Decommissioning Plan

Fansteel Inc.
Muskogee, Oklahoma Site

Volume 1 of 2

Fansteel Inc.
North Chicago, Illinois

Project No. 6473F
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1.0 Executive Summary

This Decommissioning Plan (DP) has been prepared to describe remediation activities proposed for implementation at the Fansteel Inc. (Fansteel), Muskogee, Oklahoma facility located between Oklahoma State Route 165 and the west bank of the Arkansas River at River Mile 395. The Fansteel Muskogee plant is sited in an area zoned for industrial use. This industrial use restriction is expected to persist in the future in accordance with the updated Master Plan for industrial properties issued by the Port of Muskogee (Master Plan of Development for the Muskogee Port and Industrial Park, Muskogee City-County Port Authority, November 28, 1967). Implementation of this DP will make the site suitable for unrestricted release under an industrial use scenario.

1.1 Background

Fansteel's Muskogee plant produced tantalum and columbium metals. The Fansteel processing facility had been in operation for approximately 33 years until operations ceased in 1990. The raw materials used for tantalum and columbium production contained uranium and thorium as naturally occurring trace constituents. These radioactive species were present in the process raw materials at an approximate concentration of 0.1 percent uranium oxide and 0.25 percent thorium oxide. This concentration is sufficient to cause the ores and slags to be classified by the Nuclear Regulatory Commission (NRC) as source materials. Consequently, Fansteel operated under NRC License No. SMB-911 for the possession of source materials.

The ores and slags used for tantalum and columbium production were digested in a hydrofluoric acid (HF) solution. After the digestion step, a series of unit processes to separate the tantalum and columbium products was conducted. The byproduct of the separation steps (residues from the work in progress [WIP]) was disposed in Pond Nos. 2, 3, and 5. These ponds were called acidic ponds due to their acid constituent. Acidic and ammonia waters were stored in temporary holding Pond Nos. 1S and 1N respectively prior to treatment. Uranium and thorium in the raw materials were not extracted from the ores by the digestion process. The radioactive species remained in the residues from the WIP that were disposed in the East Plant Area. Process water, as well as the Pond No. 3 french drain supernatant, was treated and then passed on to Pond Nos. 6, 7, 8, and 9 for solids precipitation prior to passing through a National Pollutant Discharge Elimination System (NPDES) discharge outfall. These ponds are referred to as alkaline ponds. The residues from WIP disposed in the ponds as a result of the manufacturing process contain U_3O_8 and ThO_2 at similar concentrations either alone or in a calcium fluoride (CaF) precipitate matrix.

In June 1989, the west embankment of Pond No. 3 failed discharging supernatant from the pond into the surrounding area and ultimately into the Arkansas River. The discharge into the river was halted by the emergency construction of containment dikes. Fluids from ponds created by the temporary diking of supernatant were routed to the plant's water treatment system as directed by the NRC. Following treatment, this material was disposed in Pond Nos. 8 and 9. After its failure, Pond No. 3 did not receive the liquid residues from the WIP from ore/slag processing. Filter presses were put into operation to remove the solid wastes from the acidic process water stream before further processing. In addition, a groundwater interception trench installed east of Pond No. 3 is used to collect alluvial groundwater and minimize the potential for discharge of contaminated groundwater to the Arkansas River. Groundwater is collected in the trench and filtered through a filter press.

In 1993, a characterization survey was performed at the Fansteel Muskogee site to determine existing site conditions. Radiological survey activities were conducted over the interior and exterior of the site structures and the external open land areas of the Fansteel site. Buildings and equipment associated with the ore-processing activities include the Chemical "C" Building, the Chemical "A" Building, and the R&D Building. The Chemical "C" Building is contaminated throughout by radioactive ore residues. Isolated areas of radioactive contamination were also identified in some of the other site buildings.

Characterization surveys in 1993 identified the highest concentrations of radiological contaminants in Pond Nos. 2 and 3. The average concentration of radiological contaminants in Pond Nos. 2 and 3 ranges from 360 to 640 picocuries per gram (pCi/g) of U-238 and 360 to 440 pCi/g of Th-232. The average concentration of radiological contaminants in Pond Nos. 5 through 9 ranges from 14 to 53 pCi/g of U-238 and 2 to 26 pCi/g of Th-232. Survey data indicate that the Th-232 and U-238 are present with their radioactive progeny in secular equilibrium. The U-235 decay series is also present, because U-235 constitutes 0.7 percent by weight (approximately 2.3 percent by radioactivity) of naturally occurring uranium.

1.2 Dose Modeling

Dose modeling evaluations have been performed using RESRAD and RESRAD-Build computer code software to demonstrate compliance with the NRC final rule on "Radiological Criteria for License Termination," published in the Federal Register (FR) (62 FR 39058) which was incorporated as Subpart E to Title 10 Code of Federal Regulations (CFR) Part 20. The site will be considered acceptable for unrestricted use after decontamination has reduced the radioactivity levels as low as reasonably achievable (ALARA), and the residual radioactivity level will not result in a total effective dose equivalent (TEDE) exceeding 25 millirem per year (mrem/year) to an industrial worker.

The remediation ALARA analysis is an optimization technique to seek the proper balance of remediation costs and benefits to achieve a TEDE as far below 25 mrem as is reasonably. "Reasonably achievable" is judged by considering the state of technology and the economics of improvements in relation to all the benefits from these improvements.

Dose modeling has been used to calculate the concentration of radioactivity that if uniformly distributed throughout the site area would result in an annual TEDE of 25 mrem to an industrial worker at the site. These radionuclide-specific values are called Derived Concentration Guideline Levels ($DCGL_W$s) for relatively uniform distributions of residual radioactivity across a survey unit. RESRAD Version 6.21 has been used to derive the radionuclide-specific $DCGL_W$s for the residual radioactivity present in land areas at the time of the Fansteel site final status survey (FSS) and site release. RESRAD-Build Version 3.21 has been used to derive the radionuclide-specific $DCGL_W$s for the residual radioactivity present on building, structural, and component surfaces at the time of the Fansteel site FSS. Under the industrial worker scenario, the worker is assumed to spend 8 hours per day on the site. Of the 8 hours, 6 hours are spent indoors and the remaining 2 hours are spent outside.

