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Plan for Injection of Treated Ground Water at the Tuba City, Arizona, UMTRA Project Site

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Prepared by
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Introduction

This plan was initially developed in March 2000 to provide information normally required by the U.S. Environmental Protection Agency (EPA) to determine the need for notification or permitting of underground injection wells that are part of remediation at the Tuba City, Arizona, Uranium Mill Tailings Remedial Action (UMTRA) Project site. It is being updated to provide current information about remediation activities.

Ground water at the Tuba City UMTRA site (Figure A) is contaminated with residual radioactive material (RRM[1]) as a result of historical processing of uranium ore. RRM has the potential to cause risks to human health and the environment. Therefore, the U.S. Department of Energy (DOE) selected active remediation to clean up ground water at the Tuba City site. DOE will clean up the ground water by extracting it from the aquifer, treating it with a distillation system, and injecting the treated water back into the aquifer. The decision to remediate was made based on the *Environmental Assessment of Ground Water Compliance at the Tuba City Uranium Mill Tailings Site* (DOE/EA-1268) and the subsequent Finding of No Significant Impact (January 1999). The Environmental Assessment analyzed the relevant environmental issues and risks to human health and the environment at the Tuba City site, which included the need to inject treated ground water into the alluvial aquifer at the site. All new and existing monitoring wells are considered compliance wells and will be used to evaluate cleanup standards.

The purpose of active remediation is to comply with EPA ground water standards defined in Title 40, Part 192 of the *Code of Federal Regulations* (40 CFR 192). A meeting/teleconference held on December 9, 1999, included representatives from DOE, DOE's contractor MACTEC–ERS, EPA Region IX, the Navajo UMTRA Project, and the Hopi Tribe to determine regulatory requirements applicable to the injection of ground water following treatment. This plan was initially prepared so that EPA Region IX could determine the appropriate level of notification and/or permitting required for compliance with the underground injection regulations (40 CFR 144) for treated water (injectate), as promulgated under the Safe Drinking Water Act. The current revision of the plan includes an updated schedule for remediation activities.

Background

The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 requires DOE to comply with 40 CFR 192 standards at 24 inactive uranium-ore processing sites. The Tuba City site is one of the 24 sites identified. During its 10 years of operation, the mill at the Tuba City site processed approximately 800,000 tons of uranium ore before it ceased operations in 1966. DOE began surface cleanup of the site in 1988. Uranium mill tailings and associated materials were moved and stabilized in an engineered disposal cell on the site. Surface cleanup was completed in April 1990. Since 1982, DOE has been monitoring contamination in the ground water beneath the site, as required by 40 CFR 192.

[1] Residual radioactive material is defined in the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (42 *U.S. Code*, Section 4321 *et seq.*) as "waste in the form of tailings, or other material that is present as a result of processing uranium ores at any designated processing site."

