U. S. NUCLEAR REGULATORY COMMISSION

REGION IV

NRC Inspection Report: 40-8027/90-04
License: SUB-1010

Docket: 40-8027

Licensee: Sequoyah Fuels Corporation
P. O. Box 610
Gore, Oklahoma 74435

Facility Name: Sequoyah Facility

Inspection At: Sequoyah Facility Site, Gore, Oklahoma

Inspection Conducted: August 27 through August 29, 1990

Team Leader: Edward F. Hawkins — 10/2/90 Date
Edward F. Hawkins, Deputy Director
Uranium Recovery Field Office
Region IV

Team Members: Pete J. Garcia Jr. — 10/2/90 Date
Pete J. Garcia, Jr., Project Manager
Uranium Recovery Field Office
Region IV

Gary R. Konwinski — 10-1-90 Date
Gary R. Konwinski, Project Manager
Uranium Recovery Field Office
Region IV

G. Michael Vasquez — 10/5/90 Date
G. Michael Vasquez, Project Manager
Region IV

1.0 General Background Information

The NRC has established a policy to provide for the timely, thorough, and systematic inspection of atypical situations at licensed facilities. This includes the use of an Augmented Inspection Team (AIT) to determine the causes, conditions, and circumstances relevant to such situations and to communicate its findings, safety concerns, and recommendations to NRC management. An AIT was sent to Sequoyah Fuels Corporation's (SFC) Sequoyah Facility on August 27, 1990, to review the circumstances associated with high uranium-bearing water discovered during excavation work at the facility. A description of the event and the AIT tasks is provided below.

1.1 Description of Event

On Wednesday, August 22, 1990, SFC notified NRC Region IV that uranium contaminated water had been discovered in an open excavation immediately adjacent to the solvent extraction (SX) building at the SFC site near Gore, Oklahoma. The water was discovered while excavating around two underground storage tanks for the purpose of constructing a reinforced concrete vault around the tanks. The tanks were being encased so that they would no longer be regulated as underground storage tanks in accordance with Environmental Protection Agency regulations.

The August 22, 1990, report from SFC indicated that "some ground water seepage occurred, along with some accumulation of rainwater during periods of rainfall." When sampled and analyzed, this water "indicated levels of uranium substantially above SFC's environmental action level for uranium in water, 225 ug/l. Some samples were in the 1-8 g/l range." The NRC considered this level in grams/liter of uranium very high (some 35,000 times the environmental action level for uranium in water as defined in the SFC license) and, as a result, although there was no indication that the seepage had been a hazard to workers or to the public, immediately dispatched a Region IV inspector to the site. After a review of the circumstances by the inspector, and the apparent lack of awareness by SFC as to the potential significance of the elevated concentrations, the NRC dispatched an AIT to the site.

1.2 AIT Tasks

The AIT dispatched to SFC consisted of a manager (the team leader) from NRC Region IV's Uranium Recovery Field office (URFO), one URFO Project Manager with past inspection experience at SFC, one URFO Project Manager with expertise in ground water, and the Region IV Project Manager assigned to SFC. The AIT tasks were specified in a

memorandum dated August 24, 1990, from the Region IV Director, Division of Radiation Safety and Safeguards to the team leader. The tasks included:

1. Determine the extent, if any, of licensee and contractor employee exposure to uranium while digging the excavation and installing the vault. Establish a chronology of licensee actions, including preparation of the excavation, discovery of the contamination, samples taken and results, notifications to offsite authorities, and related information.

2. Establish a chronology of the history of the solvent extraction (SX) building. Identify and obtain copies of licensee documents related to: (a) process system leakage; (b) degradation, leakage, and repair of the SX building floor and sump; (c) maintenance and construction activities underground outside the SX building; and (d) radiation and contamination measurements made outside the SX building.

3. Determine whether, following the January 1986 accident, Pickard, Lowe and Garrick, Inc. evaluated and commented on aspects of the SX building related to building integrity and environmental contamination.

4. Review the licensee's environmental data and reports from 1980 (or earlier) to the present time to determine whether, in retrospect, they reveal any indication of ground-water contamination attributable to the SX building.

5. Determine licensee plans concerning the decontamination of the affected areas. This includes review of the licensee's plans for characterizing the extent of contamination beneath and beyond the SX building. Determine the ability of those planned actions to quantify the depth, breadth, and concentration of the below-ground contamination and whether the planned actions could worsen the situation, for example, in causing the near-surface water to communicate with ground water.

All aspects surrounding the discovery of contamination and facility response were reviewed to determine the events that took place. Key elements of the AIT charter were to develop a thorough chronology and technical understanding of the licensee response to the event, and to review environmental monitoring reports and determine the extent of knowledge that the licensee had associated with the event.

2.0 Chronology of Event

A chronology of activities related to the discovery of water containing elevated levels of uranium in the vault excavation is provided in this section. A detailed daily chronology is provided in Enclosure A to this report.

The licensee started removing concrete around the top of the hexane tanks in preparation for excavation activities on July 31, 1990. SFC began excavating soil around the two underground tanks on August 1. Water was noted in the excavation and a water sample was taken. The sample laboratory analysis measured a concentration of uranium of 0.02 grams/liter (g/l). This analysis was available on August 2.

On August 4, a sewer line broke and dumped additional water into the excavation. A water sample was taken on August 4 with an analysis result of 2.06 g/l uranium, or approximately 1.4 times the maximum permissible concentration for restricted areas specified in 10 CFR 20, Appendix B, Table 1, Column 2. The President of SFC also left for vacation on August 4, leaving the Senior Vice President (SVP) responsible for all activities at SFC.

On August 6, a routine NRC inspection of SFC activities began. During a tour of the facility, NRC inspectors noted workers (the first day anyone actually worked in the excavated pit) in the excavated pit and questioned SFC personnel as to why water was in the excavated pit. Although laboratory results were available to responsible SFC personnel, no definite answer was given to the inspectors as to the source or that the water was contaminated. The inspectors also noted that the area had been roped off with a step pad at the entry to the pit, but SFC site personnel stated that these controls were not because of contamination concerns. Another water sample was also taken on August 6.

On August 7, the Manager, Environmental first saw the August 4 analysis result of 2.06 g/l uranium. She then talked with the SVP regarding the contamination in the excavated area, and appropriately had additional soil and water samples taken in the excavated pit. Although laboratory records indicated that the sample results were available that same day on August 7, for reasons that could not be determined at the time of the AIT, responsible site personnel were apparently not aware of the analysis results for the August 6 and 7 samples until August 17. A copy of the results was not seen by the responsible individual submitting the samples for analysis until August 23, 1990.

Excavation of the area continued, and the footing for the vault was placed on August 10. The site experienced significant rainfall on August 11 and 12, resulting in about 3000 gallons of water in the excavation. Two samples were taken on August 13 and the water was pumped

into the North Ditch where it eventually mixed with other liquid effluents and was subsequently released to the combination stream under an NPDES permit. The sample analysis indicated values of 0.01 and 0.04 g/l uranium, probably due primarily to dilution of the material in the excavation pit caused by the significant rainfall.

