *EPA Water Quality Criteria, 1972* on selenium).

The New Mexico Environmental Improvement Agency (Sections 4 and 12, Chapter 277, New Mexico Laws of 1971) is vested with authority to maintain, administer, and enforce the "Regulations Governing Water Supplies and Sewage Disposal" adopted in 1937 by the former New Mexico State Board of Public Health.

Section 1 of the aforementioned 1937 Water Supply Regulations states:

> No person, firm, corporation, public utility, city, town, village or other public body or institution shall furnish or supply or continue to furnish or supply water used or intended to be used for human consumption or for domestic uses or purposes, which is impure, unwholesome, unpotable, polluted or dangerous to health, to any person in any county, city, village, district, community, hotel, temporary or permanent resort, institution or industrial camp.

It is from this and other sections of the 1937 regulations that the NMEIA has authority to regulate public water supply systems. However, individual residential sources used for private consumption are not covered by the 1937 regulations. Therefore, the NMEIA can only advise as to the quality of the water in the case of such residential sources.

## NUISANCE SUITS

New Mexico is given specific authority to take enforcement action against a polluter under the Nuisance statute (40A-8-1 through 40A-8-10, 1953 Compilation). A section titled Polluting Water (40A-8-2) allows the New Mexico Environmental Improvement Agency to seek remedial action against any wastewater discharger that pollutes any water of the state whether it is public or private, surface or subsurface water. In 1973 the NMEIA successfully prosecuted the City of Hobbs for polluting ground water by land disposal of the city's sewage effluent. The court order required the City to remove the polluted water and supply potable water to affected parties.

# VI. WASTE SOURCE EVALUATION

Five companies are currently engaged in mining and/or milling operations in the Grants Mineral Belt, and several other companies are presently in design or construction phases. The results of waste-source evaluations at each of the operating companies are presented below.

## KERR-MCGEE NUCLEAR CORPORATION

Kerr-McGee operates mines in both the Ambrosia Lake and Churchrock Mining Districts of the Grants Mineral Belt. Water from five of the Ambrosia Lake mines (Sections 17, 22, 24, 30 and 33)* is pumped to an ion-exchange plant at the Kerr-McGee mill [Fig. 2]. The majority of ion-exchange discharge (also referred to in the mining industry as tailings) is used in the mill as process water and non-potable water. A small remainder receives additional ion-exchange treatment for potable water use within the mill. Excess ion-exchange tailings are discharged into Arroyo del Puerto. The NPDES permit** and State uranium milling license for this discharge requires that the radium 226 concentration not exceed 100 pCi/l and 30 pCi/l, respectively. The data [Table 2] shows that this discharge contained an average of 151 pCi/l radium-226 during the survey. This exceeds both the NPDES permit immediate limitations and the State license. This latter license has been in effect since the time of the construction of the ion-exchange plant. The

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* *The names of mines are based on the section in which they are located; all of these are in T14N, R9W, McKinley County, New Mexico.*

** *Kerr-McGee has requested an adjudicatory hearing on its permits for the ion-exchange plant and Section 30W mine. The company contends that an NPDES permit is not required to discharge to Arroyo del Puerto. The Kerr-McGee State license is effective for the Kerr-McGee ion-exchange plant.*

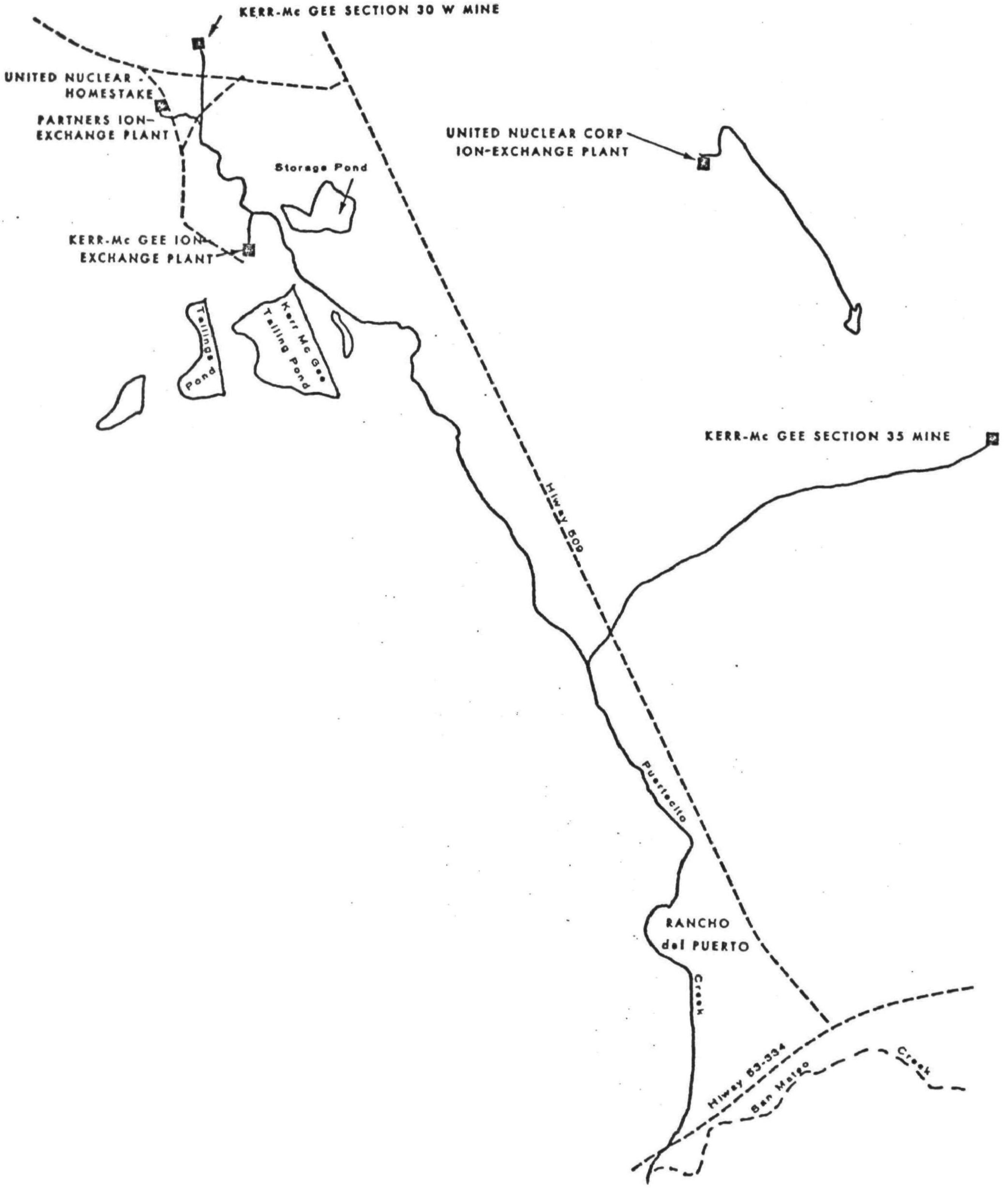

*Figure 2. Ambrosia Lake Mining District Surface Water Discharges*

### Table 3

### SUMMARY OF ANALYTICAL DATA FOR INDUSTRIAL DISCHARGES
### GRANTS MINERAL BELT SURVEY
### February 26-March 6, 1975

| Station Description | Average Flow (mgd) | Number Composite Samples | Gross Alpha (pCi/l) | | | Radium 226 (pCi/l) | | | Uranium (mg/l) | | | Total Suspended Solids (mg/l) | | | Selenium (mg/l) | | | Vanadium (mg/l) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. |
| Kerr-McGee I-X Tailings Bypass | 0.64 | 3 | 600 | 430 | 510 | 157 | 148 | 151 | 4.2 | 1.3 | 2.5 | 31 | 16 | 25 | 0.07 | 0.03 | 0.05 | 1.0 | 0.7 | 0.9 |
| Kerr-McGee Sec 30W Mine Dischg | 1.36 | 3 | 1,400 | 1,300 | 1,400 | 174 | 154 | 163 | 6.7 | 5.9 | 6.2 | 26 | 17 | 22 | 0.04 | 0.03 | 0.03 | 0.8 | 0.7 | 0.7 |
| Kerr-McGee Sec 19 Mine Discharge | 0.15 | 1 | -- | -- | 72 | - | - | 9.3 | - | - | 0.23 | - | - | 16 | - | - | <0.01 | - | - | 0.6 |
| Kerr-McGee Sec 35 Mine Discharge | 3.77 | 3 | 3,000 | 2,400 | 2.700 | 68 | 32 | 51 | 26 | 14 | 19 | 120 | 86 | 100 | 0.08 | 0.04 | 0.07 | 1.0 | 0.6 | 0.8 |
| Kerr-McGee Sec 36 Mine West Discharge | 2.07 | 3 | 850 | 570 | 680 | 178 | 101 | 131 | 3.4 | 2.6 | 3.0 | 44 | 33 | 38 | 0.01 | <0.01 | <0.01 | 1.0 | 0.8 | 0.9 |
| Kerr-McGee Sec 36 Mine East Discharge | 0.14 | 3 | 580 | 510 | 560 | 72 | 59 | 65 | 2.5 | 2.3 | 2.4 | 32 | 27 | 29 | 0.03 | <0.01 | 0.01 | 0.8 | 0.4 | 0.6 |
| Kerr-McGee Seepage below Tailings Pond | - | 1 | - | - | 144,000 | - | - | 65 | - | - | 160 | - | - | 38 | - | - | 0.70 | - | - | 5.6 |
| Ranchers Exploration-Johnny M Mine Discharge | 0.46 | 1 | - | - | 20 | - | - | 1.6 | - | - | 0.12 | - | - | 7 | - | - | <0.01 | - | - | <0.3 |
| United Nuclear Corp. Ion-Exchange Discharge | 0.08 | 3 | 2,300 | 1,400 | 1,800 | 39 | 14.3 | 31 | 11 | 5.9 | 7.8 | 7 | 3 | 5 | 0.12 | 0.02 | 0.08 | 0.5 | <0.3 | 0.3 |
| United Nuclear-Homestake Partners Ion Exchange Discharge | 0.60 | 3 | 970 | 760 | 830 | 111 | 101 | 108 | 5.8 | 2.3 | 3.7 | 16 | 7 | 10 | 0.33 | 0.30 | 0.32 | 0.5 | <0.3 | 0.3 |
| United Nuclear-Homestake Partners Tailings Pile Decant | | 1 | - | - | 29,000 | - | - | 52 | - | - | 150 | - | - | 5 | - | - | 0.92 | - | - | 6.8 |
| Anaconda Co. Injection Well Feed | 0.16 | 1 | - | - | 62,500 | - | - | 53 | - | - | 130 | - | - | 3 | - | - | 0.03 | - | - | 6.3 |
| United Nuclear Corp. Churchrock Mine Discharge | 2.06 | 3 | 870 | 730 | 810 | 27.3 | 19.8 | 23.3 | 7.6 | 6.5 | 7.2 | 71 | 33 | 50 | 0.06 | <0.01 | 0.04 | 0.5 | 0.4 | 0.4 |
| Kerr-McGee Churchrock Mine Discharge | 2.18 | 3 | 240 | 210 | 230 | 8.7 | 6.8 | 7.9 | 0.97 | 0.72 | 0.81 | 58 | 38 | 47 | 0.01 | 0.01 | 0.01 | 0.9 | 0.7 | 0.8 |

concentration of radium in the ion-exchange discharge could be reduced to meet permit conditions with the relatively simple addition of barium chloride. The New Mexico Water Quality Standards for Arroyo del Puerto, a perennial stream, limits radium concentrations to a maximum of 30 pCi/l. The Kerr-McGee ion-exchange discharge to Arroyo del Puerto contributes to violations of these standards (see Section VII. *STREAM SURVEYS*).

The NPDES permit for the Kerr-McGee ion-exchange discharge limits uranium to a daily maximum concentration of 1 mg/l. During the three days of composite sampling, the uranium concentration in the discharge ranged from 1.3 to 4.2 mg/l for an average of 2.5 mg/l, or 2.5 times the permitted maximum concentration. This violation of the permitted level probably resulted from overloading of the resin and failure to switch resin columns. The Company should adopt a regeneration cycle that will prevent resin saturation by uranium (breakthrough) which results in permit violation.

Selenium is an extremely toxic substance which behaves very similarly to arsenic. It is present in the ore of the Grants Mineral Belt, and thus it could reasonably be expected to be present in water from processing plants. The Kerr-McGee ion-exchange tailings contained from 0.03 to 0.07 mg/l, an average of 0.05 mg/l. These tailings also contained almost 1 mg/l vanadium, which has been shown to be toxic to plants when present in irrigation water. The high selenium and vanadium concentration precludes the use of Arroyo del Puerto for irrigation (discussed in Section VII).

Mine water from other Kerr-McGee Ambrosia Lake mines (Sections 19, 30W, 35, and 36) does not receive ion-exchange treatment. Section 19 Mine, currently under development, discharges approximately 378 l/min (100 gpm) of wastewater which contains 9.3 pCi/l of radium on the land surface. Since this discharge does not reach a surface water course, the Company has not applied for an NPDES permit.

The NPDES permit for the Kerr-McGee Section 30W mine imposes immediate limits on the radium-226 content of this discharge. The initial maximum limit is 150 pCi/l, with a final limit of 3.3 pCi/l [Table 1]. During the survey, this discharge contained an average concentration of 163 pCi/l of radium-226 [Table 2] which exceeds permit conditions. The discharge enters Arroyo del Puerto upstream of the Kerr-McGee ion-exchange discharge and contributes to the water quality standards violation in Arroyo del Puerto (see Section VII). The 30W discharge also contained selenium and vanadium [Table 2] and contributes to the high concentration of these elements in Arroyo del Puerto.

The uranium concentration of Section 30W mine discharge is limited to 2 mg/l daily maximum by the NPDES permit. During the survey, the uranium concentration of this discharge ranged from 5.9 to 6.7 mg/l, for an average of 6.2 mg/l, a violation of the NPDES permit conditions. The company reportedly plans to pipe this discharge to their ion-exchange plant.

During the Grants Mineral Belt survey, 14,300 $m^3$/day (3.77 mgd) of water was discharged from Kerr-McGee Section 35 mine settling ponds into a marshy area south of the mine. Company officials claim this discharge does not reach any surface water and therefore an NPDES discharge permit is not required. Visual observations by NEIC personnel showed that this discharge, estimated at several hundred gallons per minute, does enter Arroyo del Puerto. The flow rate was highly variable, depending on climatic conditions. The radium concentration in this wastewater ranged from 32 to 69 (average 51) pCi/l which exceeds limitations currently specified in permits for similar discharges. The radium concentrations can be reduced to less than 30 pCi/l with the addition of a barium chloride treatment system. Gross alpha concentrations were high, ranging from 2,400 to 3,000 pCi/l. ORP-LVF conducted analyses for the alpha emitters other than radium contained in this discharge. The analyses indicated that lead-210 may be significant in this and other discharges; however, the data are not available at this time. Uranium, selenium, and vanadium are also present in this discharge [Table 2] and contribute to high values in Arroyo del Puerto. Suspended solids in the Section 35 mine discharge were high, ranging from 86 to 120 mg/l with an average of 100 mg/l. Analysis of incoming mine water from long holes within the area indicates that the radium concentrations in natural ground water are less than 10 pCi/l. However, water moves over the entire floor of the drift, and it is subject to agitation by passage of haulage trains and during mucking. Accordingly, the suspended solids concentration in the mine water is high, producing a high dissolved radium concentration. The suspended solids and radium concentrations in the effluent could be greatly lowered by improved housekeeping in the mining operations, such as providing drainage channels along the sides of the mine workings.