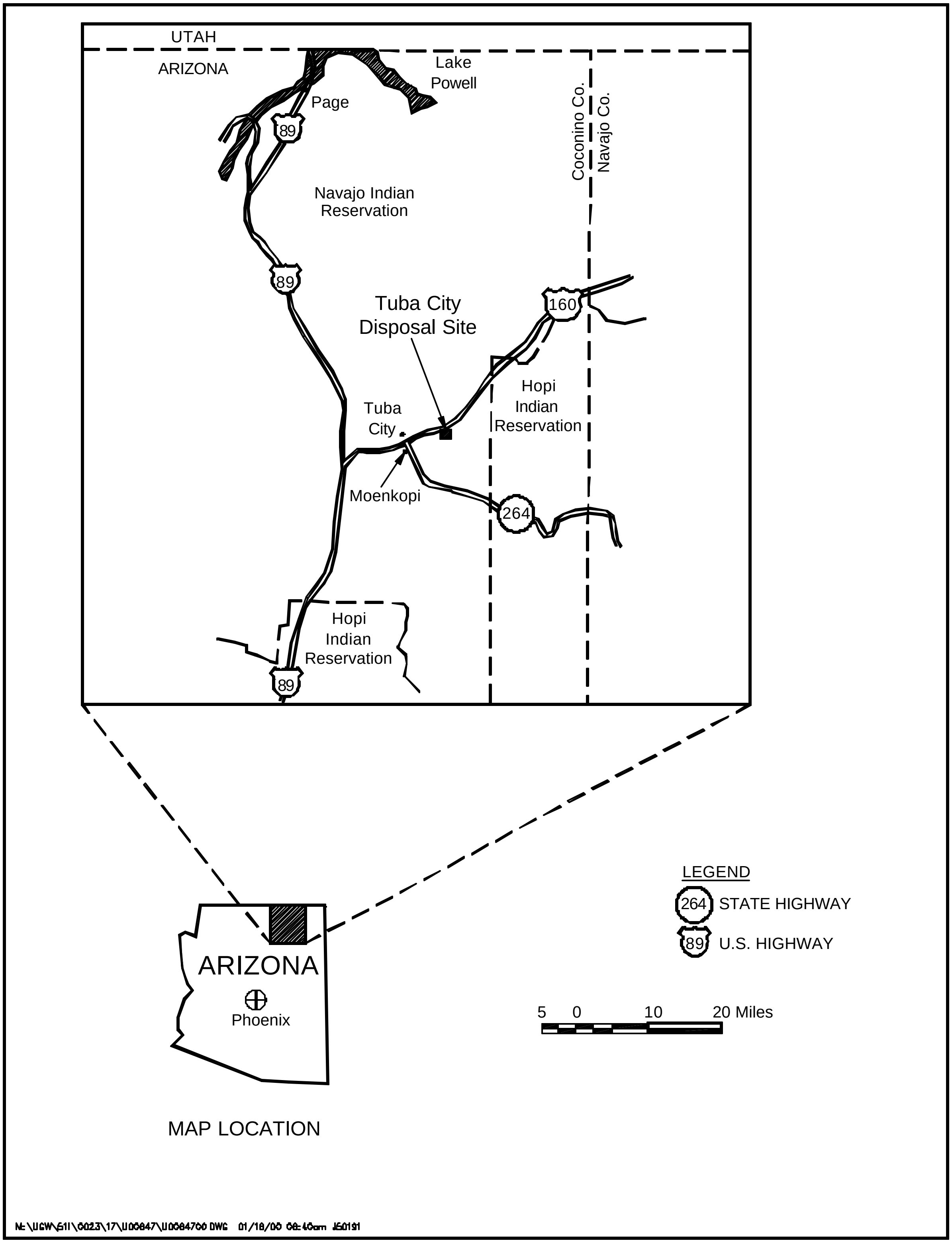

Figure A. Location of the Tuba City Site

Results of the monitoring indicate that up to 1.7 billion gallons of ground water may be contaminated as a result of RRM. Ground water contamination has been detected as far as 1,500 ft downgradient from the former millsite and may have migrated to depths of up to 700 ft near the disposal cell. This contamination currently poses no risk to human health or the environment because no domestic or drinking water wells withdraw the contaminated ground water.

The regulations also require that selection and performance of remedial action be completed with full participation of affected states, in consultation with affected Indian tribes, and with the concurrence of the Nuclear Regulatory Commission. DOE entered into a cooperative agreement in 1999 with the Navajo Nation and has held numerous meetings with representatives of the Navajo Nation to address concerns at the Tuba City site.

The *Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE/EIS**B**0198) presents a step-by-step approach for determining the appropriate compliance strategy at each UMTRA site. That approach was used to select the ground water compliance strategy for the Tuba City site. The Environmental Assessment was tiered to the PEIS in a manner consistent with the concept of tiering described in 40 CFR 1508.28.

Site Description

The Tuba City site is in Coconino County, Arizona, just south of U.S. Highway 160 in Sections 17 and 20, Township 32 North, Range 12 East, Gila and Salt River Meridian. The site is within the boundaries of the Navajo Nation and is close to the Hopi Reservation; it is approximately 5 miles east of Tuba City, and 85 miles northeast of Flagstaff, Arizona.

The site lies at an elevation of approximately 5,100 ft above sea level on a terrace that slopes gently to the south. Surface drainage is to the south toward Moenkopi Wash. The Tuba City site, which is surrounded by a chain-link security fence, comprises approximately 146 acres; the top of the disposal cell covers approximately 31 acres.

The area in the vicinity of the Tuba City site is semiarid and desertlike. Land immediately adjacent to the site is used for grazing. Lands farther from the site are used for dry farming, irrigated farming, and residences. Plates 1 and 2 in the *Final Site Observational Work Plan for the UMTRA Project Site Near Tuba City, Arizona*, show topographic features and geologic and hydrologic cross-sections of the site.

In the portions of the aquifer that are unaffected by Tuba City millsite-related contaminants, ground water is of high quality and is suitable for all domestic uses. However, past milling activities have resulted in degradation of ground water quality beneath and downgradient of the former millsite. Eighteen site-related constituents were detected in the ground water at concentrations above background; of those, four contaminants are present in concentrations that exceed maximum allowable limits (molybdenum, nitrate, selenium, and uranium) and one that could pose a future human health risk (sulfate). Table 1 lists the cleanup standards and goals for the N-aquifer at the Tuba City site. Table 4–10 of the Site Observational Work Plan shows background concentration ranges of the contaminants of concern.