Water discovered in the excavation after August 13 was pumped into barrels and stored onsite. Steel reinforcing bars for the walls of the vault were set August 13-16. The SVP left the site on August 15, leaving the UF6 Area Manager responsible for all activities at SFC. The SVP telephoned the UF6 Area Manager on August 16 to leave a list of items to be performed, including checking into the laboratory results of the water sampling in the excavation. The UF6 Area Manager contacted the laboratory to request the analysis results on August 16.

The analysis results of the sampling performed on August 6 and 7 were reviewed by the UF6 Area Manager on August 17. The concentrations were as follows (in g/l uranium): 8.2, 4.1, 0.79, 3.06, and 1.68. Based on the elevated values, the UF 6 Area Manager met with the Manager for Regulatory Compliance and Quality Assurance to discuss actions to be taken. A call was made to SVP while out of town. The decision was made to recommend to the President upon his return to the site that NRC should be notified of the results. The walls of the vault were also placed on August 17.

Steel reinforcing bars for the floor of the vault were set August 19-22. The SVP returned to the site on August 20, and met with the Operations group late in the afternoon where a decision was reached to recommend to the President that the NRC be notified of the elevated levels. August 22 was the first time since August 4 that radiological air samples were taken, and it is the first day that some workers began to wear lapel samplers. Urinalysis of workers in the excavation pit also began on August 22.

The floor of the vault was poured on August 23. An NRC inspector also arrived onsite August 23 to begin a preliminary review of the extent of contamination in the excavation area.

3.0 Causes and Corrective Actions

The AIT developed this brief history of process operations in the SX building mainly from discussions with the licensee's staff who had been employed at the facility for some time and who were at least familiar with some of the prior operating procedures and processes.

Very little documentation exists concerning the operational history of processes in this area.

The SX building at the SFC site was constructed in 1969 and operations began in 1970. The floor of the building was constructed of unprotected concrete, as were the original sumps. The building actually consists of two areas separated by a curb. One area is the solvent extraction area, which uses a tributylphosphate (TBP)-hexane solution to extract uranium from the digester slurry for the purpose of purification. The second area is the solvent rework area, where the stripped solvent from the solvent extraction area is purified and the TBP-hexane composition is adjusted for reuse in the extraction area. The floor of each half of the building is sloped toward the center curb and a sump is located on each side of the center curb.

Discussions with licensee staff indicated that early process operations in the SX building were conducted in a manner such that process solutions were routinely in contact with the concrete floor. Several steps in the process require that solutions not meeting specifications be discharged to the sump system. This was done by simply releasing the corrosive acidic solutions onto the floor, where they eventually reached the sump. In addition, during early operation of the process systems, maintenance to repair minor leaks had not been routinely performed, due to the need to minimize all work activities which had a perceived ability to aggravate the fire and explosion potential of the building contents. These practices resulted in extensive degradation of the concrete floor, particularly in the vicinity of the sumps.

As a result of the extensive degradation, the floor was completely replaced in 1983 and 1984. The north half containing the solvent rework area was refloored in 1983, and the solvent extraction section in the south half of the building was refloored in 1984. The reflooring consisted of filling holes with concrete to achieve the desired grade and elevation. The concrete was overlaid by 4 to 12 inches of an epoxy resin with coarse sand filler. Finally, a layer of vinyl ester resin was placed over the epoxy for resistance to chemical attack. The repair work also included the installation of a stainless steel sump on each half of the floor. (Initial information conveyed to the AIT indicated that the composition of the floor included 18 to 24 inches of concrete, followed by the epoxy and resin. In subsequent discussions after the AIT, licensee staff indicated that the thickness of concrete underlying the epoxy was variable, but was a minimum of 7 inches.)

Minor repairs to areas showing degradation were made in 1984, 1985, and 1989. Resurfacing of the entire building floor was performed in 1988. The licensee stated that the integrity of the floor has been evaluated annually during shutdown periods. However, on August 27, it appeared to the AIT that the licensee was prepared to restart the facility without an evaluation until questioned by the NRC.

Licensee staff stated that the vinyl ester resin has significantly reduced degradation of the floor. The inspectors toured the SX building and observed the condition of the floor. Although some deterioration was noted in the vicinity of the sumps, particularly in the rework area, the degradation was very shallow, appearing not to exceed about 0.25 inch in depth.

Licensee staff indicated that approximately 100 valves in the SX building were replaced or rebuilt as part of restart activities performed following the 1986 cylinder rupture which resulted in the death of a licensee employee. All flanged or threaded valves were replaced, and all welded valves were rebuilt to reduce the potential for leaks in the building.

Changes in operations have also occurred, with the purpose of reducing the degradation of the floor. Process piping was installed in approximately 1986 to eliminate the routine discharge of process solutions onto the floor. It was the understanding of the AIT that all process solutions are now conveyed by piping to the immediate vicinity of the sump to prevent solutions from being in contact with the floor. (Subsequently, NRC inspectors have observed some solutions on the floor of the SX building, particularly during startup of the processes.)

Discussions with licensee staff also indicated two additional sources of contamination in the vicinity of the SX building. One of the sources was an antiquated evaporator, which was located on a concrete pad immediately to the north of the SX building. This evaporator was used to increase the concentration of uranium in the solution from about 40 g/l to about 400 g/l. The evaporator routinely leaked solution onto the unprotected pad, resulting in excessive degradation of the pad. The evaporator was replaced by a new evaporator in approximately 1980, although it continued to function as an auxiliary unit until 1985. The unit was removed in 1985 and the floor rebuilt in the same manner as the rebuilt SX building floor. Several storage tanks are now located on the pad.

The other source of contamination was one of the two underground tanks. One tank is used to store hexane, while the other tank is used as emergency storage capacity for all SX building solutions. The solution level in that storage tank, which is referred to as the solvent dump tank, is measured by a differential pressure gauge. The pressure gauge provides a good measure of available capacity when it

is calibrated based on fluids of a known specific gravity. Such calibration is not possible, however, because of the various types of liquids which could be in the tank and the accumulation of solid residues in the tank. Therefore, the level was visually checked by removing a bolted flange on a tank access pipe. The flange occasionally was not placed back on the pipe correctly, and a release of material occurred when the tank was overfilled. Licensee staff also stated that routinely they knew the tank was full when liquid flowed out of the tank access pipe. A concrete floor and curb were placed around the pipe in approximately 1988 to contain future overflow. In addition, the vault constructed around the tank as part of the August 1990 construction will provide complete containment of any solution released. A stainless steel sump was also installed as part of this vault construction.

4.0 Radiation and Industrial Safety

The AIT found that the licensee's Health and Safety (H&S) technicians provided continuous coverage throughout all phases of the work in the excavation. Originally, coverage was provided because of explosive hazards due to the potential for hexane in the soil. During the excavation, H&S technicians monitored, with an explosive meter, each load of dirt brought out of the excavation. Interviews with H&S technicians revealed that excavation activities had been briefly halted several times when the explosive meter alarmed.

As excavation activities progressed and after digging operations were completed, the licensee followed their confined space procedure and evaluated oxygen, toxic, and explosive hazards during work in the excavation. Additionally, as the walls of the vault were being formed and eventually placed, a major concern was to assure the use of proper precautions against falls for personnel working at heights of 10-15 feet.