Section 36 mine has two discharges, identified as the east and west discharges in relation to the mine shaft. Samples from each discharge were collected and analyzed. Except for a minor amount of water used by drilling rigs in the area, the entire mine pumpage receives treatment in sedimentation basins before discharge into a large closed basin over the San Mateo fault. During the survey, all the water was sinking into the subsurface and moving as ground water. Survey results [Table 2] show the west discharge contained an average of 131 pCi/l radium-226 compared to 65 pCi/l in the east discharge. These concentrations exceed license criteria (10 CFR20) for discharge to an unrestricted environment. The discharge also contained from 0.4 to 1.0 mg/l vanadium, which precludes use of this water for crop irrigation on acid soils, or long-term use on any soil (Committee on Water Quality Criteria, 1972).

Company officials stated that the Section 35 and 36 mine discharges will be diverted to a new set of treatment ponds for biological removal of radium 226, utilizing algal growth and radium incorporation. If necessary, radium-226 concentrations can be further reduced by barium chloride treatment. These new ponds, to be constructed sometime during 1975, will discharge into the closed basin currently receiving the Section 36 mine discharge. The increased flow into this closed basin may result in a surface discharge to San Mateo Creek. In this case, an NPDES permit will be required which should specify an immediate radium-226 limit of 30 pCi/l.

Kerr-McGee Nuclear Corporation is developing a new mine in the Churchrock mining district. The mine water receives treatment in two sedimentation ponds. Some of the effluent from the pond is used in the mine change-house for non-potable uses such as showers and commodes, and the remainder is discharged into Rio Puerco. The immediate NPDES permit limitations for this discharge include 100 mg/l daily average and 200 mg/l daily maximum total suspended solids concentration, 2 mg/l daily maximum uranium concentration and 30 pCi/l dissolved radium-226. The lack of ongoing mining activities in the mine is reflected in the relatively low radiochemical concentration in the water from this mine [Table 2], with an average radium-226 concentration of 7.9 pCi/l.

The Kerr-McGee Nuclear Corporation mill near Ambrosia Lake removes uranium from the ore by an acid leach technique, followed by solvent extraction to concentrate the uranium, and by ammonia precipitation of yellow cake. A molybdenum byproduct recovery is also practiced at the Kerr-McGee mill. Approximately 75% of the mill water is recycled, while the other 25% is lost through seepage and evaporation. Because of dissolved solids buildup, it is thought to be impossible to practice 100% recycle without dissolved solids removal techniques. Process water for the Kerr-McGee mill is obtained from the Kerr-McGee ion-exchange treatment plant. Tailings are discharged to a single large tailings pond on the company property. Seepage from the pond is collected in a catchment basin and is then pumped to a pond upgradient from the tailings pond. Overflow from this pond is pumped upstream to another pond.

In this way, all seepage from the evaporating ponds should be captured by the catchment basin. However, physical inspection of the area indicated that a quantity of seepage is lost to the subsurface, with a portion of the seepage possibly appearing in the flow in Arroyo del Puerto. This will require control under proposed NMEIA ground-water regulations, or regulations to be proposed under the U.S. Safe Drinking Water Act.

An 8-hr composite was collected from the catchment basin and analyzed to determine the quality of waste which might enter the ground water. The sample contained 144,000 pCi/l and 65 pCi/l, respectively, of gross alpha and radium-226. The radium concentration exceeds the AEC license criteria (30 pCi/l) for discharge to a nonrestricted environment. The gross imbalance which exists between gross alpha and radium indicates high concentrations of other alpha emitters. Identification and quantification of these emitters, and the effect on ground water, is discussed in the report by ORP-LVF. This water is extremely high in sulfate (15,000 mg/l) due to the use of sulphuric acid for leaching the Kerr-McGee ore. Suspended solids concentration in the seepage was approximately 38 mg/l. Selenium was present in 0.70 mg/l concentration, or 70 times the drinking water standard. Vanadium was present in the seepage at a concentration of 5.6 mg/l.

## RANCHERS EXPLORATION AND DEVELOPMENT CORPORATION

Ranchers Exploration is currently developing the Johnny M. mine. Mine water is treated in two settling ponds before being discharged into San Mateo Creek. An NPDES permit application was filed by Ranchers Exploration, however the permit had not been issued at the time of the survey. The data [Table 2] show that the gross alpha and radium-226 concentrations were 20 and 1.6 pCi/l, respectively. This reflects the lack of ongoing mining activities in the operation. Uranium concentration in the water was 0.12 mg/l, while the suspended solids concentration was 7 mg/l.

## UNITED NUCLEAR CORPORATION

United Nuclear Corporaton has three mines (two active and one on standby) in the Ambrosia Lake area. All mine water is pumped to an ion-exchange plant for uranium recovery. Over 99% of the ion-exchange effluent is used for solution mining. The remainder is either used as potable water or is discharged into a holding pond for use in sand backfill operations. There was no discharge from the pond at the time of the survey. Although an application has been filed, company officials stated that wastewater does not reach Arroyo del Puerto; therefore an NPDES permit is not required.

Samples were collected from the ion-exchange effluent at a point ahead of its return to the underground mines. The ion-exchange effluent contained an average of 31 pCi/l radium-226 and 1,800 pCi/l of gross alpha. Suspended solids concentration in the ion-exchange discharge were from 3 to 7 mg/l. As shown in Table 2, selenium concentration ranged from 0.02 to 0.12 mg/l, for an average of 0.08 mg/l.

United Nuclear Corporation also operates an underground mine in the Churchrock mining district. The NPDES permit limits the radium-226 concentration to a maximum of 30 pCi/l. Other NPDES permit criteria include 100 mg/l of suspended solids daily average, 200 mg/l suspended solids daily maximum, and 2 mg/l uranium daily maximum. A power failure at the mine during the last week in February resulted in flooding of work areas. During the survey, company personnel were pumping out the mine and repairing underground equipment. Composite samples collected during the clean-up operations contained an average radium-226 concentration of 23.3 pCi/l. After the survey, NMEIA personnel collected a grab sample on 14 March 1975 following the resumption of mining activities. This sample contained 57 pCi/l of radium-226 which exceeds the permit limitation. The composite samples contained from 33 to 71 mg/l suspended solids concentration, while the later grab sample contained 320 mg/l suspended solids. Uranium was present in the discharge at an average concentration of 7.2 mg/l. Additional sampling is suggested to check for NPDES compliance, once the mine returns to typical operation.

## UNITED NUCLEAR-HOMESTAKE PARTNERS

The United Nuclear-Homestake Partners joint venture operates four underground mines (Sections 15, 23, 25 and 32) in the Ambrosia Lake mining district. Uranium in the mine water is removed in an ion-exchange plant. About 85% of the effluent is recycled through the mines and used for in situ leaching (solution mining). The remaining 15% (0.08 mgd) of the ion-exchange effluent is discharged into Arroyo del Puerto upstream of the Kerr-McGee mill. An NPDES application has recently been filed for this discharge. During this survey, the radium-226 concentration in this discharge exceeded 100 pCi/l. The radium-226 concentration in this discharge can be reduced to 30 pCi/l or less with the addition of a barium chloride treatment system. These high concentrations exceed the NPDES permit issued for similar discharges and the State uranium milling license currently in effect for this facility. This discharge contributes to the violation of the New Mexico Water Quality Standards for Arroyo del Puerto (see Section VII).

Suspended solids concentration in the United Nuclear-Homestake Partners ion-exchange discharge are low, ranging from 7 to 10 mg/l. Selenium concentrations range from 0.30 to 0.33 mg/l, more than 30 times the drinking water standard for selenium. These concentrations would pose a health hazard if the water were used for a potable supply.

The presence of a large supply of clear water suggests an attractive alternative to plant personnel bringing their own drinking water to the plant. Uranium concentrations averaged 3.7 mg/l, indicating a need for closer monitoring of resin loading, or more frequent resin regeneration.

The United Nuclear-Homestake Partners Uranium mill recovers uranium by alkaline leaching of the ore, followed by ammonia precipitation of yellow cake. No ion-exchange or solvent extraction is practiced. Tailings-pile decant water is recycled through the mill. Seepage from the pile also enters ground water as determined by visual observation and ORP-LVF sampling. A sample of the decant, which is indicative of the quality of the seepage, contained 29,000 pCi/l and 52 pCi/l, respectively, of gross alpha and radium-226. The radium concentrations exceed the 10CFR20 criteria for discharge to a nonrestricted environment. The seepage also was found to contain 0.92 mg/l of selenium, or 92 times the drinking water standard. This is indicative of the geochemistry of selenium, which is found to be highly mobile in alkaline solutions. Results of the seepage on ground water are discussed in the ORP-LVF report.

Additional samples have been collected from a number of wells in the area downgradient from the United Nuclear-Homestake Partners tailings pond and are currently undergoing analyses. Problems of interlaboratory agreement are being resolved by appropriate Analytical Quality Control (AQC) programs. AQC data for the NEIC determinations are included in Appendix A. Results to date indicate that alkaline leaching of uranium milling tailings or uranium ore produces water high in a mobile form of selenium, and it presents definite problems of groundwater pollution. Seepage control measures should be required at this facility. Additional laboratory analysis of existing samples, and additional sampling to define the extent of the problem are planned for the near future.

## ANACONDA COMPANY

The Anaconda Company operates the world's largest open pit uranium mine, the Jackpile Mine on the Laguna Indian Reservation. There is no discharge of mine water to Rio Paguate or Rio Maquino. Precipitation runoff from the disturbed land surface, however, adds radiochemical-bearing solids to these streams. Stream samples [Table 3] show a definite increase in radium-226 and selenium concentrations downstream from the mining operation. The data show the need for stabilization of waste material and improved handling of storm runoff.

The Anaconda Company uranium mill at Bluewater uses a Resin In Pulp (RIP) ion-exchange process on an acid leach operation (Anon, Aug. 1974). In this circuit, baskets of ion-exchange beads are agitated in a crushed slurry ore. The beads, when loaded, are eluted with a dilute solution of sulfuric acid and sodium chloride. Uranium is precipitated in two steps, with the addition of calcium hydroxide during the first step and magnesium hydroxide during the second step. This precipitate is then washed with ammonium sulfate to remove sodium and produce a saleable yellow cake.

Process wastes from the Anaconda mill are discharged into a 70-acre tailings pond constructed on a highly permeable basalt flow. The water which does not seep from this pond is decanted, filtered to remove suspended solids, and fed at a rate of 1,100 l/min (300 gpm) to an injection well. A sample of the well feed, which is indicative of the seepage to the ground water, contained 62,500 pCi/l and 53 pCi/l, respectively, of gross alpha and radium-226 [Table 2]. Vanadium was present in a concentration of 6.3 mg/l. The well feed contained 150 mg/l uranium, which corresponds to a uranium loss of 245 kg (540 lb)/day. At present values of yellow cake, this would have a market value of $8,100 to $10,800/day. This uranium could be recovered by the installation of an ion-exchange plant between the present filter and injection well.

# VII. STREAM SURVEYS

When the mines and mills were evaluated, selected stream stations were sampled to determine the effect of mine and mill discharges on water quality. The New Mexico Water Quality Standards limit the radium concentration in surface streams to a maximum of 30 pCi/l. Data on the samples collected from surface streams are provided in Table 3.

## ARROYO DEL PUERTO

Arroyo del Puerto receives waste from the United Nuclear-Homestake Partners and Kerr-McGee ion-exchange plants and from Kerr-McGee Section 30W and 35 mines. There is no flow in the creek upstream of these discharges.

Radium-226 concentrations of samples collected downstream from the Kerr-McGee mill were from 45 to 50 pCi/l. These concentrations not only violate the New Mexico Water Quality Standards, but exceed the AEC criteria (30 pCi/l) for radium in water discharged to an unrestricted environment. Radium concentrations in Arroyo del Puerto decreased near the mouth to levels ranging from 6.1 to 7.2 pCi/l. This decrease is due to the adsorption of radium on sediment and/or vegetation. During periods of heavy run-off, the radium concentration can be expected to increase due to scouring of the stream bed.

The selenium concentration of Arroyo del Puerto downstream from the Kerr-McGee mill was 0.15 mg/l, decreasing to 0.04 mg/l near the mouth. Vanadium concentrations in Arroyo del Puerto near the Kerr-McGee mill averaged 0.8 mg/l, increasing to 1.1 mg/l near the mouth. Selenium and

## *Table 3*

### *SUMMARY OF ANALYTICAL DATA FOR SURFACE WATER SAMPLING*

| Station Description | Number of Samples | Gross Alpha (pCi/l) | | | Radium-226 (pCi/l) | | | Uranium (mg/l) | | | Selenium (mg/l) | | | Vanadium (mg/l) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. |
| Arroyo del Puerto downstream of Kerr-McGee Mill | 3 | 1,700 | 1,400 | 1,500 | 50 | 45 | 47 | 12 | 5.0 | 7.7 | 0.16 | 0.13 | 0.15 | 1.0 | 0.6 | 0.8 |
| Arroyo del Puerto near the mouth | 3 | 1,500 | 750 | 1,100 | 7.2 | 6.1 | 6.5 | 6.6 | 4.7 | 5.8 | 0.07 | 0.01 | 0.04 | 1.9 | 0.5 | 1.1 |
| San Mateo Creek at Highway 53 Bridge | 1 | - | - | 1,000 | - | - | 1.09 | - | - | 4.7 | - | - | 0.02 | - | - | <0.3 |
| Rio Puerco downstream of Churchrock Mines | 3 | 500 | 470 | 490 | 2.60 | 0.97 | 2.04 | 5.0 | 3.8 | 4.2 | 0.07 | 0.03 | 0.04 | 0.6 | 0.5 | 0.6 |
| Rio Puerco upstream of Wingate Plant | 3 | 510 | 720 | 440 | 1.63 | 0.36 | 0.81 | 4.8 | 3.7 | 4.2 | 0.01 | 0.01 | 0.01 | 0.9 | 0.3 | 0.6 |
| Rio Puerco at Highway 666 Bridge | 3 | 350 | 210 | 260 | 0.42 | 0.09 | 0.22 | 2.5 | 1.7 | 2.0 | <0.01 | <0.01 | <0.01 | 0.6 | 0.3 | 0.5 |
| Rio Paguate at Paguate | 1 | - | - | 2.8 | - | - | 0.11 | - | - | <0.02 | - | - | <0.01 | - | - | 0.6 |
| Rio Moquino upstream of Jackpile Mine | 1 | - | - | 11.2 | - | - | 0.17 | - | - | <0.02 | - | - | <0.01 | - | - | 1.8 |
| Rio Paguate at Jackpile Ford | 1 | - | - | 270 | - | - | 4.8 | - | - | 1.2 | - | - | <0.05 | - | - | 0.5 |
| Rio Paguate at Paguate Reservoir Discharge | 1 | - | - | 230 | - | - | 1.94 | - | - | 1.1 | - | - | <0.01 | - | - | 0.6 |
| Rio San Jose at Interstate Bridge | 1 | - | - | 38 | - | - | 0.37 | - | - | 0.10 | - | - | <0.01 | - | - | 0.3 |

vanadium have harmful effects when present in high concentrations in water used for irrigation or livestock watering. The 1972 EPA Water Quality Criteria (Committee on Water Quality Criteria, 1972) suggests that irrigation waters not exceed 0.02 mg/l selenium and 0.1 mg/l vanadium, while livestock waters should not exceed 0.05 mg/l selenium and 0.1 mg/l vanadium. On this basis, Arroyo del Puerto is rendered unfit for irrigation and livestock watering by the uranium mining discharges throughout its entire length. This is contrary to New Mexico Water Quality Standards which require that discharges not render a water unfit for a beneficial use.