External exposure to penetrating radiation, inhalation of soil dust (while outdoors and during building occupancy), and inadvertent ingestion of soil are the exposure pathways that were considered in deriving radionuclide-specific $DCGL_W$s for residual radioactivity in site soil. Exposure pathways considered in the derivation of radionuclide-specific $DCGL_W$s for residual radioactivity on building and component surfaces included direct external gamma exposure including submersion, inhalation of resuspended residual radioactivity, inadvertent ingestion of residual radioactivity from surface sources, and ingestion of deposited radioactivity resulting from resuspension. The computed $DCGL_W$s for residual radioactivity in soils and building surfaces is presented in Tables 1-1 and 1-2. Derivation of the $DCGL_W$ incorporated the unity rule to assure that cumulative doses from Th-232, U-238, U-235, and their radioactive progeny do not result in a total annual dose that exceeds 25 mrem to an industrial worker.

Table 1-1 Industrial Worker Scenario Individual Radionuclide Decay Chain $DCGL_W$s for Soils

Radionuclide and Entire Decay Chain in Equilibrium	Industrial Worker $DCGL_W$s at Time Zero (pCi/g)	Time of Maximum Dose (yrs)
U-238 – Uranium Chain	14.1	0
U-235 – Actinium Chain	37	0
Th-232 – Thorium Chain	10	0

Table 1-2 Industrial Worker Scenario Individual Radionuclide Decay Chain $DCGL_W$s for Building and Component Surfaces

Radionuclide Decay Chain $DCGL_W$	Industrial Worker $DCGL_W$s at Time Zero (dpm/100 cm^2)	Time of Maximum Dose (yrs)
U-238 – Uranium Chain	5,200	0
U-235 – Actinium Chain	840	0
Th-232 – Thorium Chain	3,160	0

The groundwater beneath the Muskogee site contains limited amounts of radioactive material attributed to historical operations at the site. Although on-site consumption of this groundwater is excluded from the industrial worker scenario, Fansteel will evaluate the necessity of including a groundwater ingestion dose component in the remediation alternative/option ALARA analyses.

1.3 Summary of Decommissioning Activities

Cleaning of building surfaces and facility components will be performed under controlled conditions in accordance with written procedures and restricted access. Decommissioning will include decontamination of buildings and components using appropriate solvents, cleaning solutions, high-power vacuum cleaners, pressure washers, vacuums, etc. It is expected that portions of the floor (10 percent) of the Chemical "A" and Chemical "C" buildings will have to be scabbled and disposed as low-level radioactive (LLR) waste. Portions of structures or building facilities and equipment that cannot be cleaned for unrestricted release will be size reduced for handling, shipping, and/or disposal purposes.

Radiologically impacted soils and residues from WIP are isolated to plant areas within and surrounding Pond Nos. 2, 3, 5, 6, 7, 8, and 9, and areas to the east of the Chemical "A" and Chemical "C" plant buildings. Soil contamination was also detected to the east of the wastewater treatment ponds and Pond No. 5, however, at levels typically lower than that exhibited in the areas of the site associated with manufacturing and ore processing. The total impacted land area to be remediated encompasses an estimated area of 180,000 square meters (m^2).

Approximately 16,000 tons (20 percent moisture content by weight) of residues from the WIP will be excavated from Pond Nos. 2 and 3 and shipped off site to a licensed uranium reclamation facility. An estimated 68,000 tons (20 percent moisture content) of impacted material will be excavated from the alkaline process water settling ponds which received CaF and process water from the Wastewater Treatment Plant (WWTP) (Pond Nos. 5, 6, 7, 8, and 9). Excavation and disposal of soil from the surrounding plant area and beneath the ponds will account for 15,855 tons (ambient moisture content). Above-criteria soil will be transported (most likely by rail) to a licensed or permitted waste disposal facility(ies). The total quantity of soil and residue for off-site disposal is estimated to be approximately 99,855 tons.

The purpose of this DP is to decommission the facility safely and meet the NRC requirements for unrestricted use. Decontamination and excavation activities will be performed under controlled and monitored conditions with access restricted. Health Physics Technician (HPT) support will be used to monitor the soil and contaminated material removal; the surfaces and soil left in place; as well as workers, equipment, and loaded cars/containers leaving the site. Haul roads, drainage channels, culverts, berms, erosion and sedimentation (E&S) controls, and access controls will be constructed.

1.4 Summary of FSS Activities

A Final Status Survey Plan (FSSP) will be prepared in accordance with MARSSIM guidance to support remediation activities for the Fansteel site. A combination of scanning, direct measurements, and sampling for the radionuclides of concern and/or their progeny will be performed to ensure that remediation is complete. A nonparametric statistical test will be applied to the sampling data taken at distinct survey locations in each survey unit to determine whether the release criteria have been met. The nonparametric tests recommended in MARSSIM are the Wilcoxon Rank Sum (WRS) test and the Sign test.

Upon approval of this DP by the NRC, Fansteel will undertake preparation of designs and specifications. Subsequently, a construction contractor will be selected. Fansteel may choose to develop performance specifications and require the contractor to develop design details. Alternatively, Fansteel may opt to develop detailed designs/specifications. In either case, preconstruction activities are expected to take approximately 9 months.

Construction activities will not be conducted during the months of December through February. Therefore, remediation is anticipated to begin in March following completion of the design/contractor selection tasks and extend over a period of approximately 10 years. A detailed schedule will be prepared subsequent to NRC approval of the DP. This schedule will be updated as circumstances dictate.

Fansteel is seeking approval of this DP to authorize the activities described herein and NRC concurrence that if this plan is implemented as described, it will result in the property being suitable for unrestricted use. However, this remediation plan is premised on current knowledge of site conditions, regulatory guidance, disposal, and reclamation market factors. Other alternatives to disposal such as reuse of CaF residues in the cement industry will be considered as the decommissioning project progresses.