As for radiological considerations, the H&S technicians had taken several air samples on August 3 and 4. No other radiological air samples or surveys were taken in the excavation until August 22. The AIT also found in discussions with SFC site personnel that throughout excavation activities, small amounts of water would accumulate in the excavation, sometimes hampering work. This water was often yellowish in color, which may (but not always) indicate the presence of uranium. The H&S technician apparently did nothing to quantify the potential for worker exposure until August 22, even though soil and water samples were taken by H&S on August 7. In addition, concerns were expressed to the SVP by the Manager, Environmental as early as

August 7 regarding the contamination in the excavation, and information confirming this contamination was available at the SFC site, but no actions were taken to address the contamination concerns.

The AIT was aware of about fourteen samples that were taken for analysis between July 31 and August 22. Six of these were taken by the H&S department, of which five exceeded the MPC for natural uranium in water in the restricted area (10 CFR 20, Appendix B, Table 1, Column 2). The other samples were taken by the Operations or Engineering departments, some of which may also have exceeded the MPC. These samples included the ponded water in the excavation after the rainfall on August 11 and 12 and barrel sampling on August 22. These results apparently were not communicated to the H&S department even at the time of the AIT The AIT did not fully understand from its interviews with licensee personnel why these results were not in fact communicated to the responsible organization, and determined that procedures established for communicating the elevated sample results were not adequate.

The licensee appeared to control this contaminated water by pumping it into 55-gallon barrels. The only exception to this appears to have occurred on August 13 when, after rains on August 11 and 12, the licensee pumped water from the excavation to the North Ditch. Analysis of this water indicated natural uranium concentrations of 0.01 and 0.04 g/l, below the MPC for unrestricted release. The licensee conservatively estimated that this volume of water was 3000+ gallons. However, the AIT is concerned that the sample may not have been representative of the elevated concentrations in the bottom of the excavation pit. This water was diluted by the significantly greater volume of water in the North Ditch and diluted further as it was slowly released into the combination stream. Analysis of the combination stream for the month of August indicated that natural uranium concentrations did not exceed 0.0009 g/l and averaged 0.00038 g/l, far below the MPC for unrestricted release. By August 22 SFC had accumulated approximately 112 drums of contaminated water from the excavation.

On August 23, a Region IV inspector arrived onsite to investigate the contamination concerns after SFC's report on August 22. During a tour of the excavation the inspector noted a yellow precipitate stratified in the soil that formed the south wall of the excavation (directly beneath the north wall of the SX building). The precipitate was noted to occur approximately 3 feet to 5 feet below grade. The licensee had taken no direct radiological survey nor had they obtained soil samples of the yellow precipitate until recommended by the inspector.

Soil samples of the precipitate yielded natural uranium concentrations up to 0.025 grams per gram of soil (g/g-soil). Soil

samples taken on August 7, of soil directly under the hexane tank ranged up to 0.388 g/g-soil.

The licensee had not set up a step-off pad for changing contaminated boots of workers exiting the excavation (as detailed earlier in this report, on August 6, during an NRC inspection, a step-off pad was set up for workers exiting the excavation). However, after touring the excavation the inspector thoroughly surveyed his boots, and found contamination levels only slightly above background and well below the licensee's action level of 2000 dpm/100 cm^2. The licensee's H&S technicians stated that they had surveyed several workers and found similarly negative results. Therefore it appeared that step-off pad procedures were not necessary.

The inspector also learned that the excavated soil that was stockpiled east of the SX building and east of the excavation was "roped off" on August 22 and covered with plastic on August 23, the day the NRC inspector arrived onsite.

Non-routine jobs at the SFC site, including the vault excavation, are performed in accordance with Hazardous Work Permits (HWP). HWPs are initiated by an Operations or Maintenance supervisor who describes the job to be performed and the protective measures to be utilized. The HWPs are then signed by a member of the H&S staff to indicate concurrence. The AIT determined that the HWP procedure did not clearly specify who is responsible for monitoring work being performed to assure that changing conditions are evaluated and to determine whether modifications to the HWP or issuance of a new HWP are warranted. Specifically, the adequacy of the HWP issued for the vault excavation should have been evaluated following the discovery of contamination in the excavation. The AIT was concerned that the H&S department would not feel a sense of ownership regarding the HWP because their role in the HWP process is strictly one of concurrence. This possibly led to a passive role on the part of the H&S department.

The AIT concluded that the SFC H&S department did not appropriately control activities in the excavation area to assure that the potential for radiological contamination was minimized. Interviews with licensee staff indicated no surveys or evaluations were performed by the H&S department prior to workers entering the excavation pit, and the expected sensitivity to radiological concerns was not demonstrated by the department responsible for monitoring of such concerns. Fortunately, the Operations or Engineering Departments obtained water samples as work progressed so that an evaluation of levels in the excavation pit after work was completed could be performed.

The AIT also concluded that no workers involved in these operations were excessively exposed to radiation, nor were any workers

contaminated. All vehicles, equipment, and hand tools leaving the site were apparently surveyed as were all contractor workers. The special urinalysis program set up on August 22 identified two workers that received small uptakes of 22 and 21 micrograms per liter (ug/l). The licensee concluded that these two workers were mainly involved in activities above the excavation rather than inside the excavation. The two individuals were placed on work restrictions and further evaluations indicated that the workers quickly cleared the material.

During the AIT, the inspectors also noticed that barrels containing contaminated water had leaked onto the ground. The Manager, Environmental, instructed a worker to contact the control room and to have the water rebarrelled. Upon notification, the shift supervisor arranged for two operators to control the water, pump it back to nonleaking barrels, recover contaminated soil, and remove the leaking barrels from the area. Though these actions appeared appropriate, the shift supervisor did not notify the H&S department regarding the spill.

Approximately 3 hours later, an NRC inspector notified the Manager, Health, Safety, and Environment of the leaks. The Manager immediately investigated and found that, although most of the contaminated soil had been scraped from the ground, some still remained. Final cleanup and surveys were then completed.

5.0 Notification and Reporting

Discussions with site personnel indicated that visible contamination in the excavation was discussed with the SVP on August 7, although it could not be determined if the elevated value of 2.06 g/l which was available on August 7 was specifically discussed. Based on the small amount of liquid in the excavation, the SVP concluded that a french drain system being constructed around the vault for drainage would be adequate to prevent migration of the contamination. No further notification or investigation were performed until the UF6 Area Manager requested the results of the sampling conducted on August 6 and 7.

The special sample analysis request form with the results of the sample analyses are routinely returned in interdepartmental mail to the individual who requested the analyses. Laboratory documentation indicated that the results of the August 6 and 7 sampling were available on August 7. However, for whatever reason, the individual who collected the samples did not receive a copy of the results until August 23. No explanation for the delay could be identified.

As described earlier in this report, the UF 6 Operations Manager requested the water sample results on August 17. Apparently, upon returning to the site on August 20, the SVP discussed this issue with the Manager, Licensing and Regulatory Affairs, and the UF6 Operations Manager, and decided to discuss this issue with the President upon his return to the site on August 21. It was the understanding of the AIT that these individuals did not believe the issue was one that would satisfy NRC reporting requirements, but was an issue that should be communicated to the NRC. The AIT noted that the reasons given by the Manager, Licensing and Regulatory Affairs for not reporting the event to the NRC specifically addressed none of the provisions of the applicable 10 CFR Part 20.403(b) reporting criteria.