The flow of Arroyo del Puerto enters San Mateo Creek where the entire flow enters the aquifer within three miles of the confluence. This recharge adds a large loading of radium and selenium to the ground water. Ground-water evaluations by ORP-LVF will address this question.

## RIO PUERCO

The Rio Puerco receives drainage from Kerr-McGee and United Nuclear Corporation Churchrock mines. Samples collected downstream from these discharges contained a maximum radium-226 concentration of 2.6 pCi/l [Table 3]. The concentration decreased to 0.4 pCi/l at the town of Gallup. These concentrations meet the New Mexico Water Quality Criteria of 30 pCi/l, as well as the PHS Drinking Water Standard of 3 pCi/l for radium-226. Selenium concentrations downstream from the mine discharges ranged from 0.03 to 0.07 mg/l for an average of 0.04 mg/l, or four times PHS Drinking Water Standards. The selenium concentration decreased downstream to 0.01 mg/l at the Wingate plant and to less than detection limits at Gallup.

## RIO PAGUATE, RIO MOQUINO, RIO SAN JOSE

The Rio Paquate and Rio Moquino flow through the Anaconda open pit mines on the Laguna Indian Reservation. The combined flow enters Rio San Jose near Laguna, New Mexico. Samples collected from these three streams had radium concentrations of less than 5 pCi/l, which is less than the Water Quality Standard of 30 pCi/l set by the State of New Mexico. An increase in the selenium concentration of Rio Paguate was noted downstream from the Jackpile Mine. However, the concentration of selenium at Paguate reservoir and in Rio San Jose were less than detection limits.

## VIII. INDUSTRIAL WATER SUPPLIES

The majority of the mines and mills in the Grants Mineral Belt use mine water as a potable supply. The present PHS Drinking Water Standards specify that the radium concentrations not exceed 3 pCi/l, and the selenium not exceed 0.01 mg/l. The *Safe Drinking Water Act* (Public Law 92-523, Dec. 16, 1974) requires establishment of national drinking water standards. The proposed standards limit selenium to 0.01 mg/l. Also, EPA has proposed standards of 5 pCi/l for radium-226 and -228 and 15 pCi/l for gross alpha (40 CFR 141).

Data from potable water supplies in the Grants Mineral Belt are summarized in Table 4. All but one of the water-supply systems contain radium-226 in concentrations greater than the PHS Drinking Water Standard of 3.0 pCi/l. Severe violations of the 0.01 mg/l selenium standard are also present. Kerr-McGee Nuclear Corporation supplies water to mill workers and to several mobile homes within the area; the source is ion-exchange water from the mines, subsequently treated for radium removal. As shown in Table 4, the radium concentration in this water was at an acceptable level of 0.5 pCi/. The selenium in the water supply was 0.05 mg/l, or 5 times the drinking water standard. Treatment or an alternate source of supply will be required to meet the selenium standards.

Kerr-McGee operates a dual water supply system within the mill and the office facility -- a potable system described above, and a non-potable system used for washing and sanitary facilities. The latter uses ion-exchange tailings without further treatment. Radium concentrations in this water are extremely high, averaging over 150 pCi/l. Company personnel are largely uninformed about the existence of the dual water supply system and have admitted to drinking from the non-potable

*Table 4*

### *SUMMARY OF DATA FOR INDUSTRY POTABLE WATER SUPPLIES*

| Description | Gross Alpha (pCi/l) | Radium 226 (pCi/l) | Selenium (mg/l) |
|---|---|---|---|
| Kerr-McGee - Mill Water Supply | 510 | 0.5 | 0.05 |
| Kerr-McGee - Sec. 35 and 36 Mines | 3,000 | 43 | 0.05 |
| Kerr-McGee - Churchrock Mine† | 120 | 6.5 | 0.01 |
| United Nuclear Corporation - Ambrosia Lake Area | 1,500 | 23.5 | 0.11 |
| United Nuclear Corporation - Churchrock | 620 | 12.6 | 0.06 |
| United Nuclear Corporation - Mobile Home Supply at the Churchrock Mine | 1,110 | 39.7 | 0.06 |

† *Reportedly used only for showers, stools, etc. and not for drinking water.*

source. Warning signs should be posted on the non-potable water system to prevent subsequent potable use of this radioactive water.

Water from the Kerr-McGee Section 35 mine is treated by ion-exchange and used for a potable system for workers in Section 35 and 36 mines. This water contained a radium concentration of 43 pCi/l and a gross alpha concentration of 3,000 pCi/l. This exceeds existing and proposed standards for radiochemistry in the potable supply. The selenium in this supply was 0.02 mg/l, twice the level which constitutes grounds for rejection as a water supply under Drinking Water Standards.

Clarified water from the settling ponds at the Kerr-McGee Churchrock mine are pumped into the Kerr-McGee change house for use in sanitary facilities. The water contained concentrations of radium-226 approximately twice the Drinking Water Standards. It also contained selenium at a concentration of 0.01 mg/l, or the concentration which constitutes grounds for rejection as a potable water supply. The supply is not intended as potable, but it is not adequately marked as non-potable.

United Nuclear Corporation maintains a potable water supply system for its Churchrock mine as well as for mobile homes within the area. Water from the mine is pumped into a holding pond on Sunday, when mining activities are not under way. Water from this holding pond is then passed through a filter for removal of suspended solids. No further treatment is given. A sample collected from a water fountain within the United Nuclear Corporation change-house contained 12.6 pCi/l radium-226 and 0.06 mg/l selenium. These levels exceed PHS Drinking Water Standards and proposed standards under the Safe Drinking Water Act. The system is supplied to a number of private trailers in the area, and it clearly will come under the provision of the Safe Drinking Water Act.

A sample was collected on March 5, 1975 from one of the mobile homes supplied by the United Nuclear Corporation Churchrock mine water-supply system. The sample contained 39.7 pCi/l radium-226 and 0.06 mg/l selenium. The trailer was occupied by the wife and three children of one of the uranium miners. These concentrations grossly exceed the proposed and present drinking water standards and pose a health hazard to the employees and their families. The United Nuclear Corporation should take immediate action to improve the quality of this domestic supply or locate an alternate source of water.

# REFERENCES

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3. Graves, John A., Aug. 1974, Open Pit Uranium Mining, *Mining Engineering*, SME-AIME 26, 8:23-25.

4. Guccione, Eugene, Aug. 1974. Fuel Shortages Trigger a New Uranium Rush in New Mexico, *Mining Engineering*, SME-AIME, 26, 8:16-19.

5. U. S. Environmental Protection Agency, Apr. 1975. Draft Development Document for Effluent Limitations, Guidelines, and Standards of Performance for the Ore Mining and Dressing Industry Point Source Category, USEPA Contract No. 68-01-2682.

# Appendix A

# ANALYTICAL QUALITY CONTROL
FIELD AND LABORATORY PROCEDURES

# ANALYTICAL QUALITY CONTROL
# FIELD AND LABORATORY PROCEDURES

## WASTE SOURCE EVALUATIONS

Mining and milling operations operated by five companies were investigated during the Grants Mineral Belt survey. Information was obtained through in-plant surveys, review of NPDES permit applications, and interviews with industry personnel, on water pollution control practices at each site.

Sampling was conducted in accord with a previously prepared Study Plan (attached). Sampling proceeded as planned, except that conditions at United Nuclear Corporation's Churchrock mine were atypical due to power failure and subsequent mine flooding. Daily composite samples were collected manually into large cleaned containers on an equal volume basis. The composite sample was then returned to a central sample preparation site where individual samples were prepared in accord with Table 4 of the Study Plan. Company sample splits were prepared where requested. Filtering was done through a 0.45 μ filter, using stainless steel pressure filtering equipment.

Where available, industry flow-measurement equipment was used. In other cases, various standard flow measurement techniques such as "V" notch weirs and stage recorders were used.

The samples were maintained under custody procedures and transported to the NEIC laboratory in NEIC vehicles.

## STREAM SURVEYS

Limited stream surveys were conducted to determine the effects of mining and milling discharges on surface waters of the Grants Mineral Belt. Sampling was generally in accord with the Study Plan, except where there was no flow. Sampling in the Paguate area was restricted to one-time grab sampling. Sample preparation was in accord with the discussion in the previous section.

## INDUSTRY WATER SUPPLIES

Grab samples were collected from industry potable and non-potable (sanitary) water supplies, in accord with the Study Plan. Sampling sites were at water fountains, faucets, or showers. The source was permitted to run for a time before sample collection. Samples were subsequently split and preserved, as discussed in the section on waste source evaluation.

## ANALYTICAL PROCEDURES AND QUALITY CONTROL

Samples collected during this survey were, for the most part, analyzed according to procedures outlined in the EPA Manual, *Methods for Chemical Analysis of Water and Wastes, 1971*. Gross alpha and radium-226 levels were measured according to procedures described in *Standard Methods for Water and Wastewater Analysis, 13th Ed.* Uranium was measured by the fusion/fluorescence procedure described as Method #D2907-701 in the *ASTM Manual, Part 31, 1975*. Selenium was analyzed by a fluorometric procedure developed by Crenshaw and Lakin (Journal Research U.S. Geological Survey, 2 (4), 483 (1974)); the fusion step was omitted, however, since the samples were non-geological in origin. These analytical procedures are summarized below.

| Parameter | Method | Reference |
|---|---|---|
| Co, Cu, Fe<br>V, Mo | Atomic Absorption[1] | EPA Methods for Chemical Analysis, 1971 |
| Na | Atomic Emission[1] | EPA Methods for Chemical Analysis, 1971 |
| As | Colorimetric | EPA Methods for Chemical Analysis, 1971 |
| TSS, TDS | Gravimetric | EPA Methods for Chemical Analysis, 1971 |
| $SO_4$ | Turbidimetric | EPA Methods for Chemical Analysis, 1971 |
| Cl | Titrimetric | EPA Methods for Chemical Analysis, 1971 |
| $NH_3$ | Automated Colorimetric | EPA Methods for Chemical Analysis, 1971 |
| $NO_2 + NO_3$ | Automated Cadmium Reduction | EPA Methods for Chemical Analysis, 1971 |
| Gross | Internal Proportional Counting | Standard Methods, Section 302.4.a. |
| Radium-226 | Radon emanation[2] | Standard Methods, Section 305 |
| Uranium | Fusion/Fluorescence[1] | ASTM, D290F |
| Se | Fluorometric | Crenshaw and Lakin, J. Res. U.S. Geol. Survey, Vol. 2, No. 4, July-August, 1974, p. 483-487 |

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[1] *Digestion of samples per Sec. 4.1.4. EPA Methods*

[2] *$RaSo_4/BaSO_4$ precipitate collected by centrifugation, dissolved in diethylenetriamine pentaacetic acid, and placed directly in bubbler.*

Reliability of the analytical results was documented through an active Analytical Quality Control (AQC) Program. As part of this program, replicate analyses were normally performed with every tenth sample to ascertain the reproducibility of the results. In addition, every tenth sample was spiked with a known amount of the constituents to be measured and reanalyzed to determine the percent recovery. These results were evaluated in regard to past AQC data on the precision, accuracy, and detection limits of each test. As an example, AQC results for Ra-226 and Se are tabulated on the following page.

| Parameter | Radium-226 | Selenium |
|---|---|---|
| Detection Limit | 0.05 pCi/l | 0.005 mg/l |
| Percent Difference in Duplicate Measurements | 0-1 pCi/l: 0-52% 22% Avg.† | 0-0.1; 0-30%, 21% Avg. |
| | 1-200 pCi/l: 0-8%, 5% Avg. | 0.1-1.0: 9-32%, 15% Avg. |
| Percent Recovery from Spiked Samples | 1-200 pCi/l: 79-104%, 93% Avg. | 0-0.1 mg/l: 60-134%, 109% Avg. |

† *0-1 pCi/l represents the concentration range being considered, 0-52% represents the range of the percent difference between duplicates, and 22% represents the average of these variations.*

On the basis of these findings, all analytical results reported for the survey were found to be acceptable with respect to the precision and accuracy control of this laboratory.

# STUDY PLAN

## NEW MEXICO URANIUM MINING AND MILLING WATER QUALITY INVESTIGATIONS

### OBJECTIVES

1. Determine the impact of previous and existing discharges to ground and surface waters of the Grants-Mineral Belt and establish a data base for future National Pollutant Discharge Elimination System (NPDES) permits and uranium mining and milling license guidelines due to expanded mining and milling activities.

2. Determine whether the discharges from uranium mines and mills comply with existing and proposed NPDES permits and uranium-milling licenses.

3. Determine the composition of potable waters at uranium mines and mills.

4. Determine if NPDES non-filers exist in the study area.

5. Evaluate the adequacy of company monitoring networks, self-monitoring data, analytical procedures and reporting requirements.

### BACKGROUND

Uranium ore was discovered in the Grants Mineral Belt in 1950 resulting in the construction of four processing mills, three of which are still operating. The early mining started in the shallow deposits of the Bluewater area and has progressed into the Ambrosia Lake area where shaft mines of greater than 1000 ft have been developed. Ground water from the overlying Dakoata aquifer and Westwater Canyon member of the Morrison Formation is pumped from these mines and discharged to surface waters. The industry is currently experiencing a major expansion with design and/or construction of three new mills and numerous mines.

Since the discovery of ore and the construction of uranium mills, only a limited amount of company data has been developed on the chemical and radiochemical characteristics of the mining and milling wastes. The surface discharges from the mines receives only minimal treatment and companies have not made a concerted effort to prevent seepage from mill tailings ponds from entering subsurface water.

The NMEIA requested EPA, Region VI (letter dated September 25, 1974) to conduct a "definitive survey of the Grants Mineral Belt". Through meetings and subsequent correspondence, it was decided that the study will be conducted jointly by New Mexico Environmental Improvement Agency (NMEIA), National Field Investigations Center (NFIC) and Office of Radiation Programs-Las Vegas Facility (ORP).