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2.0 Facility Operating History

2.1 Licensing Number/Status/Authorized Activities

2.1.1 License Number

Fansteel's materials license number is SMB-911 (NRC Docket No. 40-7580). The initial issue of License No. SMB-911 was granted by the U.S. Atomic Energy Commission (AEC) in 1967 and has been amended and renewed in a timely manner since then. A timely license renewal application (LRA) was submitted to the NRC on August 27, 2002 to renew the current license (Amendment No. 10) issued on July 26, 2002 that was to expire on September 30, 2002. On October 22, 2002, the NRC notified Fansteel that since the August 27, 2002 LRA did not provide the decommissioning financial assurance required by 10 CFR 40.36(d), the request for license renewal is denied.

2.1.2 Possession Limits

The maximum quantity of source material to be possessed as tin slags, ores, process residues, and oxides is 43,000 kilograms (kg) of natural uranium and 71,000 kg of natural thorium. The maximum quantity of source material to be possessed and used on site as a contaminant in soils and sediment is 4,000 kg of natural uranium and 2,500 kg of natural thorium.

2.1.3 Authorized Activities

Prior to October 22, 2002, Materials License No. SMB-911 authorized Fansteel to possess, use, store, and transfer uranium and thorium and their progenies contained in processing residues. The specific activities approved were residue processing, metal reclamation, decontamination, remediation, decommissioning, and site restoration. On October 22, 2002, the NRC informed Fansteel that in accordance with 10 CFR 40.42(c), activities at the Muskogee site are to be limited to those directly related to decommissioning and maintaining control of the site and licensed materials. The NRC further indicated that although all other conditions of Materials License No. SMB-911 remain in effect until NRC terminates the license, Fansteel is required to proceed with decommissioning in accordance with 10 CFR 40.42(d).

2.1.4 Site Operations

Fansteel's Muskogee plant produced tantalum and columbium metals. Tantalum is used primarily in the electrical/electronics industry in the production of tantalum capacitors. Columbium is marketed for use in heat-resistant alloys. The Fansteel processing facility had been in operation for approximately 33 years until operations ceased in 1990. The area had not been developed for any use prior to construction of the Fansteel facility and no previous structures existed.

The site has continued to be occupied by Fansteel since termination of processing in 1990. Chemical processing equipment used in the extraction of tantalum and columbium values from ores and slags was sold and removed from the site in 1990, 1991, and 1992. Site operations since 1990 have been limited to environmental monitoring; maintenance of buildings, grounds, and equipment remaining at the site; cleanup of operating areas; and installation of new equipment for a new chemical extraction process. The new extraction process was operated briefly during 1999 and 2000 until operations were suspended.

The raw materials used for tantalum and columbium production contained uranium and thorium as naturally occurring trace constituents. These radioactive species were present in the process raw materials at an approximate concentration of 0.15 percent each of uranium oxide and thorium oxide. This concentration is sufficient to cause the ores and slags to be classified by the NRC as source materials. Consequently, Fansteel operated under NRC License No. SMB-911 for the possession of source materials. Uranium and thorium in the raw materials were not extracted from the ores by the digestion process. The radioactive species remained in the residues from the WIP that were disposed in the East Plant Area, specifically Pond Nos. 2 and 3. Therefore, the ore residues are classified as source material by the NRC.

2.1.4.1 Groundwater Interceptor Trench

A groundwater interception trench installed east of Pond No. 3 between Sumps 1 and 4 shown in Figure 2-1 is used to collect alluvial groundwater which is pumped to the WWTP and then to the treatment ponds for eventual discharge via the NPDES system.

2.1.5 License Amendments

The following table lists the license amendments since the last license renewal:

Title	Document Date
License Renewal Application	June 20, 1994
License Amendment	November 28, 1994
License Amendment Request	January 25, 1995
Response to Request for Additional Information	May 3, 1995
Response to Request for Additional Information	August 10, 1995
License Amendment Request	October 20, 1995

Title	Document Date
Response to Request for Additional Information	March 21, 1996
Request for Additional Information	December 17, 1996
License Amendment	March 25, 1997
License Amendment Request	July 30, 1997
License Renewal	September 30, 1997
Response to Request for Additional Information	October 20, 1997
Response to Request for Additional Information	November 21, 1997
License Amendment No. 1	December 18, 1997
Summary of Commitments Submittal to NRC	March 30, 1998
NRC Comments on March 30, 1998 Commitment List	April 29, 1998
License Amendment Request	September 24, 1998
Request for Additional Information	November 3, 1998
Response to Request for Additional Information	November 27, 1998
License Amendment Request	December 22, 1998
Revision to November 27, 1998 License Amendment Request	December 23, 1998
License Amendment Request	February 2, 1999
License Amendment Request	February 2, 1999
License Amendment Request	February 5, 1999
License Amendment No. 2	February 12, 1999
License Amendment Request	February 19, 1999
License Amendment No. 3	February 24, 1999
License Amendment No. 4	March 15, 1999
License Amendment Request	May 10, 1999
License Amendment Request	May 17, 1999
License Amendment No. 5	May 20, 1999
License Amendment Request	June 16, 1999
License Amendment Request	July 7, 1999
License Amendment Request	July 16, 1999
License Amendment No. 6	August 20, 1999
License Amendment No. 7	September 2, 1999
License Amendment Request	January 18, 2000
License Amendment No. 8	February 21, 2001
License Amendment Request	March 5, 2002
License Amendment No. 9	March 25, 2002
License Amendment No. 10	July 26, 2002

Title	Document Date
License Renewal Request	August 27, 2002
License Renewal Request Denied	October 22, 2002

A Finding of No Significant Impact for Fansteel's amendment request to process on-site residues (called residues from the WIP) was published in July 1996. The amendment was subsequently granted on March 25, 1997, after review of Fansteel's financial assurance mechanism was completed.

On September 30, 1997, Fansteel's Source Material License was renewed following the publication of a Finding of No Significant Impact in the FR on July 24, 1997. Renewal authorized processing of the residues from the WIP, groundwater collection and treatment, monitoring, maintenance, and laboratory activities. On July 30, 1997, Fansteel submitted an amendment application requesting processing of CaF material currently located on site in waste treatment ponds. This activity was not authorized in the renewed license.