6.0 Geological Investigation

The licensee's hydrogeological discovery program consisted of sampling ground-water quality and radionuclide content of soil, drilling exploratory borings, reviewing construction drawings, and measuring water levels. The AIT was present during the drilling of the exploratory borings.

Although five borings were made, they were not developed to be utilized as ground-water monitor wells. The lack of casings in these bore holes allowed cross communication of the various statigraphic units to take place. Due to this the water quality samples that were obtained from these borings may represent water that has seeped into the boring from overlying strata. The data that was obtained from these five borings did supply valuable information to make preliminary conclusions as to the extent of contamination. Part of the licensee's plans called for locating properly completed monitoring wells in this area.

6.1 Site Conditions - Geology

The SFC site is located in a rolling upland near the confluence of the Illinois and Arkansas rivers. Typical geology at the site consists of a shaley unit that rests upon a hard, dense, and well cemented massive sandstone. The upper 3 to 5 feet of the shaley unit is often weathered to dense low-permeability clay that acts as a barrier to vertical water movements. Over the site, it is common to have 0 - 10 feet of construction related aggregate on top of the natural sequence. A typical section is shown in Figure 1.

The local topography has been altered to an extent that much of the shale unit has been eroded. It therefore forms a partial cap over

the underlying sandstone. To explore the extent of these stratigraphic units and their effect on the transport and containment of the solution known to have leaked, five borings into the shale were made by the licensee. These borings were advanced utilizing an air rotary rig and logged as they were drilled. The approximate boring locations are shown on Figure 2.

The five borings confirmed the presence of the aggregate fill, the dense low-permeability clay, and the underlying shale. These borings did not penetrate the total thickness of shale unit. Additionally, visual observation of the hexane vault excavation shows similar stratigraphic units. Logs of the borings as well as the vault excavation are shown on Enclosure B of this report.

The five borings supplied sufficient information to construct a typical section around the SX building. Generally there is an aggregate fill ranging from 1 to 2 feet in thickness underlain by a weathered shale zone that is about 3 to 5 feet thick. This unit lies directly upon its parent material, a shale that is at least 12 feet thick, with occasional sand stringers. The underlying sandstone was not encountered in any of the borings, although it is known to occur stratigraphically below the shale. Observations made in the hexane vault excavation confirm this geologic sequence adjacent to the SX building.

In addition to five borings that were made by the licensee, 15 soil excavations were made around known pipelines. The locations of these excavations are also shown on Figure 2. These excavations, although not logged, were sampled to determine uranium concentrations in the soil and water.

6.1.1 Site Conditions - Water Levels

The bore holes, environmental monitoring wells, vault excavation and sumps yielded valuable information on the amount and quality of water around the SX building. It is important to note that the presence or absence of water as well as its quality under the SX building has not been fully explored.

The 24-hour, 48-hour, and static water levels in boreholes 1-5, as well as water levels in the vault excavation and adjacent sump area, are shown below:

	Surface Elevation	8/28/90 9:00 a.m. 24-hr	8/29/90 9:00 a.m. 48-hr	Static
Boring #1	564.8	545.3	545.8	546.9
Boring #2	565.3	546.4	547.9	554.9
Boring #3	563.2	544.2	545.5	544.7
Boring #4	562.8	543.8	545.4	544.3
Boring #5	563.6	545.8	546.6	545.6
Vault Excavation	566.9	553.5	553.5	553.5
48" Sump	567.6	553.7	553.7	553.7
18" Sump	567.6	553.7	553.7	553.7

The above data indicate that water levels adjacent to the SX building and in the aggregate fill are generally over 6.0 feet above the levels noted in the bore holes completed in the shale unit. This water level variation indicates that a potential exists for ground-water movement to take place. Because the water was noted to be flowing in the vault excavation there is a potential for the water to be at some higher level in the strata adjacent to the excavation.

Flow into the vault excavation was determined by measuring water levels in the vault excavation sump as well as the amount of water that was pumped from the sump. Water volume and/or level measurements were taken for a 10-hour period during August 29, 1990, and the rate of inflow was then calculated. The data are shown below:

Hour	Inches of rise in vault	Cubic Inches*	gal	gpm
0	3.25	1872	8.10	0.14
1	3.0	1728	7.48	0.12
2	4.0	2304	9.97	0.17
3	3.75	2160	9.35	0.16
4	1.75	1008	4.36	0.07
5	4.75	2738	11.84	0.20
6	4.75	2736	11.84	0.20
7	2.75	1584	6.86	0.11
8	3.5	2016	8.73	0.15
9	4.5	2592	11.22	0.19
10	1.75	1008	4.36	0.07
	Total gallons for 10 hours		94.11	

*Based upon 24" X 24" X 24" Sump

During the 10-hour monitoring period, roughly 94 gallons of seepage was recovered from the vault excavation with an average concentration

of 1.1 g/l uranium. This equates to a rate of about 9.4 gallons per hour. There was insufficient evidence to determine if the rate was increasing or decreasing.

The relationship of the known water levels for the various investigative points indicate that there is a potential for contaminated water to move away from the vault excavation. The various water levels are shown in Figure 3. The water level data indicates that if ground-water movement were to take place in the shale, it would be towards the north-northwest. The differential in water levels between the undisturbed shale unit, as typified by the borings, and the aggregate in the vault excavation indicate that movement of solution into the shale is either prohibited or greatly reduced due to the shale's low hydraulic conductivity. The water level in boring #2 indicates that the neighboring sewage lagoon is probably affecting this measurement by mounding water in this area. Furthermore, it appears that the aggregate structural fill acts as a reservoir, while the shale unit functions as an aquiclude.

6.1.2 Site Conditions - Water Quality

Water quality at the site was measured for natural uranium to determine if the various waters that were encountered during the exploration work were related. Water quality in the vault excavation was noted over a range of 1 to 8 g/l uranium. Similar natural uranium concentrations were noted in the 18- and 48-inch sumps located adjacent to the excavation. Natural uranium concentrations in boreholes 1-5 as well as the date sampled are shown below.

Soil Boring	Date Sampled	Uranium (ug/l)
1	08/29/90	98.6
	08/31/90	41.0
	09/05/90	38.4
	09/06/90	26.0
2	08/28/90	23.7
	08/29/90	125.0
	08/31/90	79.0
	09/05/90	86.2
3	08/28/90	27.3
	08/29/90	206.0
	08/31/90	109.0

	09/05/90	337.0
	09/06/90	706.0
4	08/28/90	15,875
	08/29/90	15,369
	08/31/90	3,240
	09/05/90	4,897
	09/06/90	5,198
5	08/28/90	45.3
	08/29/90	160.0
	08/31/90	184.0
	09/05/90	160.0
	09/06/90	116.0

The log for boring 4 indicates that the upper three feet of the drill hole was very moist. This moisture was related to a natural drainage pathway that ponds water near the boring. The elevated natural uranium concentration was, in part, a result of leakage from barrels that were utilized to store the high uranium waters that were collected from the vault excavation. During the field work it was noted that three barrels were leaking. A sample of the standing water around the base of the barrels and adjacent to boring 4 indicated a natural uranium concentration of 0.4 g/l.