The three uranium mills (Kerr-McGee, United Nuclear-Homestake Partners and Anaconda) and three mine (Kerr-McGee, United Nuclear and United Nuclear-Homestake Partners) water treatment facilities (ion exchange units or IX) operate under AEC licenses. These licenses have been transferred to NMEIA. The licenses require meeting conditions set forth in 10 CFR 20 of which the most significant is that liquid waste discharged to areas with controlled access have radium 226 levels equal to or less than 30 picocuries per liter (pCi/l).

NPDES permits have been issued for the Kerr-McGee mine discharges at Ambrosia Lake (ion exchange unit and Section 30W mine) and Churchrock, and the United Nuclear Corporation mine at Churchrock. The permit limitations are summarized in Table 1. Kerr-McGee has requested adjudicatory hearings on their permits.

General New Mexico Water Quality Standards for perennial reaches of streams, including those formed by wastewater discharges, apply to the streams in the study area. The most significant provision of these standards is that radium 226 concentrations must be less than 30 pCi/l.

## REQUIRED STUDIES

### A. Reconnaissance Survey

A reconnaissance survey was conducted by personnel of NMEIA, ORP and NFIC during the period January 27-31, 1975. Company officials were contacted to obtain existing data and facility inspections were conducted at each of the mills and mines. A number of mine discharges, which are not covered by an NPDES permit, are believed to be reaching San Mateo Creek and its tributaries. Seepage from the Anaconda, Kerr-McGee and United Nuclear-Homestake Partners mill tailings piles has an extremely high potential of degrading water in the study area. Potable water supplies at the mines and mills is, for the most part, obtained from mine water treated by sedimentation followed in a few cases by selective ion exchange units which may not remove radium and most heavy metals, if present, from the mine water.

### B. Industrial Waste Survey

Effluent monitoring of mine wastewaters will be conducted. Samples will also be collected of the mill tailings pond water to ascertain the type of pollutants which can enter the ground water.

Operating (active) mine discharges will be sampled for three consecutive days with 24-hour composite samples being collected. Mines currently under development and mill tailing piles will be monitored for 8 hours one day [Table 2 lists the stations and parameters which will be measured during the survey].

C. Stream Surveys

In conjunction with the industrial survey, selected stream stations will be sampled to determine possible water quality violations [Table 3]. These stations are located in San Mateo Creek upstream and downstream from the Johnny M Mine discharge and downstream from the confluence of Puertecito Creek; Puertecite Creek upstream of all discharges (upstream of United Nuclear-Homestake Partners IX discharge), downstream from Kerr-McGee Mill, and near the mouth at Rancho del Puerto; Rio Puerco downstream of United Nuclear and Kerr-McGee mines, upstream of Wingate plant, and in Gallup at Highway 666 Bridge; Rio Moquino upstream of Jackpile Mine; Rio Paguate at Paguate, at the Jackpile Mine Ford and at the Paguate Reservoir discharge; and the Rio San Jose at I-40 bridge east of Laguna.

The Rio Moquino, Rio Paguote and Rio San Jose are influenced by storm run-off of tailings and ore piles. These streams will be sampled during run-off.

D. Ground-Water Survey

Ground-water related activities will emphasize definition of the hydrogeologic environment and sampling of selected wells and springs to characterize existing water quality and relate it to uranium mining and milling waste discharge.

A separate study plan for this portion of the study has been prepared by ORP.

## LOGISTICS

All industrial, stream and well samples will be sent to the NFIC laboratory for analysis. Industrial samples will be split with the appropriate company. All samples will be field split for radiochemical analysis with ORP. Alpha and radium 226 screening tests at NFIC will be considered for further analyses by ORP for Th-230, Pb-210, Po-210, Th-228, and possibly Ra-228. All samples will be collected and analyzed following established NFIC Chain-of-Custody procedures. The size of sample and preservative required are summarized in Table 4.

## TIME SCHEDULE*

| | |
|---|---|
| January 27-31, 1975 | Reconnaissance Survey |
| February 3-21, 1975 | Develop sampling schedule and notify industries |
| February 24-25, 1975 | Start setting up flow monitoring equipment |
| February 26-March 8, 1975 | Sample industries and streams |
| February 24-March 14, 1975 | Sample ground water |

## PERSONNEL

### A. Field Survey

| | |
|---|---|
| NFIC | 1 Supervisory Engineer (coordinator)<br>1 Geologist<br>3 Technicians |
| NMEIA | 3 Technicians |

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*Report on the study findings will be completed within 2-3 weeks following receipt of final analytical data.

| | |
|---|---|
| ORP | 1 Hydro-Geologist<br>1 Health Physicist<br>1 Technician |
| Region VII (Kerr Water Lab) | 1 Technician (part-time) |

### B. Report Preparation

| | |
|---|---|
| NFIC | 1 Engineer<br>1 Geologist<br>1 Technician (limited time) |
| NMEIA | 1 Hydro-Geologist<br>1 Health Physicist |
| ORP | 1 Hydro-Geologist<br>1 Health Physicist<br>1 Nuclear Chemist |

## EQUIPMENT

Gaging equipment

Peristaltic pump

Sampling and metering equipment

Pressure filtering units

Vehicles

- 4 Four-Wheel drive - 2 Denver and 2 Albuquerque (NFIC)
- 1 Sedan - Albuquerque (NFIC)
- 1 Van - Las Vegas (ORP)
- 1 Panel Truck - Kerr Center, Ada (ORP)

# TABLE 1
## SUMMARY OF NPDES PERMIT CRITERIA

| | | Parameters[1/] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Period of | TSS-mg/l | | Total Uranium-mg/l | | Dissolved Radium 226-pCi/l | | pH |
| Company/Discharge | Limitation | Daily Avg. | Daily Max. | Daily Avg. | Daily Max | Daily Avg. | Daily Max. | Range |
| Kerr-McGee Corp. -Churchrock Mine Discharge | 1/28/75-6/30/77 | 20 | 30 | - | 2 | - | 30 | 6.0-9.5 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 2 | - | 3.3 | 6.0-9.0 |
| -Section 30W Mine Discharge (Ambrosia Lake) | 1/28/75-12/31/75 | 20 | 30 | - | 2 | - | 150 | 6.0-9.0 |
| | 1/1/76-6/30/77 | 20 | 30 | - | 2 | - | 30 | 6.0-9.0 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 2 | - | 3.3 | 6.0-9.0 |
| -Ion Exchange Discharge (Ambrosia Lake) | 1/28/75-12/31/75 | 20 | 30 | - | 1 | - | 100 | 6.0-9.0 |
| | 1/1/76-6/30/77 | 20 | 30 | - | 1 | - | 30 | 6.0-9.0 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 1 | - | 3.3 | 6.0-9.0 |
| United Nuclear Corporation -Churchrock Mine Discharge | 1/28/75-12/31/75 | 100 | 200 | - | 2 | - | 30 | 6.0-9.5 |
| | 1/1/76-6/30/77 | 20 | 30 | - | 2 | - | 30 | 6.0-9.5 |
| | 7/1/77-1/27/80 | 20 | 30 | - | 2 | - | 3.3 | 6.0-9.0 |

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[1/] In addition to these parameters, the companies are required to monitor flow, temperature, total molybdenum, total selenium and total vanadium.

## TABLE 2
## INDUSTRIAL SAMPLING[1/]

| Station Number | Station Description | Number Days Sampled | Type Sample | Flow By | Analysis Required[2/] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | TSS | $SO_4$ | Cl | Cu | Fe | Mo | Na | $NH_3$ & $NO_3$ | Se | V | As | Mn | Co | U-Nat | Gross Alpha | $Ra_{226}$ |
| 9001 | Kerr-McGee Ion Exchange Tailings By-Pass | 3 | 24-Hr. Comp. | Parshall | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9003 | Kerr-McGee Sec. 30 W Mine Water | 3 | 24-Hr. Comp. | Gage in Control Str. | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9005 | Kerr-McGee Sec. 19 Mine Water | 1 | 8-Hr. Comp. | Bucket and Stopwatch | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9007 | Kerr-McGee Sec. 35 Mine Water | 3 | 24-Hr. Comp. | Rectangular Weir | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9009 | Kerr-McGee Sec.[3/] 36 Mine Water | 3 | 24-Hr. Comp. | Gage or Bucket & Stopwatch | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9011 | Kerr-McGee Seepage below tailings pond | 1 | 8-Hr. Comp. | None | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 9012 | Kerr-McGee Mill Potable Water Supply | 1 | Grab | None | | | | | | X | | X | X | | X | | | | X | X |
| 9013 | Kerr-McGee Sec. 35 Mine Potable Water Supply | 1 | Grab | None | | | | | | X | | X | X | | X | | | | X | X |
| 9014 | Ranchers Exploration Johnny M. Mine Water | 1 | 8-Hr. Comp. | Gage | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9015 | Ranchers Exploration Johnny M. Mine Potable Water Supply | 1 | Grab | None | | | | | | X | | X | X | | X | | | | X | X |

TABLE 2, Page 2

| Station Number | Station Description | Number Days Sampled | Type Sample | Flow By | Analysis Required 2/ | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | TSS | $SO_4$ | Cl | Cu | Fe | Mo | Na | $NH_3$ & $NO_3$ | Se | V | As | Mn | Co | U-Nat | Gross Alpha | $Ra_{226}$ |
| 9016 | United Nuclear Corp. IX Discharge | 4/ | 24-Hr. Comp.<br>8-Hr. Comp. | Weir or Gage | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9017 | United Nuclear Corp. Potable Water Supply | 1 | Grab | None | | | | | | X | | X | X | | X | | | | X | X |
| 9018 | United Nuclear-Homestake Partners IX Discharge | 3 | 24-Hr. Comp. | Calculate from company meters | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9019 | United Nuclear-Homestake Partners Tailings Pile Decant | 1 | 8-Hr. Comp. | None | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 9021 | Anaconda Co. Injection Well Feed | 1 | 24-Hr. Comp. | Company Meter | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 9023 | United Nuclear Churchrock Mine | 3 | 24-Hr. Comp. | Parshall | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9024 | United Nuclear Churchrock Potable Water Supply | 1 | Grab | None | | | | | | X | | X | X | | X | | | | X | X |
| 9025 | Kerr-McGee Churchrock Mine | 3 | 24-Hr. Comp. | Weir & Recorder | X | | X | | | X | X | X | X | X | | X | | X | X | X |
| 9026 | Kerr-McGee Churchrock Mine Potable Water Supply | 1 | Grab | None | | | | | | X | | X | X | | X | | | | X | X |

1/ pH, conductivity and temperature will be measured periodically at all stations.

2/ Additional radiochemical (Th-230, pb-210, Po210, Th 228, Ra 228) will be required if gross alpha and radium 226 analysis indicate these compounds are present.

3/ Two separate discharges, sample will be flow composited from both sources.

4/ Three 24-hour composite samples will be collected if discharging; if however, all water is being used for solutions mining (i.e., recycled to the mines) then one 8-hr. composite will be collected.

## TABLE 3
## STREAM STATIONS[1]

| | | | | Analysis Required[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station Number | Station Description | Number Days Sampled | Type Sample | Cl | Mo | Na | $NO_3$ & $NH_3$ | Se | V | Mn | U-Nat | Gross Alpha | $Ra_{226}$ |
| 9030 | San Mateo Creek at Highway 53 Bridge West of San Mateo | 3 | Grab | X | X | X | | X | X | X | X | X | X |
| 9032 | San Mateo Creek upstream of Puertecito Creek | 3 | Grab | X | X | X | | X | X | X | X | X | X |
| 9034 | Puertecito Creek upstream of Partner's IX Plant | 3 | Grab | X | X | X | X | X | X | X | X | X | X |
| 9036 | Puertecito Creek Downstream from Kerr-McGee Mill | 3 | Grab | X | X | X | X | X | X | X | X | X | X |
| 9038 | Puertecito Creek Near the Mouth of Rancho del Puerto | 3 | Grab | X | X | X | X | X | X | X | X | X | X |
| 9040 | San Mateo Creek at Highway 53 Bridge North of Grants | 3 | Grab | X | X | X | | X | X | X | X | X | X |
| 9050 | Rio Puerco at Highway Bridge Downstream from United Nuclear and Kerr-McGee Mines | 3 | Grab | X | X | X | | X | X | X | X | X | X |
| 9052 | Rio Puerco Upstream of Wingate Plant | 3 | Grab | X | X | X | | X | X | X | X | X | X |

TABLE 3, Page 2

| Station Number | Station Description | Number Days Sampled | Type Sample | Analysis Required 2/ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Cl | Mo | Na | $NO_3$ & $NH_3$ | Se | V | Mn | U-Nat | Gross Alpha | $Ra_{226}$ |
| 9054 | Rio Puerco at Highway 666 Bridge, Gallup, N. Mex. | 3 | Grab | X | X | X | | X | X | X | X | X | X |
| 9060 | Rio Paguate at Paguate | 3/ | Grab | X | X | X | | X | X | X | X | X | X |
| 9062 | Rio Moquino Upstream of Jackpile Mine | 3/ | Grab | X | X | X | | X | X | X | X | X | X |
| 9064 | Rio Paguate at Jackpile Ford | 3/ | Grab | X | X | X | | X | X | X | X | X | X |
| 9066 | Rio Paguate at Paguate Reservoir Discharge | 3/ | Grab | X | X | X | | X | X | X | X | X | X |
| 9068 | Rio San Jose at I-40 Bridge East of Laguna | 3/ | Grab | X | X | X | | X | X | X | X | X | X |

1/ pH, conductivity and temperature will be measured periodically at all stations.

2/ Additional radiochemical (Th-230, Pb-210, Po 210, Th-228, Ra-228) will be required if gross alpha and radium 226 analysis indicate these compounds are present.

3/ This station will be sampled for 1 to 3 days if surface run-off occurs.

# TABLE 4
# PRESERVATIVES AND SAMPLE SIZE REQUIRED

| Size of Sample | Preservative | Parameter |
|---|---|---|
| 1 liter (unfiltered) | Iced | TDS, TSS, Sulfate, Chloride |
| 1 liter (unfiltered) | 5 ml $HNO_3$/l | Copper, iron, Moly, Sodium, Silenum, Vanadium, Arsenic, Manganese, Cobalt, Total Uranium |
| 125 ml (unfiltered) | 40 mg $HgCl_2$/l - Iced | Nitrate + Nitrite, Ammonia |
| 2 l (filtered) | 5 ml $HNO_3$/l | Gross alpha |
| 8 l (filtered)* | 5 ml Hcl/l | Dissolved Radium 226<br>Th-230, Pb-210, Po-210,<br>Th-228, Ra-228 |

*4 liters each to NFIC and ORP.

# Appendix B

# CHAIN OF CUSTODY PROCEDURES

# CHAIN OF CUSTODY PROCEDURES

## General:

The evidence gathering portion of a survey should be characterized by the minimum number of samples required to give a fair representation of the effluent or water body from which taken. To the extent possible, the quantity of samples and sample locations will be determined prior to the survey.