2.2 License History

This section describes the materials license history for the Muskogee site, source material possession limits and physicochemistry, and historical process activities.

2.2.1 License History and Possession Limits

The following table lists the quantity of material Fansteel was authorized to possess throughout the SMB-911 license history:

Title	Application/Amendment Date	Maximum Quantity of Source Material
Initial Issue of License	January 27, 1967	4,500 lbs Uranium and Thorium
License Renewal	January 2, 1970	3,700 lbs Uranium and Thorium
Amendment No. 1	March 17, 1971	10,000 kg Uranium and Thorium
Amendment No. 2	February 18, 1976	100,000 kg Uranium and Thorium
Amendment No. 7	July 29, 1981	30,000 kg Uranium 67,000 kg Thorium
License Renewal	June 27, 1986	50,000 kg Uranium 100,000 kg Thorium
Revised License	February 1, 1990	30,000 kg Uranium 67,000 kg Thorium

Title	Application/Amendment Date	Maximum Quantity of Source Material
Amendment No. 1 through Amendment No. 10	September 1998 to July 2002	43,000 kg Uranium (residue) 71,000 kg Thorium (residue) 4,000 kg Uranium (soil/sediment) 2,500 kg Thorium (soil/sediment)

2.2.2 Chemical Form of Radionuclides

The feed materials used for tantalum and columbium production contained uranium and thorium as naturally occurring trace constituents. These radioactive species were present in the feed material at an approximate mass concentration of 0.1 percent natural uranium (U_3O_8) and 0.25 percent natural thorium (ThO_2). These concentrations are approximately 560 pCi/g $^{238}U + ^{234}U$ and 480 pCi/g $^{228}Th + ^{232}Th$, resulting in a Th:U activity concentration ratio of 0.86. The ponded residues of the manufacturing process contain U_3O_8 and ThO_2 at similar concentrations either alone or in a CaF precipitate matrix.

2.2.3 Historical Process Activities

Tantalum- and columbium-bearing ore for processing was procured by Fansteel from several international locations. Additionally, tin slags containing residual amounts of tantalum and columbium were acquired from tin-smelting operations in Thailand. The drummed ores and slags arrived at the facility via truck and barge and were placed in the facility's storage area until required for production.

The ores and slags were digested in an HF solution. After the digestion step, a series of unit processes to separate the tantalum and columbium products was conducted. The byproducts of the separation steps (residues from the WIP) were disposed in Pond Nos. 2, 3, and 5. These ponds were called acidic ponds due to their acid constituent. Pond Nos. 1N and 1S received CaF and small quantities of WIP prior to closure in 1991. According to historical documentation, 371 tons of material were excavated and packaged during closure activities.

Process water, as well as the Pond No. 3 french drain supernatant, was treated and then passed on to Pond Nos. 6, 7, 8, and 9 for solids precipitation prior to passing through an NPDES discharge outfall. These ponds are referred to as alkaline ponds.

A typical analysis of ores purchased is shown in Table 2-1. A typical analysis of slags purchased is shown in Table 2-2. Typical analyses of residues from the WIP placed in impoundments are included as Tables 2-3 and 2-4.

The Fansteel Muskogee facility was divided into five areas based upon site operations to allow for a clear discussion of the extent and detail of the historical operation at this location. The areas are presented in Figure 2-2. Previous locations of radionuclide use are shown in Figure 2-3.

Buildings and equipment associated with the ore-processing activities include the Chemical "C" Building, the Chemical "A" Building, and the R&D Building. The Chemical "C" Building is contaminated throughout by radioactive ore residues. Isolated areas of radioactive contamination were identified in the Chemical "A" and R&D buildings. Paved ore storage and ore transportation areas west of the Chemical "A" Building also exhibit elevated levels of surface radioactivity. Residues from the WIP (licensed material) were placed in Pond Nos. 2 and 3. Pond No. 5 (currently a dry basin) formerly received residues from the WIP and Pond Nos. 6, 7, 8, and 9 are used for treatment of wastewater and storage of water treatment residues. Figure 2-1 shows the facility building and pond locations. A detailed discussion on the process activities is provided below.

The following sections present detailed physical descriptions and locations of each area and describe relevant historical operations that were conducted within them.

2.2.3.1 Area I – Pond Nos. 6, 7, 8, and 9

2.2.3.1.1 Physical Description and Location

Area I is the southernmost area at the site and contains four alkaline process water settling ponds: Pond Nos. 6, 7, 8, and 9. The settling ponds were placed into service in 1973, 1975, 1978, and 1985 respectively. Pond Nos. 6 and 7 have clay liners while Pond Nos. 8 and 9 have single 30-mil synthetic liners and leak detection systems. All of the settling ponds' respective dimensions and construction information are listed in Table 2-5. Pond No. 5 was designed and installed as an alkaline pond also, but was used for various purposes during historical facility operations. Pond No. 5 has accepted treated process water, typically handled in acidic ponds. It has been grouped in Area III because low-level radioactivity has been detected historically in samples collected within its boundary.

2.2.3.1.2 Description of Past Operations

The surface impoundments in Area I were constructed and placed into service as process water settling ponds beginning in 1973. These ponds were constructed to accept treated process water and Pond No. 3 french drain supernatant after lime addition, neutralization, and precipitation. All other waste streams that were collected were routed to the water treatment system and subsequently discharged into the alkaline ponds for settling and further pH adjustment.

The treated process water was initially routed to Pond Nos. 8 and 9 for precipitation and then to Pond Nos. 6 and 7 for additional clarification. The precipitants utilized in this area were primarily calcium hydroxide and CaF with the occasional minor addition of several metal hydroxides. After physical separation had occurred, the supernatant was discharged through the NPDES-permitted Outfall 001 and the precipitant remained in the ponds.