An additional input to the uranium concentration was undoubtedly due to flow through the process area aggregate that receives uranium from point and nonpoint sources within the restricted area. The aggregate in the plant yard acts as a travel path for precipitation and the uranium that is associated with spillage. This solution is free to travel to low areas on the property, where it is collected in a culvert and conveyed to the North Ditch. It then enters the combination stream and is discharged from the site.

An additional water quality review of environmental monitoring wells located around the site, for the years 1985 to 1990, indicate that uranium is present at elevated levels in several wells. However, the data review as well as discussions with the licensee staff indicate that these elevated levels are not related to the SX floor leakage, but to other events that have taken place in the past. There are also several unlined waste impoundments onsite that have unknown water quality. Solutions from these impoundments may contribute to the elevated uranium concentrations noted around the site.

The licensee made 15 soil excavations to determine if uranium contaminated water was moving along buried utility lines. Twelve of

these excavations had sumps installed into them to monitor water levels as well as act as recovery points. The locations of these sumps are shown on Figure 2. The presence of water in the pipeline bedding would appear to suggest that the bedding is providing a pathway for contaminated fluids.

There is sufficient data to indicate that the aggregate in and around the SX building, as well as similar materials located under and adjacent to ancillary facilities, supplies a path of least resistance allowing SX building seepage and other contaminated waters to form a near surface plume. Years of small process related spills have resulted in uranium contaminated water forming a plume which is moving towards the northwest. The presence of elevated uranium concentrations in boreholes 3, 4, and 5, as well as similarly elevated levels in sumps 1, 9, 17, and 14, confirm this plume movement. The aggregate provides a pathway for solution movement from the process areas to the surface ditch located near the cooling tower. From this point, water either seeps into the sewage lagoon or gravity drains to the North Ditch.

6.2 Extent of Contamination

The extent of contamination at the site, relative to the SX building vicinity, needs to be considered based upon high uranium solutions that have the immediate potential to migrate and uranium salts that have the potential to go into solution and become mobile.

There is evidence that quantities of water laden with uranium remain within the vault excavation. Licensee records indicate that roughly 4000 gallons of this solution have been recovered. Based upon the size of the excavation and construction drawings showing the depth of the tank supports, it appears that, conservatively, 9,000 to 11,000 gallons of solution may remain in the vault excavation. Additionally, an unknown volume of similar waters likely reside under and near the SX building slab. There also appears to be a potential aggregate-filled reservoir near the pulse columns in the SX building. Construction drawings for this feature indicate that 6 to 8 feet of aggregate was used to fill the construction void. It is likely that this area contains uranium contaminated water similar to that encountered in the vault excavation.

In addition to the uranium in solution, there exists precipitated uranium salts in the aggregate fill above the existing water level. Aggregate from these areas was measured to have 5,000 to 25,000 ug/g of natural uranium. Gamma readings were 1 mR/hr shielded and

10 mR/hr unshielded, utilizing a GM probe on the most obvious uranium salt deposits. Currently these salts are relatively immobile. However, precipitation events as well as other introduced waters may cause these salts to solubilize and move in solution to downgradient locations, as previously discussed.

Independent samples of the soil and water were taken at locations shown on Enclosure C to this report to characterize the site adjacent to the SX building. The samples were delivered to Oak Ridge National Laboratory for the analysis. The results of the analysis will be published upon receipt from the laboratory.

The soil samples will be analyzed for several radionuclides as well as nitrates. The water samples will be characterized for radionuclides, trace metals, nitrates, and common ions. These data will be used to verify similar data collected by the licensee.

6.3 Licensee Mitigation Efforts

In response to the discovery of uranium contaminated water in the vault excavation, as well as in several buried utility corridors, the licensee installed pipe collars and sumps to stop water migration and collect the seepage. The water collected from these sumps is barreled and returned to the process for uranium recovery. This remediation technique controls the contaminated water at many locations and has the potential to remove a portion of the contaminated water. There is, however, a need to install a perimeter seepage collection system that will recover water from the general aggregate fill throughout the entire facility yard.

6.4 Summary

The uranium contaminated water that has been removed from the vault excavation or currently resides within aggregate apparently related to the SX building foundation and adjoining subbases represents a problem that is related to past practices at the site. From the information obtained by the AIT, it is apparent that solutions were routinely spilled on the SX building floor from its construction in 1969 until the floor was replaced in 1983 and 1984. The corrosive nature of the solutions deteriorated the floor to such an extent that direct hydraulic communication with the underlying aggregate was created. The process solutions and wash-down water containing uranium apparently found little resistance leaving the SX building as well as other buildings and the overall site. When these solutions encountered moisture in the aggregate, the uranium and other process chemicals were free to move to low spots in the aggregate filled

voids and through the aggregate used as a subbase for other buildings and excavated materials in the general process area. It is reasonable to assume that some water penetrated into the shale material.

It is also likely that radionuclides and other process chemicals are attenuated at the aggregate/shale interface or shortly thereafter. The shale strata is therefore probably not saturated with contaminated water.

Where process solutions accumulated in depressions, capillary action likely redistributed the uranium rich salts into overlying layers of aggregate as well as into the residual floor materials. This process has likely contaminated up to about 4100 cubic yards of aggregate and weathered shale materials directly under the SX building (based upon a building size of 78' X 52' X 3' subbase) with uranium concentrations similar to those mentioned earlier. There is also some contaminated material associated with the old evaporator pad and the area around the solvent dump tank. Additionally, a much larger, though less concentrated, volume of contaminated water is in the voids of the vault excavation backfill and general yard aggregate that is relatively free to move.

Based upon the current integrity of the SX building floor and the past remedial actions related to the old evaporator and solvent dump tank, it is reasonable to assume that no more liquid contributions are being made to the aggregate from the vicinity of the the SX building. However, years of small amounts of uranium contamination in this area have caused uranium contaminated water to form a plume that is traveling through the aggregate in the general direction of the North Ditch.

An unknown quantity of the contaminated water remains entrained in the aggregate material. The shale is apparently forming a vertical barrier to movement, causing the contaminated water to pond in the aggregate, follow utility line bedding, and move through the surface aggregate. The sump that was placed adjacent to the tank vault is incapable of removing these solutions because it was not constructed to sufficient depth. However, the other sumps installed by the licensee will recover much of the contaminated water. There is also a high likelihood that uneven excavation and deep excavations have stored solutions within the SX building subbase. This needs to be researched by the licensee.

The uranium salts underneath the SX building and in the aggregate fill will probably continue to go into solution and be transported as

they come in contact with infiltration from precipitation events. The licensee should therefore implement a remediation program that has the ability to remove small volumes of contaminated waters from the aggregate for a period of several years.

It appears that the shale materials and particularly the upper weathered zone have effectively formed a barrier to vertical water movement. Although buried utility lines may form pathways for contaminated water, it appears that the licensee has identified these pathways and constructed barriers and sumps to prevent movement offsite.

Data on the flow rate and quality of contaminated water entering the vault sump, as well as other sumps, should be maintained to determine the mass of hazardous constituents that are being recovered from the aggregate.