Chain of Custody procedures must be followed to maintain the documentation necessary to trace sample possession from the time taken until the evidence is introduced into court. A sample is in your "custody" if:

1. It is in your actual physical possession, or
2. It is in your view, after being in your physical possession, or
3. It was in your physical possession and then you locked it up in a manner so that no one could tamper with it.

All survey participants will receive a copy of the survey study plan and will be knowledgeable of its contents prior to the survey. A pre-survey briefing will be held to re-appraise all participants of the survey objectives, sample locations and Chain of Custody procedures. After all Chain of Custody samples are collected, a de-briefing will be held in the field to determine adherence to Chain of Custody procedures and whether additional evidence type samples are required.

## Sample Collection:

1. To the maximum extent achievable, as few people as possible should handle the sample.
2. Stream and effluent samples shall be obtained, using standard field sampling techniques.
3. Sample tags (Exhibit I) shall be securely attached to the sample container at the time the complete sample is collected and shall contain, at a minimum, the following information: station number, station location, date taken, time taken, type of sample, sequence number (first sample of the day - sequence No. 1, second sample - sequence No. 2, etc.), analyses required and samplers. The tags must be legibly filled out in ballpoint (waterproof ink).

## Sample Collection (Continued)

4. Blank samples shall also be taken with preservatives which will be analyzed by the laboratory to exclude the possibility of container or preservative contamination.

5. A pre-printed, bound Field Data Record logbook shall be maintained to record field measurements and other pertinent information necessary to refresh the sampler's memory in the event he later takes the stand to testify regarding his action's during the evidence gathering activity. A separate set of field notebooks shall be maintained for each survey and stored in a safe place where they could be protected and accounted for at all times. Standard formats (Exhibits II and III) have been established to minimize field entries and include the date, time, survey, type of samples taken, volume of each sample, type of analysis, sample numbers, preservatives, sample location and field measurements such as temperature, conductivity, DO, pH, flow and any other pertinent information or observations. The entries shall be signed by the field sampler. The preparation and conservation of the field logbooks during the survey will be the responsibility of the survey coordinator. Once the survey is complete, field logs will be retained by the survey coordinator, or his designated representative, as a part of the permanent record.

6. The field sampler is responsible for the care and custody of the samples collected until properly dispatched to the receiving laboratory or turned over to an assigned custodian. He must assure that each container is in his physical possession or in his view at all times, or locked in such a place and manner that no one can tamper with it.

7. Colored slides or photographs should be taken which would visually show the outfall sample location and any water pollution to substantiate any conclusions of the investigation. Written documentation on the back of the photo should include the signature of the photographer, time, date and site location. Photographs of this nature, which may be used as evidence, shall also be handled recognizing Chain of Custody procedures to prevent alteration.

## Transfer of Custody and Shipment:

1. Samples will be accompanied by a Chain of Custody Record which includes the name of the survey, samplers signatures, station number, station location, date, time, type of sample, sequence number, number of containers and analyses required (Fig. IV). When turning over the possession of samples, the transferor and transferee will sign, date and time the sheet. This record sheet

allows transfer of custody of a group of samples in the field, to the mobile laboratory or when samples are dispatched to the NFIC - Denver laboratory. When transferring a portion of the samples identified on the sheet to the field mobile laboratory, the individual samples must be noted in the column with the signature of the person relinquishing the samples. The field laboratory person receiving the samples will acknowledge receipt by signing in the appropriate column.

2. The field custodian or field sampler, if a custodian has not been assigned, will have the responsibility of properly packaging and dispatching samples to the proper laboratory for analysis. The "Dispatch" portion of the Chain of Custody Record shall be properly filled out, dated, and signed.

3. Samples will be properly packed in shipment containers such as ice chests, to avoid breakage. The shipping containers will be padlocked for shipment to the receiving laboratory.

4. All packages will be accompanied by the Chain of Custody Record showing identification of the contents. The original will accompany the shipment, and a copy will be retained by the survey coordinator.

5. If sent by mail, register the package with return receipt requested. If sent by common carrier, a Government Bill of Lading should be obtained. Receipts from post offices and bills of lading will be retained as part of the permanent Chain of Custody documentation.

6. If samples are delivered to the laboratory when appropriate personnel are not there to receive them, the samples must be locked in a designated area within the laboratory in a manner so that no one can tamper with them. The same person must then return to the laboratory and unlock the samples and deliver custody to the appropriate custodian.

Laboratory Custody Procedures:

1. The laboratory shall designate a "sample custodian." An alternate will be designated in his absence. In addition, the laboratory shall set aside a "sample storage security area." This should be a clean, dry, isolated room which can be securely locked from the outside.

2. All samples should be handled by the minimum possible number of persons.

3. All incoming samples shall be received only by the custodian, who will indicate receipt by signing the Chain of Custody Record Sheet

accompanying the samples and retaining the sheet as permanent records. Couriers picking up samples at the airport, post office, etc. shall sign jointly with the laboratory custodian.

4. Immediately upon receipt, the custodian will place the sample in the sample room, which will be locked at all times except when samples are removed or replaced by the custodian. To the maximum extent possible, only the custodian should be permitted in the sample room.

5. The custodian shall ensure that heat-sensitive or light-sensitive samples, or other sample materials having unusual physical characteristics, or requiring special handling, are properly stored and maintained.

6. Only the custodian will distribute samples to personnel who are to perform tests.

7. The analyst will record in his laboratory notebook or analytical worksheet, identifying information describing the sample, the procedures performed and the results of the testing. The notes shall be dated and indicate who performed the tests. The notes shall be retained as a permanent record in the laboratory and should note any abnormalities which occurred during the testing procedure. In the event that the person who performed the tests is not available as a witness at time of trial, the government may be able to introduce the notes in evidence under the Federal Business Records Act.

8. Standard methods of laboratory analyses shall be used as described in the "Guidelines Establishing Test Procedures for Analysis of Pollutants," 38 F.R. 28758, October 16, 1973. If laboratory personnel deviate from standard procedures, they should be prepared to justify their decision during cross-examination.

9. Laboratory personnel are responsible for the care and custody of the sample once it is handed over to them and should be prepared to testify that the sample was in their possession and view or secured in the laboratory at all times from the moment it was received from the custodian until the tests were run.

10. Once the sample testing is completed, the unused portion of the sample together with all identifying tags and laboratory records, should be returned to the custodian. The returned tagged sample will be retained in the sample room until it is required for trial. Strip charts and other documentation of work will also be turned over to the custodian.

Chain of Custody Procedures (Continued)

11. Samples, tags and laboratory records of tests may be destroyed only upon the order of the laboratory director, who will first confer with the Chief, Enforcement Specialist Office, to make certain that the information is no longer required or the samples have deteriorated.

# EXHIBIT I

**EPA, NATIONAL FIELD INVESTIGATIONS CENTER - DENVER**

|  |  |  |  |
|---|---|---|---|
| Station No. | Date | Time | Sequence No. |

Station Location

________Grab

________Comp.

________BOD
________Solids
________COD
________Nutrients
________Metals
________Oil and Grease
________D.O.
________Other

Remarks/Preservative:

Samplers:

FRONT

**ENVIRONMENTAL PROTECTION AGENCY**

OFFICE OF ENFORCEMENT

NATIONAL FIELD INVESTIGATIONS CENTER — DENVER

BUILDING 53, BOX 25227, DENVER FEDERAL CENTER

DENVER, COLORADO 80225

BACK

EXHIBIT II

FOR ______________________________ SURVEY, PHASE ______, DATE ______________

TYPE OF SAMPLE ______________________

| | | | | | ANALYSES REQUIRED | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION NUMBER | STATION DESCRIPTION | TOTAL VOLUME | TYPE CONTAINER | PRESERVATIVE | NUTRIENTS | BOD | COD | TOC | TOTAL SOLIDS | SUSPENDED SOLIDS | ALKALINITY | DO | pH* | CONDUCTIVITY* | TEMPERATURE* | TOTAL COLIFORM | FECAL COLIFORM | TURBIDITY | OIL AND GREASE | METALS | BACTI | PESTICIDES | HERB | TRACE ORGANICS | PHENOL | CYANIDE |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
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REMARKS

EXHIBIT III

**Samplers:** ____________________

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# FIELD DATA RECORD

| STATION | NUMBER | DATE | TIME | TEMPERATURE °C | CONDUCTIVITY µmhos/cm | pH S.U. | D.O. mg/l | Gage Ht. or Flow Ft. or CFS |
|---|---|---|---|---|---|---|---|---|
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EXHIBIT IV

## ENVIRONMENTAL PROTECTION AGENCY

Office Of Enforcement

NATIONAL FIELD INVESTIGATIONS CENTER—DENVER
Building 53, Box 25227, Denver Federal Center
Denver, Colorado 80225

# CHAIN OF CUSTODY RECORD

| | |
|---|---|
| SURVEY | SAMPLERS: *(Signature)* |

| STATION NUMBER | STATION LOCATION | DATE | TIME | SAMPLE TYPE | | | SEQ NO | NO OF CONTAINERS | ANALYSIS REQUIRED |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Water | | Air | | | |
| | | | | Comp | Grab | | | | |
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| Relinquished by: *(Signature)* | Received by: *(Signature)* | Date/Time |
| Relinquished by: *(Signature)* | Received by: *(Signature)* | Date/Time |
| Relinquished by: *(Signature)* | Received by: *(Signature)* | Date/Time |
| Relinquished by: *(Signature)* | Received by Mobile Laboratory for field analysis: *(Signature)* | Date/Time |

| | | | |
|---|---|---|---|
| Dispatched by: *(Signature)* | Date/Time | Received for Laboratory by: | Date/Time |

Method of Shipment:

Distribution: Orig — Accompany Shipment
1 Copy— Survey Coordinator Field Files

GPO 854-409

# Appendix C

# CHEMICAL ANALYSES DATA
# NEW MEXICO SURVEY
Feb. 26-Mar. 14, 1975

# CHEMICAL ANALYSES DATA
NEW MEXICO SURVEY
Feb. 26-Mar. 14, 1975

| Sample No.† | Station Description | Analyses Performed | | | | |
|---|---|---|---|---|---|---|
| | | Dis. Grossα | ±95%CL | Dis. Ra-226 | ±95%Cl | Total U |
| | | (pCi/l) | | | | (mg/l) |
| 9001-30-0227 | KM I-X TAILINGS BY-PASS | 600 | 60 | 149 | 1 | 4.2 |
| 9001-30-0228 | KM I-X TAILINGS BY-PASS | 490 | 60 | 148 | 1 | 2.0 |
| 9001-30-0301 | KM I-X TAILINGS By-PASS | 430 | 50 | 157 | 1 | 1.3 |
| 9003-30-0227 | KM SEC 30W MINE WATER | 1300 | 100 | 174 | 1 | 1.3 |
| 9003-30-0228 | KM SEC 30W MINE WATER | 1400 | 100 | 161 | 1 | 6.1 |
| 9003-30-0301 | KM SEC 30W MINE WATER | 1400 | 100 | 154 | 1 | 6.7 |
| 9005-30-0227 | KM SEC 19 MINE WATER | 72 | 19 | 9.3 | 0.1 | 0.23 |
| 9007-30-0227 | KM SEC 35 MINE WATER | 3000 | 100 | 32 | 1 | 17 |
| 9007-30-0828 | KM SEC 35 MINE WATER | 2400 | 100 | 52 | 1 | 14 |
| 9007-30-0301 | KM SEC 35 MINE WATER | 2800 | 100 | 69 | 1 | 26 |
| 9009-30-0227 | KM SEC 36 MINE WATER | 570 | 60 | 113 | 1 | 2.6 |
| 9009-30-0228 | KM SEC 36 MINE WATER | 630 | 60 | 178 | 1 | 3.4 |
| 9009-30-0301 | KM SEC 36 MINE WATER | 850 | 70 | 101 | 1 | 3.0 |
| 9010-30-0227 | KM SEC 36 MINE WATER | 580 | 70 | 59 | 1 | 2.5 |
| 9010-30-0228 | KM SEC 36 MINE WATER | 510 | 60 | 72 | 1 | 2.3 |
| 9010-30-0301 | KM SEC 36 MINE WATER | 580 | 60 | 65 | 1 | 2.3 |
| 9011-01-0227 | KM SEEPAGE BELOW T POND | 144000 | 3000 | 65 | 1 | 160 |
| 9012-01-0226 | KM POTABLE WATER SUP | 510 | 60 | 0.54 | 0.02 | - |
| 9013-01-0226 | KM SEC 35 WATER SUP | 3000 | 150 | 43 | 1 | - |
| 9014-30-0228 | RE JOHNNY M MINE WATER | 20 | 10 | 1.6 | 0.1 | 0.12 |
| 9016-30-0227 | UNC I-X DISCHARGE | 1600 | 100 | 14.3 | 0.4 | 6.6 |
| 9016-30-0228 | UNC I-X DISCHARGE | 2300 | 100 | 39 | 1 | 11 |
| 9016-30-0301 | UNC I-X DISCHARGE | 1400 | 100 | 39 | 1 | 5.9 |
| 9017-01-0226 | UNC POTABLE WATER SUP | 1500 | 100 | 23.5 | 0.5 | - |
| 9018-30-0227 | UN-HP I-X DISCHARGE | 760 | 70 | 111 | 2 | 2.3 |
| 9018-30-0228 | UN-HP I-X DISCHARGE | 770 | 70 | 101 | 2 | 3.0 |
| 9018-30-0301 | UN-HP I-X DISCHARGE | 970 | 70 | 111 | 1 | 5.8 |
| 9019-30-0228 | UN-HP T PILE DECANT | 29000 | 1000 | 52 | 1 | 150 |
| 9021-30-0228 | ANAC INJ WELL FEED | 62500 | 1300 | 53 | 1 | 130 |
| 9023-30-0304 | UNC CHURCHROCK MINE D | 730 | 60 | 19.8 | 0.5 | 7.6 |
| 9023-30-0305 | UNC CHURCHROCK MINE D | 840 | 70 | 22.9 | 0.5 | 6.5 |