2.2.3.2 Area II – Chemical "C" Process, Pond Nos. 2 and 3

2.2.3.2.1 Physical Description and Location

Area II is located in the northern portion of the plant site. Included within this area are Chemical "C" Building, acidic Pond No. 3 and the related french drain/sump system, and former acidic Pond No. 2. Outfall 003 discharges surface water from the subject area into the Arkansas River.

Pond No. 3 has a synthetic liner and the other acidic pond was lined with clay. Physical dimensions and construction details for all remaining settling ponds in existence at the site are presented in Table 2-5.

2.2.3.2.2 Description of Past Operations

Storm water runoff in the southeastern area of Pond No. 3 drains into two relatively small catchment basins located to the south and east of the subject pond. The supernatant residues from the WIP placed in these basins had been historically pumped into Pond No. 3 for treatment. Since the Pond No. 3 failure in 1989, water from these ponds has been discharged directly to the treatment plant located in Area V. All other storm water runoff from Area V is channeled to NPDES-permitted Outfall 003 which discharges to the Arkansas River.

Pond No. 3 was designed and constructed as a total retention structure for residues from the WIP produced during the digestion and liquid-liquid exchange processes that occurred in the Chemical "C" Building. Materials stored in the pond include digested ores and slags and fluid comprised of HF and sulfuric acid (H_2SO_4) containing methyl isobutyl ketone (MIBK), heavy metals, and LLR species. Former Pond No. 2, located in the same area as Pond No. 3, accepted the same residues from the WIP which were more recently placed in Pond No. 3.

Because groundwater was encountered in the alluvium during construction of the pond, a french drain network was installed around the structure to collect groundwater and route it to a sump. A single synthetic liner was installed at the base of the pond with the intent to retain all fluids and residues from the WIP placed in the structure. The original design of the french drain collection system allowed groundwater to discharge to a small valley east of Outfall 003 (see Figure 2-2). The sump discharge was then pumped from the sump to Pond No. 3 or to the plant's process water treatment facility.

During the summer of 1982, piezometer measurements of the groundwater level in monitoring wells around Pond No. 3 indicated leakage was occurring. In response to this indicated leakage, Fansteel applied over 1.5 million pounds of hydrated lime to Pond No. 3 to promote CaF precipitation and seal the leakage paths. In August 1984, the leakage condition appeared to have been abated based on the well monitoring data.

The west embankment of Pond No. 3 failed in June 1989, discharging supernatant from the pond into the surrounding area and ultimately into the Arkansas River. The discharge into the river was halted by the emergency construction of containment dikes in the western and northeastern sections of the study area. Fluids from ponds created by the temporary diking of Area II and supernatant that remained within Pond No. 3 were routed to the plant's water treatment system as directed by the NRC. Following treatment, this material was placed into Pond Nos. 8 and 9.

After its failure, Pond No. 3 did not receive the liquid residues from the WIP from ore/slag processing. Filter presses were put into operation to remove the solid wastes from the acidic process water stream before further processing. Filtered solid wastes were placed in 55-gallon drums and stored on the barrel storage pad in Area V.

Chemical processes which occurred in the Chemical "C" Building included the digestion of raw ores and slag and the liquid-liquid extraction process. The processes that were utilized by Fansteel in the Chemical "C" Building are described below. The raw materials containing the tantalum and columbium oxides that were processed by the Fansteel facility consisted of the following types:

- Tin-smelting slag
- Natural ores
- Chemically or physically upgraded ores and concentrates

The physical condition and the constituents of the raw materials determined if they required grinding before dissolution. The ores were removed from their containers and fed into the ball-type mill by a conveyor belt. The ore was pulverized by a ball mill and then discharged from the mill.

The ground material was transferred into a feeder hopper. The hopper was hoisted into position over the ore or slag feeder for dissolution. The material was fed into a vessel containing HF by an auger-type screw feeder. The dissolution process began when the ore or slag came in contact with 70 percent HF. The slurry was transferred from the digester by a pump through a plate filter press.

The residue in the press was placed in drums and sampled for tantalum. If the tantalum content was less than 1 percent, it was placed in the disposal pond (Pond No. 3). If the percentage was greater than 1 percent, it was recycled. After the tantalum and columbium were separated from the residues and contained in the aqueous solution, the solutions then became feed material for a mixer settler box operation for the separation and purification of the two metals.

The purpose of the first box was to remove the tantalum and columbium from the aqueous solution with the aid of MIBK and an H_2SO_4 solution. The MIBK which had become saturated with tantalum and columbium was discharged. The aqueous solution was transmitted to another box of the same kind and was stripped of any trace of tantalum and columbium with a clean solution of MIBK. The aqueous solution was discharged to the waste treatment center for neutralization and removal of fluoride.

The tantalum/columbium/MIBK solution was then transferred to another box for separation of the tantalum and columbium metals. A solution of H_2SO_4 was injected into this box. Through a series of mixing and settling chambers, the columbium was removed from the organic layer and discharged into another box as an aqueous solution. This box removed traces of tantalum by using a clean solution of MIBK. The aqueous solution containing the high-purity columbium was retained in storage tanks to be held until it was ready for further processing. The organic layer containing the tantalum was transferred into another box and mixed with deionized water. The tantalum was transferred from the organic solution into the water layer. This tantalum aqueous solution was then contained and held in separate holding tanks until it was ready for further processing. All organic liquids used in the removal of the metals were recycled for use again in the mixer settling box operation.

2.2.3.3 Area III – Former Storage Areas and Pond No. 5

2.2.3.3.1 Physical Description and Location

Area III is divided into two distinct sections: the former ore and slag storage area and Pond No. 5. The former ore and slag storage area is located in the western section of the site between Areas I and IV. Pond No. 5 is a clay-lined settling pond located in the northeastern corner of Area I. For characterization purposes, it has been grouped with the former storage areas due to their similar LLR contamination. However, Pond No. 5 also shares similarities with the alkaline and acidic settling ponds located in Areas I and II respectively as it has accepted both types of liquid residues.