By implementing the proposed action alternative, DOE will attempt to remediate the contaminated portion of the aquifer until contaminant concentrations are within EPA standards and, to the extent practicable, until concentrations are within the cleanup goals requested by the Navajo Nation.

Table 1. Cleanup Standards and Goals for the Tuba City UMTRA Site

Contaminant	Cleanup Level	Concentration in Plume
Aquifer Restoration Standards required by 40 CFR 192		
Nitrate (as nitrate)	44 mg/L	840–1,500 mg/L
Molybdenum	0.10 mg/L	0.01–0.58 mg/L
Selenium	0.10 mg/L	0.01–0.10 mg/L
Uranium	0.044 mg/L	0.3–0.6 mg/L
Aquifer Restoration Goals requested by the Navajo Nation		
Total Dissolved Solids	500 mg/L	3,500–10,000 mg/L
Sulfate	250 mg/L	1,700–3,500 mg/L
Chloride	250 mg/L	20–440 mg/L
pH	6.5–8.5	6.3–7.6
Corrosivity	Noncorrosive	Not applicable

Project Information/Contacts

EPA Identification Number: No number is needed; RRM is regulated by UMTRCA and is not regulated as a hazardous waste.

Applicant Name and Address:

Donald Metzler
U. S. Department of Energy
Grand Junction Office
2597 B 3/4 Road
Grand Junction, CO 81503

Operator Name and Address:

Sam Marutzky
MACTEC-ERS
2597 B 3/4 Road
Grand Junction, CO 81503

Key Regulatory and Cooperating Agencies

U. S. Department of Energy Grand Junction Office	Don Metzler (Project Manager) Audrey Berry (Public Relations)	(970) 248-7612 (970) 248-7727
U.S. EPA, Region IX Ground Water Office	Laura Bose (Manager) Shannon Fitzgerald (Env. Scientist)	(415) 744-1835 (415) 744-1830

Note: EPA Region IX is the regulatory agency with primacy for administering the underground injection program.

Nuclear Regulatory Commission Uranium Recovery Branch	Thomas Essig (Chief)	
Navajo UMTRA Program Window Rock, Arizona	Madeline Roanhorse (Director) Levon Benally (Env. Specialist)	(928) 871-6982 (928) 871-7594

Navajo EPA	Derrith Watchman Moore (Director)	(928) 871-7692
	Deb Misra	(928) 871-7701
	Eric Rich (Water Programs)	(928) 871-7690
Navajo Water Code Administration	Johnnie Francis (Director)	(928) 729-4003
	Bennie Williams (Administrator)	(928) 729-4130

Key Stakeholders

Navajo Nation tribal members and Hopi tribal members

DOE Contractor Points of Contact

MACTEC–ERS	Sam Marutzky (Project Manager)	(970) 248-6059
(DOE contractor for the	Randy Juhlin (Site Manager)	(970) 248-6502
Grand Junction Office)	Robert Bleil (Compliance Specialist)	(970) 248-6503
	Michelle Smith (Public Relations)	(970) 248-6583

Project Description

DOE has (1) installed wells to extract contaminated ground water, (2) treated the recovered water by a distillation process, (3) installed Class V wells in defined areas of the plume and an infiltration trench to inject the treated ground water (injectate) back into the aquifer, and (4) conducted monitoring within the plume area, near the injection wells, and near the infiltration trench. The objectives of the extraction and injection system are to contain the spread of contaminants while removing contamination from the ground water to achieve compliance with ground water standards. DOE obtained the necessary permits from the Navajo Water Code Administration for installation of the wells.

Two phases for implementing the extraction and injection system are planned. Phase I has been constructed. It involved installing 25 extraction wells and 6 injection wells in and around the site and installing an infiltration trench north of the disposal cell (see Figure 1). Figure 2 shows the construction details for the infiltration trench, and Figure 3 shows construction details and depths for the wells.

The treatment system required installation of a large (40 ft high, 50 ft long, and 13 ft wide) treatment unit on the site. The Phase I treatment unit can process up to 140,000 gallons of contaminated ground water per day and is expected to operate for 2 to 4 years before a second treatment system is considered for Phase II. During this initial operating period, sampling of the extracted and treated water (injectate) will be conducted periodically to evaluate the effectiveness of the system. The monitoring plan gives details of sampling to be done. Monitoring and modeling results will be used to design Phase II of the system, which may involve the installation of 40 to 55 additional extraction wells, 20 to 30 additional injection wells, and an additional treatment unit.