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† *Sample numbers are presented by station number-sequence-date.*

| | | | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| Sample No. | Station Description | Date | Dis. Gross$\alpha$ | ±95%CL | Dis. Ra-226 | ±95%Cl | Total U |
| | | | (pCi/l) | | | | (mg/l) |
| 9023-30-0306 | UNC CHURCHROCK MINE D | | 870 | 70 | 27.3 | 0.6 | 7.6 |
| 9023-01-0314 | UNC CHURCHROCK MINE D | | 3100 | 90 | 53 | 1 | 20 |
| 9024-01-0303 | UNC CHURCHROCK POTABLE WATER SUP | | 620 | 60 | 12.6 | 0.1 | - |
| 9025-30-0304 | KM CHURCHROCK MINE DIS | | 240 | 40 | 8.1 | 0.3 | 0.97 |
| 9025-30-0305 | KM CHURCHROCK MINE DIS | | 210 | 30 | 6.8 | 0.2 | 0.74 |
| 9025-30-0306 | KM CHURCHROCK MINE DIS | | 230 | 40 | 8.7 | 0.2 | 0.72 |
| 9026-01-0303 | KM CHURCHROCK H POTABLE WIS | | 120 | 30 | 6.5 | 0.1 | - |
| 9036-01-0226 | PUERTECITO CK DS KM | | 1700 | 100 | 45 | 1 | 12 |
| 9036-01-0227 | PUERTECITO CK DS KM | | 1400 | 100 | 47 | 1 | 6.2 |
| 9036-01-0228 | PUERTECITO CK DS KM | | 1400 | 100 | 1 | 1 | 5.0 |
| 9038-01-0226 | PUERTECITO CK @ RAN D PUERTO | | 1500 | 100 | 6.1 | 0.1 | 6.6 |
| 9038-01-0224 | PUERTECITO CK @ RAN D PUERTO | | 1100 | 100 | 6.2 | 0.1 | 6.2 |
| 9038-01-0225 | PUERTECITO CK @ RAN D PUERTO | | 750 | 60 | 7.2 | 0.1 | 4.7 |
| 9040-01-0226 | SAN MATEO CK AT HWY 53 | | 1000 | 80 | 1.09 | 0.03 | 4.7 |
| 9050-01-0303 | RIO PUERCO DS UN & KM | | 500 | 50 | 0.97 | 0.05 | 5.0 |
| 9050-01-0304 | RIO PUERCO DS UN & KM | | 470 | 50 | 2.54 | 0.05 | 3.8 |
| 9050-01-0305 | RIO PUERCO DS UN & KM | | 490 | 60 | 2.60 | 0.05 | 3.8 |
| 9052-01-0303 | RIO PUERCO US WINGATE | | 480 | 40 | 0.36 | 0.05 | 4.1 |
| 9052-01-0304 | RIO PUERCO US WINGATE | | 510 | 60 | 0.43 | 0.02 | 4.8 |
| 9052-01-0305 | RIO PUERCO US WINGATE | | 320 | 40 | 1.63 | 0.04 | 3.7 |
| 9054-01-0303 | RIO PUERCO @ HWY 666 | | 350 | 50 | 0.42 | 0.05 | 1.7 |
| 9054-01-0304 | RIO PUERCO @ HWY 666 | | 230 | 40 | 0.15 | 0.01 | 1.7 |
| 9054-01-0305 | RIO PUERCO @ HWY 666 | | 210 | 30 | 0.09 | 0.01 | 2.5 |
| 9060-01-0228 | RIO PAGUATE @ PAGUATE | | 2.8 | 6.8 | 0.11 | 0.01 | <.02 |
| 9062-01-0228 | RIO MOQUINO | | 11.2 | 9.9 | 0.19 | 0.01 | <.02 |
| 9064-01-0228 | RIO PAGUATE @ JACKPILE FORD | | 270 | 40 | 4.8 | 0.1 | 1.2 |
| 9066-01-0228 | RIO PAG @ PAG RES DIS | | 230 | 40 | 1.94 | 0.04 | 1.1 |
| 9068-01-0228 | RIO SAN JOSE | | 38 | 18 | 0.37 | 0.02 | 0.10 |
| 9080-01-0304 | KM SEC 36 3000 DRIFT | | 51 | 21 | 7.5 | 0.1 | 0.12 |
| 9081-01-0304 | KM SEC 36 0900 DRIFT | | 47 | 20 | 8.7 | 0.1 | 0.05 |

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Dis. Grossα | ±95%CL | Dis. Ra-226 | ±95%Cl | Total U |
| | | | (pCi/l) | | | | (mg/l) |
| 9082-01-0305 | UNC CHURCHROCK POT WS @ SOWERS TR | | 1110 | 80 | 39.7 | 0.6 | 7.6 |
| 9101-01-0224 | | | 9 | 11 | 0.13 | 0.01 | - |
| 9102-01-0224 | | | <3† | 13 | 0.19 | 0.01 | 0.07 |
| 9103-01-0225 | | | 7 | 10 | 0.09 | 0.01 | - |
| 9104-01-0225 | | | 13 | 14 | 0.08 | 0.01 | - |
| 9105-01-0225 | | | 140 | 30 | <0.05† | 0.01 | - |
| 9106-01-0225 | | | 12 | 11 | 0.05 | 0.01 | - |
| 9107-01-0225 | | | 2500 | 200 | 0.72 | 0.02 | 14 |
| 9108-01-0225 | | | 47 | 23 | 0.34 | 0.02 | - |
| 9109-01-0225 | | | 39 | 17 | 0.13 | 0.01 | - |
| 9110-01-0225 | | | <1† | 6 | <0.05† | 0.01 | - |
| 9111-01-0225 | | | 7 | 9 | 0.24 | 0.01 | - |
| 9112-01-0225 | GRANTS POTABLE | | 19 | 13 | 0.42 | 0.2 | - |
| 9113-01-0226 | | | 31 | 17 | 0.17 | 0.02 | 0.08 |
| 9114-01-0226 | | | 42 | 18 | 0.26 | 0.01 | - |
| 9115-01-0226 | | | 7 | 12 | 0.18 | 0.01 | - |
| 9116-01-0226 | | | 12 | 10 | 0.14 | 0.01 | - |
| 9117-01-0227 | MONITOR, ANAC. | | 180 | 40 | 2.6 | 0.1 | 0.56 |
| 9118-01-0227 | | | 290 | 50 | 0.5 | 0.02 | 1.3 |
| 9119-01-0227 | | | 12 | 11 | 0.20 | 0.01 | - |
| 9120-01-0227 | | | 21 | 12 | 0.27 | 0.02 | - |
| 9121-01-0227 | | | 12 | 14 | 6.3 | 0.1 | - |
| 9123-01-0227 | | | 30 | 17 | 0.17 | 0.01 | - |
| 9123-01-0228 | | | 20 | 13 | 0.26 | 0.01 | - |
| 9124-01-0228 | | | 16 | 12 | 0.06 | 0.01 | - |
| 9125-01-0228 | | | 8 | 10 | 0.22 | 0.01 | - |
| 9126-01-0228 | | | 5 | 9 | 0.11 | 0.01 | - |
| 9127-01-0228 | | | 10 | 10 | 0.21 | 0.01 | - |
| 9128-01-0228 | | | 11 | 11 | 0.15 | 0.01 | - |
| 9129-01-0228 | | | <1.6† | 7 | 0.14 | 0.01 | - |
| 9130-01-0301 | | | 3 | 8 | 0.11 | 0.01 | - |
| 9131-01-0301 | | | 18 | 13 | <0.05† | 0.01 | - |
| 9132-01-0301 | | | <1† | 9 | 0.31 | 0.02 | 0.10 |
| 9133-01-0302 | | | 10 | 12 | 0.61 | 0.03 | - |

| | | | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| Sample No. | Station Description | Date | Dis. Gross$\alpha$ | ±95%CL | Dis. Ra-226 | ±95%Cl | Total U |
| | | | (pCi/l) | | | | (mg/l) |
| 9134-01-0303 | | | 8 | 11 | 0.24 | 0.01 | 0.04 |
| 9135-01-0303 | | | 400 | 70 | 1.92 | 0.04 | 2.6 |
| 9136-01-0303 | | | 22 | 16 | 0.27 | 0.02 | - |
| 9137-01-0303 | | | 10 | 9 | 0.68 | 0.03 | - |
| 9138-01-0303 | | | 6 | 8 | 0.64 | 0.02 | - |
| 9139-01-0305 | | | 14 | 11 | 0.22 | 0.01 | - |
| 9140-01-0305 | | | 6 | 10 | 0.10 | 0.01 | - |
| 9141-01-0305 | | | 3 | 7 | 0.12 | 0.01 | 0.02 |
| 9142-01-0305 | | | 9 | 9 | 0.16 | 0.01 | - |
| 9143-01-0305 | | | 14 | 9 | 0.83 | 0.04 | - |
| 9201-01-0226 | | | 110 | 40 | 3.6 | 0.1 | 1.0 |
| 9202-01-0226 | | | 86 | 31 | 0.30 | 0.02 | - |
| 9203-01-0226 | | | 33 | 15 | 0.07 | 0.01 | - |
| 9204-01-0226 | | | 8 | 13 | 0.14 | 0.01 | - |
| 9205-01-0226 | | | 170 | 40 | 0.18 | 0.01 | - |
| 9206-01-0226 | | | 56 | 25 | 0.60 | 0.02 | - |
| 9207-01-0227 | | | 410 | 120 | 1.15 | 0.03 | - |
| 9208-01-0227 | | | 49 | 35 | 4.0 | 0.1 | - |
| 9209-01-0227 | | | <2† | 10 | 1.95 | 0.04 | - |
| 9210-01-0227 | | | 45 | 29 | 0.26 | 0.02 | - |
| 9211-01-0227 | | | <3† | 15 | 0.20 | 0.01 | - |
| 9212-01-0303 | | | 112000 | 3000 | 4.9 | 0.1 | - |
| 9213-01-0303 | | | 8 | 32 | 6.6 | 0.1 | - |
| 9214-01-0303 | | | 14 | 34 | 1.18 | 0.03 | - |
| 9215-01-0303†† | | | 104 | 37 | 2.5 | 0.2 | - |
| 9216-01-0303 | | | 45 | 25 | 0.64 | 0.02 | - |
| 9217-01-0303 | | | 70 | 38 | 0.94 | 0.03 | - |
| 9218-01-0303 | | | 20 | 24 | 0.34 | 0.02 | - |
| 9219-01-0303 | | | 67 | 42 | 0.59 | 0.02 | - |
| 9220-01-0305 | | | 12 | 10 | 0.12 | 0.01 | - |
| 9221-01-0305 | | | 17 | 10 | 0.56 | 0.02 | - |

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Dis. Grossα | ±95%CL | Dis. Ra-226 | ±95%Cl | Total U |
| | | | (pCi/l) | | | | (mg/l) |
| 9222-01-0305 | | | 2 | 9 | 0.57 | 0.02 | - |
| 9223-01-0305 | | | 4 | 9 | 0.37 | 0.02 | - |
| 9224-01-0305 | | | 24 | 12 | 0.13 | 0.01 | - |
| 9225-01-0305 | | | 12 | 15 | 0.29 | 0.01 | - |
| 9230-01-0228 | | | <2† | 6 | 0.31 | 0.02 | - |
| 9231-01-0228 | | | 10 | 10 | 1.7 | 0.05 | - |
| 9232-01-0228 | | | 18 | 13 | 3.7 | 0.08 | 0.02 |
| 9233-01-0228 | | | 2 | 4 | 0.18 | 0.02 | 0.04 |

† *Minimum detectable concentration*

†† *Gross alpha sample used for radium determination*

| Sample No. | Station Description | Date | Analyses Performed | | | |
|---|---|---|---|---|---|---|
| | | | Cu | Fe | As | Co |
| | | | mg/l | | | |
| 9011-30-0227 | | | 1.9 | 1,500 | 1.1 | 0.94 |
| 9012-01-0226 | | | - | - | <0.05 | - |
| 9013-01-0226 | | | - | - | <0.05 | - |
| 9017-01-0226 | | | - | - | <0.05 | - |
| 9019-38-0228 | | | 0.1 | 0.22 | 3.0 | 0.10 |
| 9021-30-0228 | | | 0.5 | 200 | 0.15 | 0.62 |
| 9024-01-0303 | | | - | - | <0.05 | - |
| 9026-01-0303 | | | - | - | <0.05 | - |

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Mo | Na | Se | V | Mn |
| | | | mg/l | | | | |
| 9001-30-0227 | KM I-X TAILINGS BYPASS | | 2.5 | 180 | 0.06 | 0.7 | 0.03 |
| 9001-30-0228 | KM I-X TAILINGS BYPASS | | 2.3 | 180 | 0.03 | 1.0 | 0.03 |
| 9001-30-0301 | KM I-X TAILINGS BYPASS | | 2.4 | 180 | 0.07 | 1.0 | 0.03 |
| 9003-30-0227 | KM Sec 30W MINE WATER | | 2.8 | 160 | 0.03 | 0.8 | 0.15 |
| 9003-30-0228 | KM Sec 30W MINE WATER | | 2.6 | 160 | 0.04 | 0.7 | 0.18 |
| 9003-30-0301 | KM Sec 30W MINE WATER | | 2.6 | 160 | 0.03 | 0.7 | 0.17 |
| 9005-30-0227 | KM Sec 19 MINE WATER | | 0.6 | 120 | <0.01 | 0.6 | 0.03 |
| 9007-30-0227 | KM Sec 35 MINE WATER | | 5.2 | 190 | 0.08 | 0.6 | 0.09 |
| 9007-30-0228 | KM Sec 35 MINE WATER | | 5.0 | 200 | 0.08 | 0.7 | 0.04 |
| 9007-30-0301 | KM Sec 35 MINE WATER | | 4.7 | 210 | 0.04 | 1.0 | 0.06 |
| 9009-30-0227 | KM Sec 36 MINE WATER | | 0.3 | 190 | 0.01 | 1.0 | 0.12 |
| 9009-30-0228 | KM Sec 36 MINE WATER | | 0.3 | 190 | <0.01 | 0.8 | 0.10 |
| 9009-30-0301 | KM Sec 36 MINE WATER | | 0.3 | 180 | 0.01 | 0.8 | 0.12 |
| 9010-30-0227 | KM Sec 36E MINE WATER | | 0.2 | 170 | <0.01 | 0.8 | 0.10 |
| 9010-30-0228 | KM Sec 36E MINE WATER | | 0.5 | 170 | 0.03 | 0.6 | 0.08 |
| 9010-30-0301 | KM Sec 36E MINE WATER | | 0.3 | 170 | 0.01 | 0.4 | 0.08 |
| 9011-30-0227 | KM SEEPAGE BELOW T POND | | 11 | 1,500 | 0.70 | 5.6 | 120 |
| 9012-01-0226 | KM POTABLE WATER SUP | | 3.3 | - | 0.05 | - | - |
| 9013-01-0226 | KM Sec 35 WATER SUP | | 8.2 | - | 0.02 | - | - |
| 9014-30-0228 | RE JOHNNY M MINE WATER | | 0.3 | 60 | <0.01 | <0.3 | 0.01 |
| 9016-30-0227 | UNC I-X DISCHARGE | | 4.4 | 310 | 0.11 | <0.3 | 0.22 |
| 9016-30-0228 | UNC I-X DISCHARGE | | 4.4 | 360 | 0.12 | 0.4 | 0.18 |
| 9016-30-0301 | UNC I-X DISCHARGE | | 4.4 | 360 | 0.02 | 0.5 | 0.28 |
| 9017-01-0226 | UNC POTABLE WATER SUP | | 6.0 | - | 0.11 | - | - |
| 9018-30-0227 | UN-HP I-X DISCHARGE | | 1.3 | 140 | 0.33 | 0.4 | 0.05 |
| 9018-30-0228 | UN-HP I-X DISCHARGE | | 1.5 | 140 | 0.33 | <0.3 | 0.05 |
| 9018-30-0301 | UN-HP I-X DISCHARGE | | 1.3 | 140 | 0.30 | 0.5 | 0.04 |
| 9019-30-0228 | UN-HP T PILE DECANT | | 70 | 4,300 | 0.92 | 6.8 | <0.01 |
| 9021-30-0228 | ANAC INJ WELL FEED | | 0.2 | 1,200 | 0.03 | 6.3 | 340 |
| 9023-30-0304 | UNC CHURCHROCK MINE D | | 0.2 | 100 | 0.06 | 0.5 | 0.05 |
| 9023-30-0305 | UNC CHURCHROCK MINE D | | 0.2 | 100 | 0.06 | 0.4 | 0.06 |
| 9023-30-0306 | UNC CHURCHROCK MINE D | | 0.1 | 90 | <0.01 | 0.4 | 0.07 |
| 9023-01-0314 | UNC CHURCHROCK MINE D | | 0.2 | 90 | 0.05 | 0.7 | 0.18 |
| 9024-01-0303 | UNC CHURCHROCK POTABLE WATER SUP | | 1.9 | - | 0.06 | - | - |