2.2.3.3.2 Description of Past Operations

Pond No. 5 is a clay-lined pond originally put into service as an alkaline pond, accepting process water streams identical to those stored in Pond Nos. 6 through 9. However, in the short interim between the closing of Pond No. 2 and the completion of Pond No. 3, Pond No. 5 accepted acidic residual materials. The pond was removed from service in 1975. The pond has been designated as an LLR-contaminated area. The portion of Area III west of Area V was formerly used to store ore and slag prior to processing.

2.2.3.4 Area IV – Former Drum Storage Area

Area IV is located in the western section of the facility adjacent to the northern boundary of the former ore storage area (Area III).

2.2.3.5 Area V – Chemical "A" Building, Process Water Treatment Plant, Former Pretreatment Pond Nos. 1S and 1N

2.2.3.5.1 Physical Description and Location

Area V is located in the eastcentral section of the site between Areas I and II. Chemical "A" Building, the process water treatment plant, Sodium Reduction Building, former pretreatment Pond Nos. 1S and 1N, ammonia storage tanks, the ore barrel storage area, the equipment storage area, and Outfall 002 are all located within the limits of this area. The majority of the chemical processes that were performed at the Muskogee facility, with the exception of ore handling and liquid-liquid extraction, were completed within this area.

2.2.3.5.2 Description of Past Operations

Many different processes were accomplished within the limits of Area V. Tantalum and columbium production processes incorporating the raffinates resulting from the liquid-liquid extraction performed in the Chemical "C" Building, the processing of scrap materials from each of the chemical processes, sodium reduction, and process water treatment were all accomplished within their respective buildings within Area V. Untreated process wastewater to be routed to the WWTP was stored in synthetic-lined Pond Nos. 1S and 1N prior to treatment. The barrel storage and equipment storage were also handled within the area.

Catchment Basin No. P10 collected storm water runoff from the northeastern section of Area V. The supernatant contents of this basin were pumped to the treatment plant for processing and eventually stored in Settling Pond Nos. 8 and 9 located in Area I. This area has since been paved with concrete and Pond No. P10 no longer exists. Runoff currently gravity drains to the west and is discharged into the treatment plant. All other surface water runoff from the area is discharged to the Arkansas River through NPDES Outfall 002. The following sections present detailed descriptions of the chemical processes that were conducted within this area.

2.2.3.5.2.1 Scrap Processing

A large amount of scrap was generated and accumulated throughout the tantalum and columbium production process. The scrap was reclaimed by various processes in two different areas at the facility. One facility within this study area handled bulk quantities of scrap such as residues from ore and slag dissolutions, sodium reduction residues, acid powder wash residues, off-specification tantalum powder lots, and columbium press cake. HF and nitric acid were used in the processing of this scrap which was subsequently processed by liquid-liquid extraction.

A second facility reprocessed high-purity scrap materials such as bar ends, ingot ends and filings, beam melt furnace cleanings, tantalum wire, capacitors, sheet, foil, and other off-specification materials. The scrap material was purchased from customers that produced tantalum products. HF and nitric acid were again used in the scrap dissolving process.

2.2.3.5.2.2 Columbium Processing

The high-purity columbium solution was sparged with anhydrous ammonia to precipitate the columbium. The slurry was pumped through a plate and frame press to remove the columbium oxide. The liquor from the columbium precipitation was stored in a separate holding tank where any remaining columbium was allowed to settle. The liquor was then removed and routed through a stripping tower for removal of ammonia. Remaining slurry was pumped through a separate plate filter and remaining liquids were transferred to wastewater treatment for removal of ammonia.

The columbium filter press cake was removed from the press and dried in a gas-fired calciner. The exhaust was routed through a water scrubber system to remove any ammonium fluoride before emission to the atmosphere. The dried press cake was then placed in a blender and packaged.

2.2.3.5.2.3 Tantalum Processing

A solution of potassium fluoride was added to the high-purity tantalum obtained from the liquid-liquid process, precipitating the tantalum to form a potassium heptofluortantalate (K_2TaF_7) crystal. The crystals were centrifuged to remove any remaining liquids and then washed by spraying with a solution of potassium chloride. The liquids removed from the crystals and resulting from the washing were caught and stored for further processing. The crystals from the centrifuge were then placed in a rotary vacuum dryer. After drying, the K_2TaF_7 was transferred to another area of the facility for sodium reduction.

All liquors or solutions from the precipitation process were treated with anhydrous ammonia or sodium hydroxide (NaOH) to remove all further traces of tantalum. These solutions were pumped through a plate press to remove or separate crystals from the liquid. The ammoniated water was routed through a stripping tower for removal of ammonia.

2.2.3.5.2.4 Sodium Reduction of K_2TaF_7

In the later 1950s, the process for controlled sodium reduction of tantalum powder was introduced at Fansteel. This was the first exothermic-type reduction utilizing the addition of sodium to K_2TaF_7 at a controlled rate and temperature. Three types of reductions were made at the Fansteel plant including BV, FM, and TF.

BV reduction is a high-temperature reduction using K_2TaF_7 with tantalum fines, sodium chloride, and molten sodium with an argon blanket. After the sodium addition was complete, the metal powder cake is crushed, milled, and water washed. After water washing, the powder is milled, screened, and acid washed to eliminate free iron and nickel and to lower the oxygen that accumulated during milling. This powder is produced for use in wire and sheet bar applications. The wastewater from this operation contained fluorides and chlorides. It was stored in a pretreatment holding (Pond No. 1) from which it was pumped to the wastewater treatment system.

FM reduction produces a powder used for high-charge capacitor applications. This reduction is completed with K_2TaF_7, sodium chloride, tantalum fines, sodium sulfate, and molten sodium. The reduction is then crushed, milled, and water washed. The washed powder is placed into a vacuum cart to remove excess water, acid washed, dried, and screened. Tests are then conducted on the powder for chemical impurities and capacitance. The wastewater from this operation contained fluorides and chlorides. It was stored in a pretreatment holding pond (Pond No. 1) from which it was pumped to the wastewater treatment system.