7.0 Findings of Fact:

The AIT members reached the following findings of fact:

- During the excavation for the vault around the hexane tanks, uranium contaminated waters and uranium salts were discovered in the pit.
- Measurements of water samples showed uranium levels as high as 8.1 g/l.
- Sometime after discovery of the water, the licensee began to collect and store it in 55-gallon barrels for introduction back into the process at some future time.
- On August 13, 1990, after rainfall on August 11 and 12, the licensee sampled the water in the excavation and pumped it to the North Ditch, upon determining that the uranium concentration sampled about 0.01 and 0.04 g/l.
- The licensee control of personnel entering and leaving the site, and surveys of equipment and personnel associated with the excavation, indicated that no contamination related to the excavation was allowed offsite.
- Initial investigations of ground water in the vicinity of the solvent extraction building apparently indicate that contamination to date has not migrated offsite or come in

contact with any aquifers that may be used by members of the public.

- Backfill around pipelines and utility lines in the vicinity of the SX building has apparently served as conduits for the migration of liquids. The licensee has effectively eliminated these pathways by construction of barriers around the lines and installation of upgradient sumps to collect any liquid.

- Uranium contaminated water also exists in the aggregate fill under and in the vicinity of the SX building. Some of this water will probably remain relatively immobile. The remainder is probably moving at a very slow rate towards the North Ditch or the sewage lagoon.

- The sources of the contamination were apparently solutions that had seeped over the years through the floor of the SX building, leakage from the old evaporator pad that was located adjacent to the SX building, and overflow from the solvent dump tank.

- These sources have been eliminated by constructing a new floor and sump in the SX building and changing procedures to eliminate running contaminated, corrosive liquids over the floor, removing the old evaporator, constructing a new evaporator pad and sump system, and constructing the vault with a sump to capture spillage from the solvent dump tank.

- The sumps and french drain in and around the hexane vault can remove a relatively large amount of the uranium contaminated water in the aggregate fill, but are not deep enough to capture all of the water.

- After August 22, upon discovery of the high levels of uranium in the water in the excavation, the licensee proceeded to survey and sample the area and require daily urinalyses of all personnel associated with the construction. Two workers, who apparently did not enter the excavation but worked above ground, did record slightly elevated levels. They were placed on work restrictions and had lowered urinalysis upon testing.

- The Pickard, Lowe, and Garrick, Inc. reports were reviewed to determine if any information in them would be helpful in this investigation. No information related to seepage from the SX building or other areas was contained in the reports.

- The soil removed from the excavation has been partially barreled with the remainder moved to the "yellowcake pad" where it was placed on Hypalon and covered with plastic.

- Environmental data from monitoring stations around the site were reviewed and uranium and other contaminants have been detected, although at levels below MPC. The amount that may have been contributed by the seepage is unknown at this time.

- The visible contamination in the excavation was discussed by the Manager, Environmental and Senior Vice President on August 7, 1990. At the time of the AIT, the Manager, Environmental stated that the uranium concentration of 2.06 g/l was known to her. No further notifications or investigations were performed by the licensee until August 17, 1990, when the UF6 Area Manager requested results from sampling conducted on August 6 and 7, 1990.

- The Environmental Manager, who collected samples on August 7, 1990, and requested the analysis, did not receive a copy of the results until August 23, 1990.

- The Manager, Health Safety, and Environment was not informed of laboratory results until August 22, 1990. He was informed of a "rumor" of high values, but he did not substantiate the rumor.

- The NRC was informed on August 22, 1990, of the discovery of uranium contaminated water in the hexane vault excavation.

- The plans by the licensee to further characterize the extent of contamination and develop remediation actions were determined to be sufficient as an initial effort. Future, more detailed plans will be reviewed as they are available from the licensee.

8.0 Conclusions

The following conclusions were reached as a result of the AIT review of the events surrounding the detection of uranium contamination in the hexane vault excavation.

- The AIT concluded that the licensee's investigations of this occurrence once the contamination problem in the excavated pit was known and communicated to the President of SFC on August 22, were adequate to initially characterize the environmental problem and determine the sources of contamination.

- The AIT concluded that the contributions to contamination by current SX processing have been effectively eliminated.

- The AIT concluded that there is no evidence that contamination was transported off site.

- The AIT concluded, based on the information to date, that a seepage collection system should be instituted to capture uranium contaminated water that is moving through the general yard fill in the vicinity of the SX building.

- The AIT concluded that the licensee apparently surveyed individuals to the extent that site and contractor personnel were not over-exposed due to the contamination in the excavation.

- The AIT concluded that the licensee did not act in a timely manner to address the potential problems associated with the discovery, apparently due to the lack of effective communication between different organizational units of the company.

- The AIT concluded that the HWP procedure used at the site does not specify which department is responsible for monitoring changing conditions during the performance of work, and did lead to a passive role on the part of the H&S department.

- The AIT concluded that the licensee did not notify the NRC of the discovery of the contamination in a timely manner, there being approximately 15 days between the time the high levels of uranium were discussed by licensee management and notification of NRC.

- The AIT concluded that the licensee placed the floor of the hexane vault knowing that the soil underneath may have been contaminated with high levels of uranium, but did not evaluate the potential impact of proceeding with construction.

- The AIT concluded that follow-up inspections should be conducted to determine if NRC regulations and requirements of the license were fully complied with during the course of the events.

- The AIT concluded that the entire site should be fully characterized from a ground water and surface water standpoint to ensure that this and any other contamination onsite will be detected and remediated before it can migrate offsite.

9.0 Persons Contacted:

Reau Graves, President
Jim Mestepey, Senior Vice President
Ron Adkisson, Vice President, Business Development
Lee Lacey, Vice President, Regulatory Affairs
Mike Nichols, Manager, Health, Safety, and Environment
Mike Chilton, Area Manager, UF6
Carol Couch, Manager, Environment
Ken Simeroth, Health Physics Supervisor/Assistant RSO
Rick Callahan, Health Physics Supervisor
Don Knoke, Manager, Facility Laboratory
Sam Fryer, Manager, Engineering
Gary Jackson, Staff Technical Specialist
Reggie Cook, Vice President, Administration
Bob Kuehn Engineering Department
Sue Smith, Supervisor, Waste Treatment and Solid Waste
Richard Parker, Manager, Maintenance

The inspectors also interviewed other site personnel during the course of the inspection.

ENCLOSURE A

Detailed Chronology of Events

This chronology of events was compiled from information obtained by the AIT through interviews with SFC personnel, review of laboratory reports and review of facility logs.

Note: M, E = Manager, Environmental
SVP = Senior Vice President
UF6 AM = UF6 Area Manager
M, RC & QA = Manager, Regulatory Compliance and Quality Assurance
H&S technicians = Health and Safety technicians
M, H, S, & E = Manager, Health, Safety, and Environment

July 31, 1990, Tuesday

Started removing concrete around the top of the hexane tanks in preparation for excavating.

August 01, 1990, Wednesday

Started excavation. H&S technicians concerned about explosive gases (Hexane vapors in soil). Constant coverage by H&S technicians. First water sample taken (reported August 2).

August 02, 1990, Thursday

Excavation continues with H&S technicians continuing coverage. Representative from Oklahoma Water Resources Board visits SFC to visually inspect tanks. First water sample available from laboratory showed a concentration of 0.02 g/l of U-natural.

August 03, 1990, Friday

Excavation continues with H&S technicians covering. Incident at DUF6 that causes shutdown of that facility.