| Sample No. | Station Description | Date | Analysis Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Mo | Na | Se | V | Mn |
| | | | mg/l | | | | |
| 9025-30-0304 | KM CHURCHROCK MINE DIS | | 0.2 | 90 | 0.01 | 0.7 | 0.07 |
| 9025-30-0305 | KM CHURCHROCK MINE DIS | | 0.2 | 100 | 0.01 | 0.8 | 0.08 |
| 9025-30-0306 | KM CHURCHROCK MINE DIS | | 0.2 | 100 | 0.01 | 0.9 | 0.10 |
| 9026-01-0303 | KM CHURCHROCK MINE POTABLE WATER SUP | | 1.4 | - | 0.01 | - | - |
| 9036-01-0226 | PUERTECITO CK DS KM | | 1.4 | 180 | 0.13 | 1.0 | 0.25 |
| 9036-01-0227 | PUERTECITO CK DS KM | | 1.5 | 180 | 0.16 | 0.8 | 0.24 |
| 9036-01-0228 | PUERTECITO CK DS KM | | 1.5 | 180 | 0.16 | 0.6 | 0.26 |
| 9038-01-0226 | PUERTECITO CK @ RAN d PUERTO | | 2.1 | 160 | 0.07 | 0.5 | 0.08 |
| 9038-01-0227 | PUERTECITO CK @ RAN d PUERTO | | 0.3 | 130 | 0.04 | 1.9 | 0.13 |
| 9038-01-0028 | PUERTECITO CK @ RAN d PUERTO | | 1.5 | 130 | 0.01 | 0.8 | 0.11 |
| 9040-01-0226 | SAN MATEO CK @ HWY 53 | | 1.3 | 130 | 0.02 | <0.3 | 1.8 |
| 9050-01-0303 | RIO PUERCO DS UN & KM | | 0.5 | 110 | 0.07 | 0.5 | 1.9 |
| 9050-01-0304 | RIO PUERCO DS UN & KM | | 0.3 | 100 | 0.03 | 0.6 | 0.19 |
| 9050-01-0305 | RIO PUERCO DS UN & KM | | 0.3 | 100 | 0.03 | 0.6 | 0.19 |
| 9052-01-0303 | RIO PUERCO US WINGATE | | 0.2 | 100 | 0.01 | 0.9 | 1.7 |
| 9052-01-0304 | RIO PUERCO US WINGATE | | 0.2 | 90 | 0.01 | 0.5 | 0.61 |
| 9052-01-0305 | RIO PUERCO US WINGATE | | 0.2 | 90 | 0.01 | 0.3 | 1.1 |
| 9054-01-0303 | RIO PUERCO @ HWY 666 | | 0.1 | 90 | <0.01 | 0.3 | 0.12 |
| 9054-01-0304 | RIO PUERCO @ HWY 666 | | 0.2 | 90 | <0.01 | 0.6 | 2.1 |
| 9054-01-0305 | RIO PUERCO @ HWY 666 | | 0.2 | 90 | <0.01 | 0.6 | 2.0 |
| 9060-01-0228 | RIO PAGUATE @ PAGUATE | | <0.1 | 30 | <0.01 | 0.6 | 0.11 |
| 9062-01-0228 | RIO MOQUINO | | 0.2 | 70 | <0.01 | 1.8 | 0.15 |
| 9064-01-0228 | RIO PAGUATE @ JACKPILE FORD | | 0.2 | 120 | 0.05 | 0.5 | 0.28 |
| 9066-01-0228 | RIO PAG @ PAG RES DIS | | 0.2 | 160 | <0.01 | 0.6 | 0.14 |
| 9068-01-0228 | RIO SAN JOSE | | 0.1 | 230 | <0.01 | <0.3 | 0.09 |
| 9080-01-0304 | KM Sec 36 3000 DRIFT | | 0.1 | 220 | 0.01 | <0.3 | 0.02 |
| 9081-01-0304 | KM Sec 36 0900 DRIFT | | 0.4 | 260 | <0.01 | <0.3 | 0.06 |
| 9082-01-0305 | UNC CHURCHROCK POT WS @ SOWERS TR | | <0.1 | 100 | 0.06 | 0.6 | 0.03 |
| 9101-01-0224 | | | | | - | - | |
| 9102-01-0224 | G WILCOX - MURRAY ACRES | | | | 1.06 | <0.3 | |
| 9103-01-0225 | | | | | - | - | |
| 9104-01-0225 | | | | | - | - | |
| 9105-01-0225 | | | | | - | - | |
| 9106-01-0225 | | | | | - | - | |

| Sample No. | Station Description | Date | Analysis Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Mo | Na | Se | V | Mn |
| | | | mg/l | | | | |
| 9107-01-0225 | C WORTHEN, BROADVIEW ACRES | | | | 1.06 | 0.3 | |
| 9108-01-0225 | | | | | - | - | |
| 9109-01-0225 | | | | | - | - | |
| 9110-01-0225 | | | | | - | - | |
| 9111-01-0225 | | | | | - | - | |
| 9112-01-0225 | | | | | - | - | |
| 9113-01-0226 | C MEADOR - BROADVIEW ACRES | | | | 0.20 | 0.3 | |
| 9114-01-0226 | | | | | - | - | |
| 9115-01-0226 | | | | | - | - | |
| 9116-01-0226 | | | | | - | - | |
| 9117-01-0227 | | | | | 0.01 | 0.3 | |
| 9118-01-0227 | | | | | 0.01 | 0.8 | |
| 9119-01-0227 | | | | | <0.01 | 0.9 | |
| 9120-01-0227 | | | | | 0.01 | 1.0 | |
| 9121-01-0227 | | | | | 0.01 | 0.8 | |
| 9122-01-0227 | | | | | - | - | |
| 9123-01-0228 | | | | | 0.01 | 1.1 | |
| 9124-01-0228 | | | | | - | - | |
| 9125-01-0228 | | | | | - | - | |
| 9126-01-0228 | | | | | - | - | |
| 9127-01-0228 | | | | | - | - | |
| 9128-01-0228 | | | | | - | - | |
| 9129-01-0228 | | | | | 0.02 | 1.3 | |
| 9130-01-0301 | | | | | - | - | |
| 9131-01-0301 | | | | | - | - | |
| 9132-01-0301 | MARCUS WINDMILL | | | | 0.13 | <0.3 | |
| 9133-01-0302 | | | | | - | - | |
| 9134-01-0303 | | | | | <0.01 | 1.3 | |
| 9135-01-0303 | UNHP WELL P | | | | 1.52 | 0.4 | |
| 9136-01-0303 | | | | | - | - | |
| 9137-01-0303 | | | | | - | - | |
| 9138-01-0303 | | | | | <0.01 | <0.3 | |
| 9139-01-0305 | | | | | - | - | |
| 9140-01-0305 | | | | | <0.01 | <0.3 | |

| Sample No. | Station Description | Date | Analysis Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | Mo | Na | Se | V | Mn |
| | | | mg/l | | | | |
| 9141-01-0305 | 06 KM 43 14N, 9W Sec 32 | | | | <0.01 | <0.3 | |
| 9142-01-0305 | | | | | <0.01 | <0.3 | |
| 9143-01-0305 | | | | | - | - | |
| 9201-01-0226 | | | | | <0.01 | <0.3 | |
| 9202-01-0226 | | | | | - | - | |
| 9203-01-0226 | | | | | - | - | |
| 9204-01-0226 | | | | | - | - | |
| 9205-01-0226 | | | | | - | - | |
| 9206-01-0226 | | | | | - | - | |
| 9207-01-0227 | | | | | <0.01 | 0.4 | |
| 9208-01-0227 | | | | | 0.29 | 0.8 | |
| 9209-01-0227 | | | | | 0.01 | <0.3 | |
| 9210-01-0227 | | | | | - | - | |
| 9211-01-0227 | | | | | <0.01 | 0.5 | |
| 9212-01-0303 | | | | | - | - | |
| 9213-01-0303 | | | | | <0.01 | 0.6 | |
| 9214-01-0303 | | | | | 0.02 | <0.3 | |
| 9215-01-0303 | | | | | <0.01 | <0.3 | |
| 9216-01-0303 | | | | | - | - | |
| 9217-01-0303 | | | | | - | - | |
| 9218-01-0303 | | | | | - | - | |
| 9219-01-0303 | | | | | 0.01 | <0.3 | |
| 9220-01-0305 | | | | | - | - | |
| 9221-01-0305 | | | | | 0.01 | <0.3 | |
| 9222-01-0305 | | | | | - | - | |
| 9223-01-0305 | | | | | <0.01 | <0.3 | |
| 9224-01-0305 | | | | | - | - | |
| 9225-01-0305 | | | | | - | - | |
| 9230-01-0228 | | | | | <0.01 | <0.3 | |
| 9231-01-0228 | | | | | - | - | |
| 9232-01-0228 | | | | | <0.01 | <0.3 | |
| 9233-01-0228 | | | | | <0.01 | 0.3 | |

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | TSS | $SO_4$ | Cl | $NH_3$† | $NO_2 + NO_3$† |
| | | | mg/l | | | | |
| 9001 | KERR-MCGEE I-X TAILINGS BYPASS | Feb. 26 | - | - | - | 0.06 | 0.88 |
| | | Feb. 27 | 16 | - | 45 | 0.06 | 0.79 |
| | | Feb. 28 | 31 | - | 68 | 0.05 | 0.90 |
| | | Mar. 1 | 29 | - | 20 | - | - |
| 9003 | KERR-MCGEE Sec 30W MINE WATER | Feb. 26 | - | - | - | 0.19 | 1.3 |
| | | Feb. 27 | 26 | - | 52 | 0.21 | 1.2 |
| | | Feb. 28 | 23 | - | 49 | 0.18 | 0.94 |
| | | Mar. 1 | 17 | - | 53 | - | - |
| 9005 | KERR-MCGEE Sec 19 MINE WATER | Feb. 27 | 16 | - | 7.9 | 0.13 | 1.4 |
| 9007 | KERR-MCGEE Sec 35 MINE WATER | Feb. 26 | - | - | - | 0.11 | 0.22 |
| | | Feb. 27 | 120 | - | 9.4 | 0.15 | 0.39 |
| | | Feb. 28 | 93 | - | 7.6 | 0.06 | 0.44 |
| | | Mar. 1 | 86 | - | 8.4 | - | - |
| 9009 | KERR-MCGEE Sec 36 W MINE WATER | Feb. 26 | - | - | - | 0.07 | 0.30 |
| | | Feb. 27 | 36 | 13 | - | 0.04 | 0.21 |
| | | Feb. 28 | 44 | 13 | - | 0.04 | 0.26 |
| | | Mar. 1 | 33 | 13 | - | - | - |
| 9010 | KERR-MCGEE Sec 36 E MINE WATER | Feb. 26 | - | - | - | 0.04 | 0.34 |
| | | Feb. 27 | 32 | 14 | - | 0.03 | 0.26 |
| | | Feb. 28 | 29 | 17 | - | 1.8 | 0.28 |
| | | Mar. 1 | 27 | 14 | - | - | - |
| 9011 | KERR-MCGEE SEEPAGE BELOW TAILINGS POND | Feb. 27 COMP | 38 | 2,200 | 15,000 | - | - |
| | | Feb. 27 GRAB | 48 | 2,200 | 16,000 | 460 | 16 |
| 9012 | KERR-MCGEE POTABLE WATER SUPPLY | Feb. 26 | - | - | - | 0.13 | 1.0 |
| 9013 | KERR-MCGEE Sec 35 WATER SUPPLY | Feb. 26 | - | - | - | 0.18 | 0.32 |
| 9014 | RANCHERS EXPL JOHNNY M MINE WATER | Feb. 28 | 7 | 6.1 | - | - | - |
| 9016 | UNITED NUCLEAR CORP 1-X DISCHG | Feb. 26 | - | - | - | 0.07 | 0.28 |
| | | Feb. 27 | 5 | - | 190 | 0.04 | 0.07 |
| | | Feb. 28 | 7 | - | 200 | 0.01 | 0.06 |
| | | Mar. 1 | 3 | - | 190 | - | - |
| 9017 | UNC POTABLE WATER SUPPLY | Feb. 26 | - | - | - | 0.08 | 0.06 |
| 9018 | UNC-HP I-X DISCHARGE | Feb. 26 | - | - | - | 0.05 | 2.1 |
| | | Feb. 27 | 7 | - | 49 | 0.06 | 2.1 |
| | | Feb. 28 | 16 | - | 49 | 0.10 | 2.2 |
| | | Mar. 1 | 7 | - | 49 | - | - |