The TF reduction is different from the two processes described above. Potassium compounds are used with the feed stack. After the material has dried, the next step is to begin the reduction. After the reduction, the material is crushed and placed into a large wash tank. The washed powder is placed into a vacuum cart to remove excess water, acid washed, dried, and screened. The water from the acid wash operations contained fluorides, nitric acid, tantalum powder, and other minute quantities of metal. This effluent was pressed and the aqueous phase was stored in a pretreatment holding pond (Pond No. 1) from which it was pumped to the wastewater treatment system.

2.2.3.5.2.5 Wastewater Treatment

Process water produced by the various processes was treated at the water treatment facility east of the Chemical "A" Building. Acidic and ammonia waters were stored in temporary holding Pond Nos. 1S and 1N respectively prior to treatment. The treatment facility consists of a series of concrete tanks surrounded by a concrete pad. Supernatant was pumped from these holding ponds and treated by employing lime neutralization to remove fluoride by CaF precipitation. Treated water from this facility was stored in settling Pond Nos. 8 and 9 in Area I.

2.3 Previous Decommissioning Activities

2.3.1 Northwest Property

Fansteel has already decontaminated approximately 35 acres of the Muskogee facility designated as the "Northwest Property" (see Figure 2-1) and NRC has released this area for unrestricted use per License No. SMB-911 Amendment No. 6, Condition No. 9, August 20, 1999.

The Northwest Property Area during plant operations was never utilized for the processing, generation, or disposal of licensed material; however, some temporary storage activities did occur in discrete areas of this portion of the site. The Northwest Property Area was involved with the processing of the intermediate products (tantalum and columbium powder) which were free of licensed material. The intermediate products were pressed and sintered in the Sintering Building. These sintered products were either sold as is or further refined prior to sale by electron beam melting in the Electron Beam (EB) Building.

The Northwest Property Area consists of buildings, an asphalt-paved parking lot, and an electrical substation. The buildings and the prior uses are identified as follows:

- Building No. 1 – Service Building. This building consists of office areas, a warehouse, a machine shop, and chemical and metallurgical laboratories. A laboratory for measuring environmental radioactivity consisting of alpha and beta counting equipment was formerly located in this structure. Building No. 1 is part of the original plant construction.

- Building No. 2 – Sintering Building. This building formerly contained sintering furnaces, storage areas, offices, and support equipment as well as a machine shop. This building received purified nonradioactive tantalum or columbium powder. Processes which occurred in this building involved pressing the nonradioactive powders into shapes specified by Fansteel's customers and sintering the powdered shapes into metal. The sintering furnaces have been sold and removed from the site. Building No. 2 is part of the original plant construction.

- Building No. 3 – EB Building. This building was constructed to house an EB furnace for the production of high-purity tantalum. Building No. 3 also contains a vacuum arc furnace (VAF) which was used for tantalum refining. These furnaces would receive nonradioactive, relatively pure metals and remelt and reshape the material to achieve a higher degree of purity. Raw materials utilized and final products generated in this building were nonradioactive. Building No. 3 was constructed in 1989 just prior to the termination of plant manufacturing operations.

- Building No. 4 – Guard House. Building No. 4 is part of the original plant construction. No processing activities occurred in this building.

- Building No. 5 – Metal Storage Building. This building was used to store laboratory glassware supplies.

- Building No. 6 – Metal Storage Building. This building was used to store grounds maintenance tools and equipment.

An initial decommissioning survey was conducted for the Northwest Property Area in 1992 and 1993. The results of this survey were submitted to the NRC for review in July of 1993. The NRC issued several comment letters on the original Northwest Property Area Decommissioning Survey Report raising issues which required clarification or the acquisition of additional data. Fansteel responded to these comment letters with additional submittals to the NRC dated December 28, 1993; May 24, July 27, and December 1, 1994; December 18, 1995; and March 16, 1996.

The Northwest Property Area radioactivity surveys examined areas of land, buildings, and equipment for the presence of radioactive materials or contamination. A combination of field instrumental measurements and laboratory analysis was used to detect and quantify radioactivity in this area. Survey and sampling activities were tied into various grids established both over the Northwest Property Area land and within and on the buildings located in this portion of the site. These activities were performed in accordance with the "Manual for Conducting Radiological Surveys in Support of License Termination" (NUREG/CR-5849). Specific details of these activities are contained in the NRC submittals listed above.

NRC released the Northwest Property Area for unrestricted use per License No. SMB-911 Amendment No. 6, Condition No. 9, dated August 20, 1999.

2.3.2 Pond No. 1 Closure

According to historical documentation, Pond No. 1 was located at the current location of Pond Nos. 1N and 1S which replaced Pond No. 1 in 1981.

2.3.3 Pond No. 2 Closure

According to historical documentation, Pond No. 2 closure activities occurred in 1979 at which time it was filled to capacity and covered with a polyvinylchloride sheet, a polyethylene sheet, and between 6 and 24 inches of soil to support vegetation.

2.3.4 Pond No. 5 Removal Activities

According to historical documentation, Pond No. 5 closure activities occurred in 1991 at which time 827 tons of material were removed from Pond No. 5 and packaged.

2.3.5 Groundwater Interceptor Trench Installation

After the Pond No. 3 liner failed in June 1989, a groundwater interception trench was installed east of Pond No. 3 to collect alluvial groundwater and minimize the potential for discharge of contaminated groundwater to the Arkansas River. As shown in Figure 2-1, the trench is located between Sumps 1 and 4. Alluvial groundwater collected in the trench is pumped to the WWTP and then to the treatment ponds for eventual discharge via the NPDES system. Approximately 7,000 cubic yards of radiologically contaminated soil removed during the excavation of the trench are stored on site in storage pillows.

2.4 Spills

2.4.1 Pond No. 3 Liner Failure

Pond No. 3 was the source of the only liquid release incident recorded at the facility. It is located in the northern portion of the plant site and has been in existence for approximately 19 years. The pond was constructed as a total retention structure for ore/slag residues produced during the digestion and liquid-liquid exchange processes that occurred in the Chemical "C" Building. Materials placed in the pond include residues from the WIP and fluid comprised of HF and H_2SO_4 and, in addition, contain MIBK, heavy metals, and LLR species.