Phase I extraction wells are located in areas of highest contaminant concentrations. Spreading of the plume will be controlled primarily by the placement of the Phase II extraction wells and, to a lesser extent, by the downgradient pressure barrier created by the injection wells. A monitoring well will be installed slightly downgradient (southeast) of injection wells 1005 and 1004 (Figure 1) to verify containment of the plume.

For Phase I, water from the 25 extraction wells is pumped to an aboveground storage tank located near the treatment system. From this tank, the water is pumped through one of two softeners. These softeners contain an ion-exchange resin that will remove calcium and magnesium from the ground water, replacing it with sodium. After passing through the softener, the softened water flows to a second aboveground storage tank and is then pumped through a degassifier where it is treated with concentrated sulfuric acid to remove carbonates. The softened, degasified ground water is pumped to the treatment system. Inside the treatment system vessel, which operates under vacuum, the ground water is circulated over heat-transfer elements and the water is vaporized. The water vapor is condensed to form high-quality liquid water that is pumped to the infiltration tank (Tank T-2 on Figure 1), from where it flows to the infiltration trench and/or to the injection wells.

As the water is evaporated in the treatment system, the nonvolatile contaminants concentrate to form a circulating brine. A small amount of this brine, constituting approximately 5 percent of the influent to the treatment vessel, is continuously withdrawn and pumped to the evaporation pond. Additional flow to the evaporation pond comes from periodic regeneration of the softeners, which is achieved by flushing a sodium chloride solution through the softener bed to remove the calcium and magnesium and replace it with sodium. The regeneration is followed by a rinse with clean water. The spent regenerant solution and rinse water will flow to the evaporation pond. The total flow of the waste streams from the regeneration process is expected to average between 5 and 10 percent of the total influent.

In the evaporation pond, the water evaporates and the nonvolatile contaminants remain in the pond. A spray system will be added to the evaporation pond to enhance the natural evaporation rate. Water will be pumped through the spray system on days when there is little or no wind, except during the winter months when the system will not be operated.

The evaporation pond has two 60-mil-thick high-density polyethylene liners with a leachate collection system between the two liners. The contaminants will remain in the evaporation pond until the end of the project, at which time they will be transported to a facility licensed to accept RRM.

The quality of treated water returned to the aquifer will be significantly better than that of natural background water. Table 2 shows the average quality of the treated water, the quality of natural background water, and the standards and goals for the injectate. During start-up testing in 2000, the system had significant problems, but was able to produce injectate to the levels shown in Table 2 under the "Treated Water Quality" column.

The injectate standards and goals are based on the aquifer restoration standards and goals listed in Table 1, except for pH. The pH goal for the injectate (5.5 to 9.5) is broader than the aquifer cleanup goal to allow greater flexibility in the treatment process. The average pH of the injectate is anticipated to be about 6.5. However, because of its low total dissolved solids, injectate with a pH that is lower or higher than the average but within the range of 5.5 to 9.5 will be buffered immediately by the subsurface materials and the aquifer ground water and will not adversely affect minerals in the formation. This will be verified with monitoring wells located near the infiltration trench and the injection wells. If analytical results from the injection monitoring wells indicate that the broader range for pH is altering the aquifer matrix, the pH range for the injectate will be modified. Calcium, silica, and alkalinity as calcium carbonate also will be monitored in the injection monitoring wells as shown in Table 3.

At the completion of ground water cleanup, DOE would remove the distillation treatment units, water storage tank, evaporation ponds, existing ponds, and infiltration trench. The pipelines also would likely be removed. A limited number of the injection and extraction wells would be left in place for use as ground water monitoring wells. All wells would be decommissioned in accordance with Navajo Water Code Administration regulations. At the end of the project, selected monitoring will be sampled for a full suite of organic and inorganic analyses.

Table 2. Quality of Treated Water at the Tuba City UMTRA Site

Contaminant	Treated Water Quality	Natural Background	Injectate Standards/Goals
Molybdenum	< 0.002 mg/L	< 0.001 mg/L	0.10 mg/L
Nitrate (as nitrate)	< 2.0 mg/L to 10 mg/L	13 mg/L	44 mg/L
Selenium	< 0.002 mg/L	0.002 mg/L	0.010 mg/L
Uranium	< 0.002 mg/L	0.002 mg/L	0.044 mg/L
Injectate Goals			
Sulfate	< 2.0 mg/L	19 mg/L	250 mg/L [a]
Total dissolved solids	20 mg/L–50 mg/L	170 mg/L	500 mg/L [a]
Chloride	<0.10 mg/L	7 mg/L	250 mg/L [a]
pH	6.0–9.0	7.7	5.5–9.5 [a]
Conductivity	50 µS/cm–150 µS/cm	250 µS/cm	–