August 04, 1990, Saturday

Excavation continues with H&S technicians covering. Sewer line breaks and dumps water into excavation. Water sample taken at approximately 10 am. (Analysis results available in laboratory August 6.) Day of company picnic. President arrives on site and NRC notified of incident in DUF6 facility. President then leaves on vacation and returns August 21.

August 05, 1990, Sunday

No work.

August 06, 1990, Monday

Excavation continues with H&S technicians covering. Water pumped to barrels. First day of NRC's routine inspection. First day anyone works in the excavation. NRC inspectors ask about water. No definite answer. Sample taken August 4 is available in laboratory: 2.06 g/l of U-natural. Another water sample taken (reported August 7).

August 07, 1990, Tuesday

Excavation continues with H&S technicians covering. Water pumped to barrels. Approximate day M, E first sees sample analysis results of 2.06 g/l. M, E states that she talked to SVP regarding high U concentrations in the excavation. (M, E does not see any other analysis sample results until August 23.)

M, E has soil samples and water samples taken. Water sample results analyzed and available in laboratory same day: 8.2, 0.79, 4.1 g/l of U-natural. Analysis results from water sample taken August 6 available: 3.06 g/l and 1.68 g/l of U-natural. These 5 analysis results are not seen by anyone until August 17 (until requested by UF6 AM).

August 08, 1990, Wednesday

Excavation continues with H&S technicians covering. Water pumped to barrels. Water samples taken to analyze for tributylphosphate (TBP).

August 09, 1990, Thursday

Excavation completed (19-foot depth). Water pumped to barrels.

August 10, 1990, Friday

Workers set rebar and start pouring footing. Water pumped to barrels. NRC routine inspection concludes and inspectors leave.

August 11, 1990, Saturday

No work. 0.82 inches rain.

August 12, 1990, Sunday

No work. 0.81 inches rain.

August 13, 1990, Monday

Water is sampled and then water pumped out to North Ditch (inside restricted area). Water samples indicate 0.04 and 0.01 g/l U-natural. Workers start setting rebar for the walls. H&S technicians covering.

August 14, 1990, Tuesday

Water pumped to barrels. Workers setting rebar for wall. H&S technicians covering.

August 15, 1990, Wednesday

Setting rebar for wall. H&S technicians covering. SVP leaves town. UF6 AM is left in charge of operations. Water pumped to barrels.

August 16, 1990, Thursday

Setting rebar for wall. H&S technicians covering. Water pumped to barrels. SVP calls UF6 AM and gives him a list of items to do, including to look at the water samples from the excavation. UF6 AM calls laboratory and requests all laboratory analysis results regarding the excavation.

August 17, 1990, Friday

Water pumped to barrels. Wall is poured. H&S technicians covering. First day UF6 AM sees high results. M, RC, & QA discusses a "rumor" of high uranium content in water from excavation with M, H, S, and E. They call the environmental laboratory and look for analysis results without finding them. Later, the UF6 AM discussed the high values with the M, RC, & QA. No further discussions occur with the M, H, S, and E.

August 18, 1990, Saturday

Approximate day UF6 AM calls SVP.

August 19, 1990, Sunday

Workers start setting rebar for floor. H&S technicians covering Water pumped to barrels.

August 20, 1990, Monday

Setting rebar for floor. H&S technicians covering. M, RC, & QA off for the day. Water pumped to barrels.

SVP arrives in afternoon. Operations department holds a meeting at 4 pm in which they decide to recommend to President that NRC be notified.

August 21, 1990, Tuesday

Setting rebar for floor. H&S technicians covering. Water pumped to barrels. First day President returns to facility. First day radiological air samples are taken in excavation and that some workers begin wearing lapel samplers. Issue discussed with President.

August 22, 1990, Wednesday

Still setting rebar for floor. H&S technicians covering. Water pumped to barrels. Water sample taken in every 8th drum. Analyzed same day: average concentration is 1.086 g/l. Approximately 4 pm, M, RC and QA calls NRC Region IV inspector and informs him of the problem. Licensee begins urinalysis of workers.

August 23, 1990, Thursday

Water pumped to barrels. Poured floor in the morning. NRC inspector arrives on site at approximately midday. Soil samples taken of south wall of excavation. Highest analysis result is 0.024 grams of U-natural per gram of soil. First radiological direct survey of the south wall of excavation. First day M, E sees laboratory analysis results of samples taken August 06-07.

ENCLOSURE B

Boring Logs

Boring #1 Surface elevation 564.8 Bottom elevation 544.0
0.0-2.5' aggregate fill
2.5-8.0' reddish brown and gray mottled clay
8.0-20.8' dark reddish brown shale, moisture noted at 17.5 and 19.5 feet.

Boring #2 Surface elevation 565.3 Bottom elevation 545.0
0.0-2.0' aggregate fill
2.0-3.0' brown sandy clay
3.0-7.4' reddish brown and gray mottled clay, dry
7.4-20.3' reddish brown shale, dry dark red seams at 12.0, 13.5 and 15.5 feet.

Boring #3 Surface elevation 563.2 Bottom elevation 543.2
0.0-1.5' aggregate fill
1.5-6.5' reddish brown and gray mottled clay, dry
6.5-20.0' brown clayey shale, dry darkened bands at 11.5, 13.0 and 17.0 feet.

Boring #4 Surface elevation 562.8 Bottom elevation 542.6
0.0-1.0' aggregate fill
1.0-2.0' dark brown sandy clay moist
2.0-3.0' yellowish brown very moist clay
3.0-7.7' reddish brown and gray mottled clay
7.7-17.8' brown shale dry
17.8-19.0' dry hard brown sandstone
19.0-20.2' gray sandy shale with sand seams

Boring #5 Surface elevation 563.6 Bottom elevation 543.2
0.0-1.0' aggregate fill
1.0-2.0' brown sandy clay with gravel
2.0-3.0' dark grayish brown topsoil moist
3.0-5.0' red sandy clay moist
5.0-6.9' yellowish brown mottled clay moist
6.9-16.0' brown clayey shale dry
16.0-20.4' sandy shale

Vault Excavation Top of enclosure 566.9 Bottom elevation 547.9
0.0-3.5' aggregate fill
3.5-5.5' gray and brown weathered shale moist
5.5-19.0' gray and brown shale moist

ENCLOSURE C

Locations of Independent Sampling Sites

Vault excavation, S.W. corner, 6' below surface, wet location.

Vault excavation, S. wall 6' below surface, dry location.

Vault excavation W. wall 8' below surface, wet location.

Vault excavation S. wall 3' below SX building floor.

French drain around excavated vault.

The barreled solution pumped from the vault.

Sump within the tank vault.