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† *Grab Samples*

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | TSS | $SO_4$ | Cl | $NH_3$† | $NO_2 + NO_3$† |
| | | | mg/l | | | | |
| 9019 | UNC-HP TAILINGS PILE DECANT | Feb. 28 | 5 | 4,300 | 1.5 | 4.4 | 4.4 |
| 9021 | ANACONDA CO INJECTION WELL FEED | Feb. 27 | - | 4,900 | - | 69 | 7.4 |
| | | Feb. 28 | 3 | - | 65 | - | - |
| 9023 | UN CHURCHROCK MINE DISCHARGE | Mar. 3 | - | | - | 0.04 | 0.23 |
| | | Mar. 4 | 33 | | 5.2 | 0.03 | 0.24 |
| | | Mar. 5 | 47 | | 4.5 | - | - |
| | | Mar. 6 | 71 | | 5.0 | 0.07. | 0.20 |
| | | Mar. 14 | 320 | | - | - | - |
| 9024 | UNC POTABLE WATER SUPPLY | Mar. 3 | - | | - | 0.05 | 0.25 |
| 9025 | KM CHURCHROCK MINE DISCHARGE | Mar. 3 | - | | - | 0.03 | 0.34 |
| | | Mar. 4 | 38 | | 0 | 0.06 | 0.45 |
| | | Mar. 5 | 45 | | 0.5 | - | - |
| | | Mar. 6 | 58 | | 3.2 | 0.07 | 0.79 |
| 9026 | KM CHURCHROCK MINE POTABLE WS | Mar. 3 | - | | - | 0.02 | 0.42 |
| 9036 | PUERTECITO CREEK | Feb. 26 | | | 72 | 0.38 | 2.3 |
| | | Feb. 27 | | | 83 | 0.40 | 1.8 |
| | | Feb. 28 | | | 71 | 0.26 | 2.9 |
| 9038 | PUERTECITO CREEK | Feb. 26 | | | 42 | 0.10 | 0.22 |
| | | Feb. 27 | | | 48 | 0.13 | 0.06 |
| | | Feb. 28 | | | 48 | 0.11 | 0.25 |
| 9040 | SAN MATEO CREEK | Feb. 26 | | | 39 | - | - |
| 9050 | RIO PUERCO @ HWY BRIDGE | Mar. 3 | | | 5.9 | | |
| | | Mar. 4 | | | 3.8 | | |
| | | Mar. 5 | | | 3.8 | | |
| 9052 | RIO PUERCO UPSTREAM OF WINGATE PLANK | Mar. 3 | | | 6.9 | | |
| | | Mar. 4 | | | 6.8 | | |
| | | Mar. 5 | | | 6.5 | | |
| 9054 | RIO PUERCO @ HWY 666 | Mar. 3 | | | 23 | | |
| | | Mar. 4 | | | 20 | | |
| | | Mar. 5 | | | 17 | | |
| 9068 | RIO-PAGUATE | Feb. 28 | | | 0.6 | | |
| 9062 | RIO MOQUINO | Feb. 28 | | | 8.3 | | |
| 9064 | RIO PAGUATE | Feb. 28 | | | 2.0 | | |
| 9066 | RIO PAGUATE | Feb. 28 | | | 15 | | |
| 9068 | RIO SAN JOSE | Feb. 28 | | | 154 | | |

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† *Grab Samples*

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | TDS | $SO_4$ | Cl | $NH_3$ | $NO_2 + NO_3$ |
| | | | mg/l | | | | |
| 9101 | MT TAYLOR MILL WORKS OLD RTE 66 | Feb. 24 | 780 | | 25 | 0.04 | 4.2 |
| 9102 | G WILCOX - MURRAY ACRES | Feb. 24 | 2,300 | | 180 | 0.01 | 5.5 |
| 9103 | Q CONNERLY - ZUNI TRAILER PARK | Feb. 25 | 880 | | 33 | <0.01 | 6.2 |
| 9104 | T SIMPSON - MURRAY ACRES | Feb. 25 | 1,400 | | 37 | <0.01 | 0.08 |
| 9105 | SCHWAGERTY - MURRAY ACRES | Feb. 25 | 1,300 | | 46 | <0.01 | 1.00 |
| 9106 | J PITMAN - BROADVIEW ACRES | Feb. 25 | 1,300 | | 39 | <0.01 | 0.33 |
| 9107 | C WORTHEN - BROADVIEW ACRES | Feb. 25 | 3,800 | | 260 | 0.01 | 14 |
| 9108 | PITNEY - MURRAY ACRES | Feb. 25 | 2,200 | | 110 | 0.01 | 3.3 |
| 9109 | T A CHAPMAN - MURRAY ACRES | Feb. 25 | 1,300 | | 9.5 | 0.01 | 2.5 |
| 9110 | 1-X WATER HOLIDAY INN - GRANTS | Feb. 25 | 430 | | 55 | 0.01 | 0.11 |
| 9111 | C&E CONCRETE - GRANTS | Feb. 26 | 560 | | 30 | 0.05 | 3.4 |
| 9112 | GRANTS CITY HALL-CITY WATER SUP | Feb. 26 | 730 | | 32 | 0.02 | 0.47 |
| 9113 | C MEADOR - BROADVIEW ACRES | Feb. 26 | 1,600 | | 120 | 0.01 | 2.9 |
| 9114 | BELL - TRAILER PARK | Feb. 26 | 970 | | 34 | <0.01 | 0.08 |
| 9115 | COWELL - SE OF ANACONDA | Feb. 26 | 1,100 | | 6.2 | 0.02 | 3.9 |
| 9116 | MILAN WELL #1 CITY WATER | Feb. 26 | 500 | | 14 | 0.02 | 1.6 |
| 9117 | ANACONDA - MONITOR WELL | Feb. 27 | 2,300 | | 11 | 0.03 | 1.5 |
| 9118 | ANACONDA - WELL 2 | Feb. 29 | 1,900 | | 270 | 0.64 | 9.0 |
| 9119 | ANACONDA - WELL 4 | Feb. 27 | 880 | | 42 | 0.13 | 5.7 |
| 9120 | ANACONDA - MEXICAN CAMP | Feb. 27 | 490 | | 10 | 0.04 | 0.73 |
| 9121 | ANACONDA - GERRYHILL Sec 5 | Feb. 27 | 2,000 | | 4.2 | 0.14 | 0.05 |
| 9122 | ANACONDA - NORTH WELL | Feb. 27 | 1,900 | | 4.2 | 0.08 | 1.3 |
| 9123 | ANACONDA - ENGINEERS' WELL | Feb. 28 | 960 | | 61 | 0.09 | 3.20 |
| 9124 | ANACONDA - BERRYHILL HOUSE | Feb. 28 | 940 | | 65 | 0.05 | 0.80 |
| 9125 | ANACONDA - LOS BLUEWATER | Feb. 28 | 1,000 | | 12 | 0.05 | 0.95 |
| 9126 | ANACONDA - ROUNDY | Feb. 28 | 1,100 | | 110 | 0.04 | 6.5 |
| 9127 | ANACONDA - FRED FREAS | Feb. 28 | 540 | | 18 | 0.03 | 0.03 |
| 9128 | ANACONDA - LEROY CHAPMAN | Feb. 28 | 490 | | 18 | 0.03 | 1.4 |
| 9129 | ANACONDA - JACK FREAS | Feb. 28 | 780 | | 54 | 0.04 | 2.5 |
| 9130 | N MARQUEZ - HOUSE WELL | Mar. 1 | 720 | | 4.8 | 0.04 | 0.06 |
| 9131 | C SANDOVAL - WINDMILL | Mar. 1 | 660 | | 27 | 0.06 | 1.2 |
| 9132 | N MARQUEZ - WINDMILL | Mar. 1 | 2,200 | | 43 | 0.22 | 24 |
| 9133 | G ENYART - GRANTS | Mar. 2 | 1,600 | | 50 | 0.26 | 0.97 |

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | TDS | $SO_4$ | Cl | $NH_3$ | $NO_2$ + $NO_3$ |
| | | | mg/l | | | | |
| 9134 | UN HP SUPPLY WELL 2 | Mar. 3 | 1,600 | | 0.2 | 0.03 | 0.42 |
| 9135 | UN HP WELL D | Mar. 3 | 4,500 | | 340 | 1.0 | 2.6 |
| 9136 | UN HP SUPPLY WELL 1 | Mar. 3 | 2,000 | | <0.2 | 0.07 | 0.28 |
| 9137 | ERWIN WELL - GALLUP | Mar. 5 | 740 | | 14 | 0.09 | 0.02 |
| 9138 | BOARDMAN TRAILER PARK - GALLUP | Mar. 5 | 930 | | <0.2 | 0.50 | 1.2 |
| 9139 | G HASSLER - GALLUP | Mar. 5 | 880 | | 98 | 0.02 | 27 |
| 9140 | DIXIE WELL - GALLUP | Mar. 5 | 1,500 | | <0.2 | 0.30 | 0.16 |
| 9141 | CHURCHROCK VILLAGE | Mar. 5 | 720 | | 0.5 | 0.50 | 0.18 |
| 9142 | WHITE WELL - GALLUP | Mar. 5 | 620 | | 630 | 0.01 | 0.02 |
| 9143 | TOGAY WELL - GALLUP | Mar. 5 | 340 | | 14 | 0.02 | 8.0 |
| 9201 | PHIL HARRIS (WILCOXSON) KM 46 | Feb. 26 | 1,900 | | 23 | 0.14 | 0.09 |
| 9202 | COUNTY LINE STOCK TANK KM 52 | Feb. 26 | 2,100 | | 56 | 0.06 | 14 |
| 9203 | NAVAHO WIND MILL KM 45 | Feb. 26 | 400 | | 6.8 | 0.02 | 4.0 |
| 9204 | INGERSOLL RAND KM 49 | Feb. 26 | 2,200 | | 36 | 0.05 | 18 |
| 9205 | BINGHAM (RAGLAND) KM 47 | Feb. 26 | 2,000 | | 40 | 0.04 | 4.7 |
| 9206 | MARQUEZ (RAGLAND) KM 63 | Feb. 26 | 1,900 | | 34 | 0.05 | 44 |
| 9207 | KM-S-12 | Feb. 27 | 14,000 | | 3,100 | 0.50 | 0.04 |
| 9208 | KM-43 | Feb. 27 | 7,800 | | 38 | NS | NS |
| 9209 | KM-44 | Feb. 27 | 2,700 | | 17 | 0.66 | 11 |
| 9210 | KM-51 | Feb. 27 | 6,300 | | 44 | 0.30 | 79 |
| 9211 | KM-48 | Feb. 27 | 4,100 | | 31 | 0.80 | 1.3 |
| 9212 | KM SEEPAGE RETURN | Mar. 3 | 36,000 | | 3,100 | 590 | 12 |
| 9213 | KM B-2 | Mar. 3 | 8,900 | | 3,400 | 0.12 | 0.25 |
| 9214 | KM 36-2 | Mar. 3 | 9,100 | | 1,700 | 2.9 | 8.0 |
| 9215 | KM 46 | Mar. 3 | 3,200 | | 100 | 10 | 2.0 |
| 9216 | KM 47 | Mar. 3 | 2,600 | | 74 | 0.80 | 2.6 |
| 9217 | KM 50 | Mar. 3 | 4,700 | | 470 | 9.1 | 16 |
| 9218 | KM 51 | Mar. 3 | 4,800 | | 61 | 0.16 | 0.40 |
| 9219 | KM 52 | Mar. 3 | 6,700 | | 1,300 | 0.08 | 1.3 |
| 9220 | HARDGROUND FLATS WELL CRKM 2 | Mar. 5 | 850 | | 0.2 | 0.03 | 0.28 |
| 9221 | E PUERCO R WELL CRKM 11 | Mar. 5 | 340 | | 14 | 0.04 | 14 |

| Sample No. | Station Description | Date | Analyses Performed | | | | |
|---|---|---|---|---|---|---|---|
| | | | TDS | $SO_4$ | Cl | $NH_3$ | $NO_2$ + $NO_3$ |
| | | | mg/l | | | | |
| 9222 | PUERCO WELL CRKM 16 | Mar. 5 | 1,600 | | <0.2 | 34 | 0.01 |
| 9223 | PIPELINE ROAD WELL CRK M 5 | Mar. 5 | 880 | | <0.2 | 1.4 | 1.6 |
| 9224 | NOSEROCK WELL CRKM 3 | Mar. 5 | 980 | | <0.2 | 0.07 | 0.03 |
| 9225 | NORTHEAST PIPELINE WELL CRK M10 | Mar. 5 | 2,300 | | 8.1 | 0.12 | 0.01 |
| 9230 | ANACONDA JACKPILE WELL 4 | Feb. 28 | 540 | | <0.2 | 0.05 | 0.05 |
| 9231 | ANACONDA JACKPILE WELL P 10 | Feb. 28 | 1,200 | | 0.5 | 0.08 | 0.04 |
| 9232 | ANACONDA JACKPILE WELL - NEW SHOP | Feb. 28 | 1,400 | | 0.5 | 0.14 | 0.05 |
| 9233 | PUGUATE MUNICIPAL WELL | Feb. 28 | 340 | | 6.6 | 0.08 | 0.20 |

# Appendix D

## SELENIUM
## EPA WATER QUALITY CRITERIA 1972

# SELENIUM*

The toxicity of selenium resembles that of arsenic and can, if exposure is sufficient, cause death. Acute selenium toxicity is characterized by nervousness, vomiting, cough, dyspnea, convulsions, abdominal pain, diarrhea, hypotension, and respiratory failure. Chronic exposure leads to marked pallor, red staining of fingers, teeth and hair, debility, depression, epistaxis, gastrointestinal disturbances, dermatitis, and irritation of the nose and throat. Both acute and chronic exposure can cause odor on the breath similar to garlic (The Merck Index of Chemicals and Drugs 1968).[336] The only documented case of selenium toxicity from a water source, uncomplicated with selenium in the diet, concerned a three-month exposure to well water containing 9 mg/l (Beath 1962).[331]

Although previous evidence suggested that selenium was carcinogenic (Fitzhugh et al. 1944),[332] these observations have not been borne out by subsequent data (Volganev and Tschenkes 1967).[346] In recent years, selenium has become recognized as a dietary essential in a number of species (Schwarz 1960,[341] Nesheim and Scott 1961,[338] Oldfield et al. 1963[339]).

Elemental selenium is highly insoluble and requires oxidation to selenite or selenate before appreciable quantities appear in water (Lakin and Davidson 1967).[335] There is evidence that this reaction is catalyzed by certain soil bacteria (Olson 1967).[340]

No systematic investigation of the forms of selenium in excessive concentrations in drinking water sources has been carried out. However, from what is known of the solubilities of the various compounds of selenium, the principal inorganic compounds of selenium would be selenite and selenate. The ratio of their individual occurrences would depend primarily on pH. Organic forms of selenium occurred in seleniferous soils and had sufficient mobility in an aqueous environment to be preferentially absorbed over selenate in certain plants (Hamilton and Beath 1961).[334] However, the extent to which these compounds might occur in source waters is essentially unknown. Toxicologic examination of plant sources of selenium revealed that selenium present in seleniferous grains was more toxic than inorganic selenium added to the diet (Franke and Potter 1935).[333]

Intake of selenium from foods in seleniferous areas (Smith 1941),[342] may range from 600 to 6,340 µg/day, which approach estimated levels related to symptoms of selenium toxicity in man based on urine samples (Smith et al. 1936,[343] Smith and Westfall 1937[344]). If data on selenium in foods (Morris and Levander 1970)[337] are applied to the average consumption of foods (U.S. Department of Agriculture, Agriculture Research Service, Consumer and Food Economics Research Division 1967),[345] the normal dietary intake of selenium is about 200 µg/day.

If it is assumed that two liters of water are ingested per day, a 0.01 mg/l concentration of total selenium would increase the normal total dietary intake by 10 per cent (20 µg/day). Considering the range of selenium in food associated with symptoms of toxicity in man, this would provide a safety factor of from 2.7 to 29. A serious weakness in these calculations is that their validity depends on an assumption of equivalent toxicity of selenium in food and water, in spite of the fact that a considerable portion of selenium associated with plants is in an organic form. Adequate toxicological data that specifically examine the organic and the inorganic selenium compounds are not available.

### Recommendation

**Because the defined treatment process has little or no effect on removing selenium, and because there is a lack of data on its toxic effects on humans when ingested in water, it is recommended that public water supply sources contain no more than 0.01 mg/l selenium.**

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* *Water Quality Criteria, 1972, Environmental Protection Agency, Washington, D.C.*