[a]There are not enforceable standards for these constituents. The concentrations listed are goals established by DOE.
mg/L = milligrams per liter
µS/cm = microSiemons per centimeter

Injectate Monitoring Plan

The monitoring plan covers monitoring of treated water from the treatment plant (the injectate), the injection monitoring wells located near the infiltration trench, and the injection wells. DOE will sample the injectate and the injection monitoring wells frequently at the startup of the system and reduce the frequency of sampling with time. Table 3 shows the frequency of sampling and the analyses to be performed for each sample. During the 15-day startup test of the treatment system, DOE will collect daily samples of the injectate and analyze them at the on-site laboratory. In addition, three samples will be analyzed by the Analytical Chemistry Laboratory at the DOE Grand Junction Office. The frequency of sample collection will decrease after completion of the startup test, when analytical results have established sufficient confidence in the treatment system. Electrical conductivity of the injectate will be monitored continuously during operation of the treatment system. Conductivity can be directly correlated to the concentration of total dissolved solids in the injectate.

The six injection monitoring wells were sampled immediately after the wells were installed and developed in 1999. Thereafter they will be sampled according to the frequency shown in Table 3. DOE will sample the injection monitoring wells less frequently than the injectate because the effects of treatment will show up more slowly in the monitoring wells. Preliminary modeling indicates it will take 6 months for water injected into the infiltration trench or the injection wells to reach the monitoring wells. Depth to the water table will be monitored regularly to track any changes in hydraulic gradient, and equipotential maps of the water table will be included with the analytical reports of monitoring. The monitoring reports will be generated semi-annually and sent to the Navajo EPA, Navajo UMTRA Project Office, and EPA Region IX.

Contingency Plan

If sampling results show that the injectate water quality does not meet the injectate standards listed in Table 2, the treatment system will be shut down and modified to produce treated water that meets the injectate standards. Conductivity of the injectate will be correlated to the concentration of total dissolved solids. An injectate conductivity equivalent to a total dissolved solids concentration of 500 mg/L will be the threshold indicator to shut down the system and correct the problem.

Table 3. Summary of Injectate and Injection Monitoring Well Sampling

Item Sampled	Samples and Frequency	Analyses
Injectate	Daily samples (total of 15) during startup test	On-site testing for nitrate, sulfate, alkalinity, pH, and conductivity.
Injectate	3 samples during startup test.	Laboratory analysis for ammonium, cadmium, calcium, chloride, gross alpha, iron, lead, magnesium, manganese, molybdenum, nitrate, potassium, selenium, silica, sodium, strontium, sulfate, total dissolved solids, and uranium.
Injectate	1 sample per month for the first six months, then 4 samples per year thereafter.	On-site testing for nitrate, sulfate, alkalinity, pH, and conductivity. Laboratory analysis for ammonium, cadmium, calcium, chloride, gross alpha, iron, lead, magnesium, manganese, molybdenum, nitrate, potassium, selenium, silica, sodium, strontium, sulfate, total dissolved solids, and uranium.
Injectate	Continuous during operation of the treatment system	Conductivity (this measurement is directly related to total dissolved solids).
Injection monitoring wells	1 sample immediately after well development, then 1 sample every 6 months for 3 years, then 1 sample per year.	Field measurements for alkalinity, redox potential, pH, conductivity, turbidity, and temperature after installation. Laboratory analysis for ammonium, cadmium, calcium, chloride, gross alpha, iron, lead, magnesium, manganese, molybdenum, nitrate, potassium, selenium, silica, sodium, strontium, sulfate, total dissolved solids, and uranium.

Sampling results from the injection monitoring wells will be used to determine if the pH range for the injectate should be adjusted. If sampling results show increased concentrations of contaminants in the monitoring wells, the pH range for the injectate standards will be modified.

Status and Schedule of Activities

Activity	Start	Finish
Startup testing for the treatment system	March 2002	April 2002
Full-scale operation of treatment system	April 2002	2020?

Initial startup activities for the treatment system were performed during the spring and summer of 2000. During that time, treated water that met the injectate standards was set to the infiltration trench. DOE decided to delay sending injectate to the injection wells until sustained operation of the treatment system could be achieved. Operation of the treatment system was unsuccessful and operation was suspended in September 2000 in favor of pilot-scale studies. The small amount of treated water produced in these studies was sent to the evaporation pond. As a result of the pilot studies, the treatment process has been modified by the addition of the softening step, as described in the Project Description section. The modified treatment process will be put into service in March 2002.