FIGURE 1 TYPICAL STRATA UNDERLYING THE SEQUOYAH FACILITY

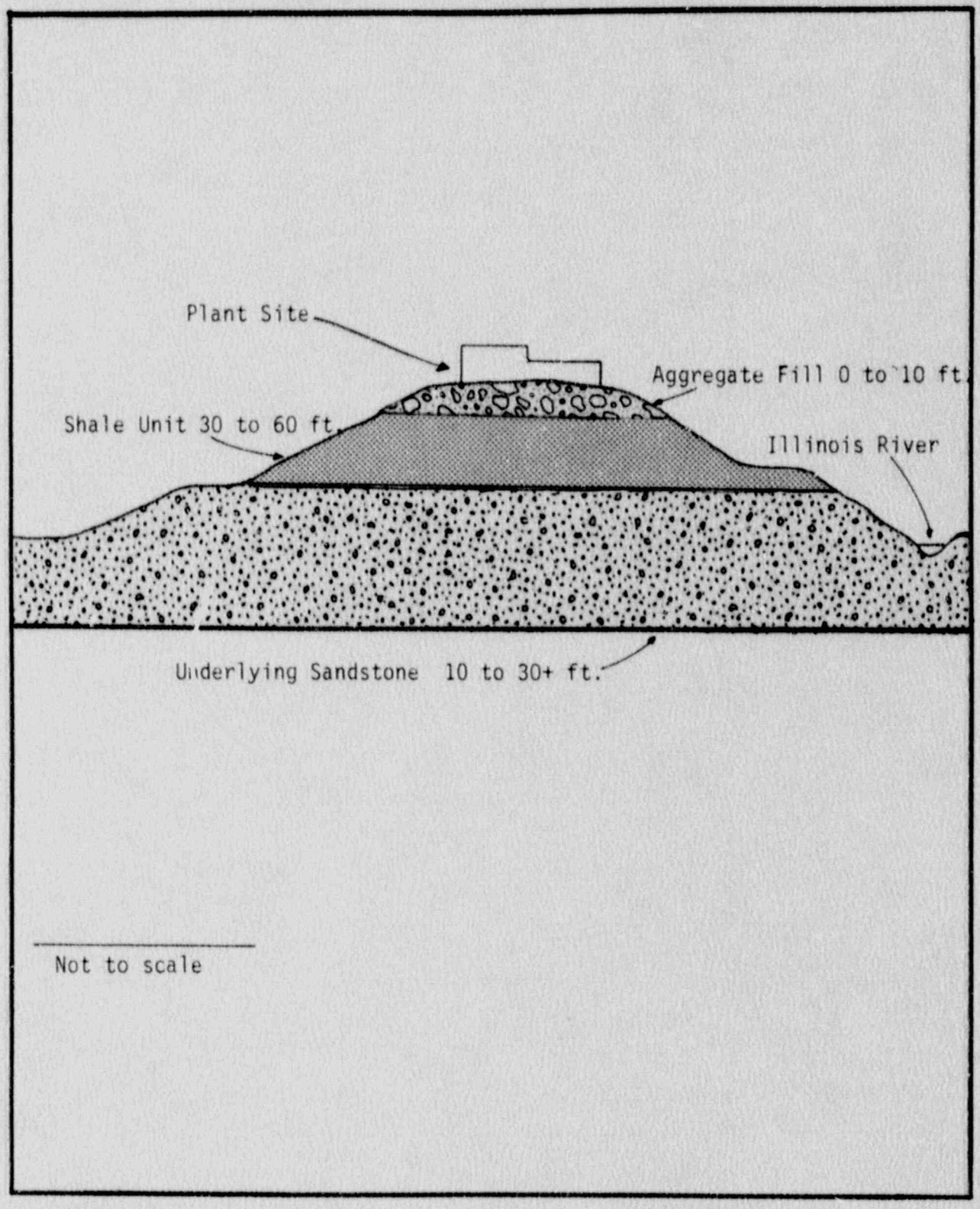

FIGURE 2 SOIL BORING AND SUMP EXCAVATION LOCATIONS

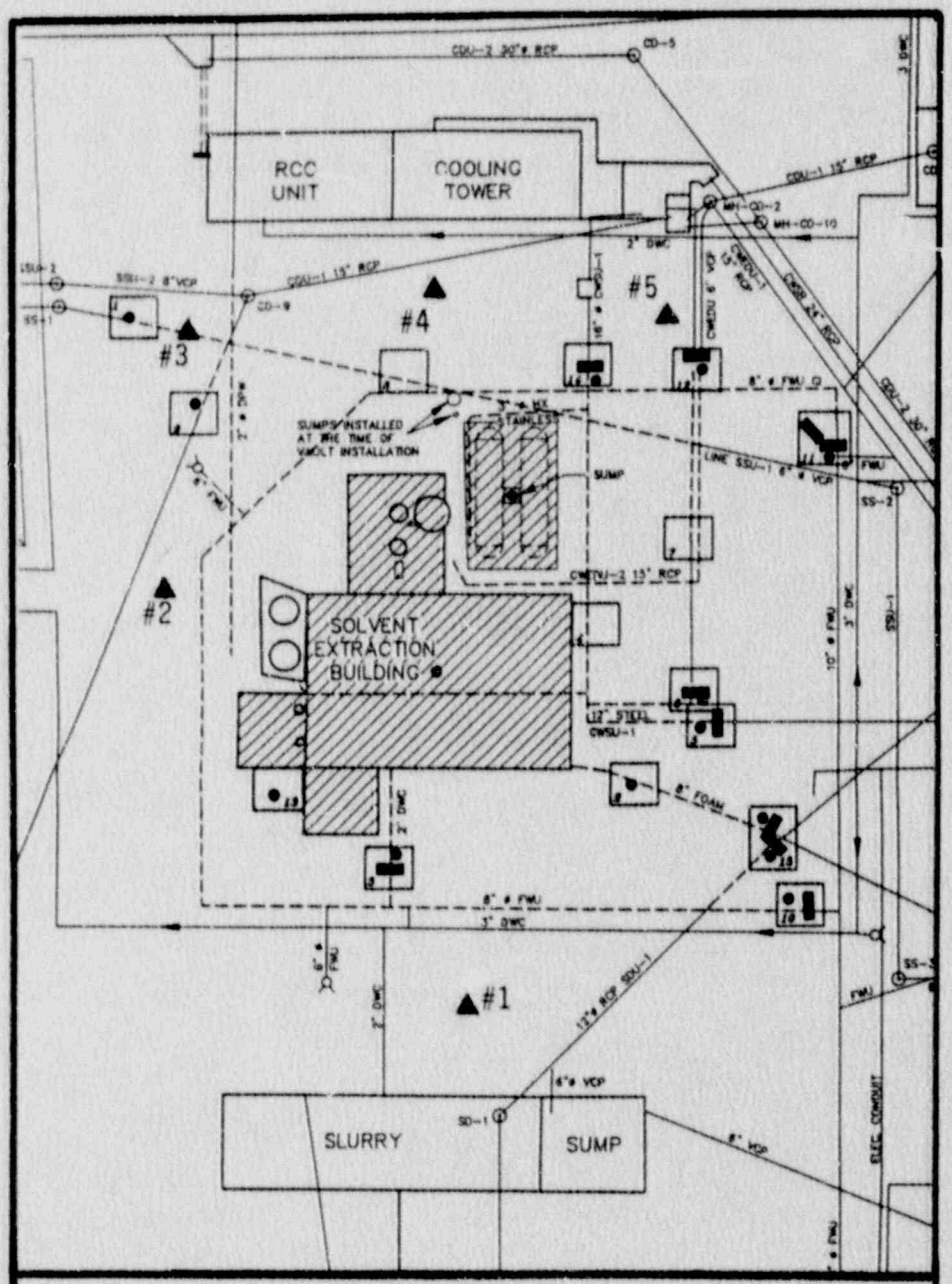

FIGURE 3 SOIL PENETRATIONS AND ASSOCIATED WATER LEVELS