Pond No. 3 was constructed by excavating the alluvial soils to the top of the local shale bedrock. Because groundwater was encountered in this alluvium, a french drain network was installed around the structure to collect groundwater and route it to a wet well (collection sump). A single synthetic liner was installed in the pond with the intent to retain all fluids and residues discharged to the structure.

On June 18, 1989, a large supernatant discharge from Pond No. 3 occurred from the wet well and french drain system adjacent to the subject pond and several seeps near the southwestern corner of Pond No. 3 causing portions of the french drain system to collapse. The suspected cause of this release was a failure of the Pond No. 3 liner. The released fluid traveled along the natural drainage course around the western and northern sides of Pond No. 3 and discharged through storm water Outfall 003. Plant personnel immediately mobilized Fansteel employees and local contractors to contain the discharge.

Fluid discharge to the river was terminated by the construction of a temporary dike near Outfall 003 and a second dike near the northwestern corner of Pond No. 3 as shown in Figure 2-4. An estimated 90,000 gallons of fluid was released into the Arkansas River before the discharge was arrested. Fansteel notified the National Response Center, State Response Commission, Muskogee Local Emergency Committee, and NRC immediately after the release was brought under control and again in writing on June 22, 1989. The fluids from the temporary ponds and Pond No. 3 subsequently were removed and routed to the plant's wastewater treatment system as directed by the NRC.

This release resulted in contamination of adjacent soils with some source material (see Figure 2-4). Cleanup activities were immediately undertaken and subsequent characterization revealed no radiological impact as supported by the 1993 characterization survey. The scope of the characterization event included evaluation of soil and monitoring well data, as well as a geophysical survey of Pond No. 3 to delineate a potential groundwater contaminant plume and groundwater quality.

After its failure, Pond No. 3 did not receive residues from the WIP. Filter presses were put into operation to remove solid material from the acidic process water stream before further processing. Filtered solid materials were placed in 55-gallon drums and stored on the barrel storage pad near the Chemical "A" Building.

Storm water runoff in the southeastern area of Pond No. 3 drains into two relatively small catch basins located to the south and east of the subject pond. Prior to the release of Pond No. 3, the supernatant contents of these catch basins were into Pond No. 3. Since the failure of Pond No. 3 in 1989, water from this area has been discharged directly into the existing waste/groundwater treatment plant. All other storm water runoff in this area is channeled to NPDES-permitted Outfall 003 which discharges to the Arkansas River.

2.4.2 <u>1999 Tornado</u>

On June 1, 1999, an F1 (moderate tornado with winds of 73 to 112 miles per hour (mph) producing moderate damage) tornado touched down near the Port of Muskogee and moved south for 2.25 miles. As summarized by the National Climatic Data Center, a cold front moving in from the northwest moved into an extremely unstable air mass on the afternoon of June 1, 1999. Along the front, an isolated supercell thunderstorm developed around the Pryor/Locust Grove area then moved in a slow and unusual south-southwest direction. This storm produced very large hail in addition to several strong tornados.

The tornado struck the Fansteel plant, damaging buildings and causing up to $1.5 million damage there. The damaged buildings include the Chemical "A," Chemical "C," Service, R&D, Sintering, Sodium Reduction, Weir, Machine Shop, Little Bertha, Whitehouse, and EB buildings, as well as the Guardhouse and Groundwater Treatment Plant. In addition, the liners of Pond Nos. 3, 8, and 9 were torn above the water line and a stored soils cover was ripped.

The only release of radioactive material was contained on site. The damage to the Sodium Reduction Building allowed bagged Pond No. 5 material to fall out of the building and tear open. The bags were filled with moist, LLR material that had been excavated from Pond No. 5 in 1993. Analyses of Pond No. 5 material in 1993 contained an average of 21 pCi/g uranium-235 and 6 pCi/g thorium-232.

Approximately 500 pounds of material were released to the ground surface within a 10-foot-diameter area before being recovered and rebagged.

2.5 Prior On-Site Burials

No on-site burials are known to have occurred at the site other than those associated with Pond No. 1 closure (see Section 2.3.2).

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4. Earth Sciences Consultants, Inc., June 1999, Decommissioning Plan, Eastern Property Area, Fansteel Inc., Muskogee, Oklahoma.
5. Earth Sciences Consultants, Inc., December 1993, Remediation Assessment, Fansteel Inc., Muskogee, Oklahoma.
6. Earth Sciences Consultants, Inc., July 1993, Radiation Survey and Remedial Assessment, Northwest Property Area, Fansteel Inc., Muskogee, Oklahoma.
7. Earth Sciences Consultants, Inc., December 1994, Supplement No. 1, (Gamma Readings/MicroRad Per Hour), Radiation Survey and Remedial Assessment, Northwest Property Area, Fansteel Inc., Muskogee, Oklahoma.
8. Earth Sciences Consultants, Inc., December 1995, Additional Radiation Survey Activities, Northwest Property Area, Fansteel Inc., Muskogee, Oklahoma.
9. Earth Sciences Consultants, Inc., March 1996, Supplement to Additional Radiation Survey Activities, December 1995, Fansteel Inc., Muskogee, Oklahoma.
10. Earth Sciences Consultants, Inc., February 1991, Revised January 1992, Remedial Assessment Work Plan, Fansteel Metals, Muskogee, Oklahoma.

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Tables

Table 2-1
Typical Analyses - Ores/Slags
Purchased Ores for Processing

Constituent	% by wt. High	% by wt. Low
Ta205	32	21
Nb205	55	35
Ti02	3	1.4
Sn02	4	0.4
U308	0.32	0.03
Th02	0.03	0.01

Table 2-2
Typical Analyses - Ores/Slags
Purchased Slags for Processing

Constituent	% by wt. High	% by wt. Low
Ta205	19	14
Nb205	14	8
U308	0.15	0.11
Th02	0.28	0.25

Table 2-3
Typical Composition
Pond Nos. 2, 3, and 5

Component	% Dry Weight
Ta205	1.4
Cb205	1.5
Sc203	0.27
Calcium	14
Tin	0.73
Magnesium	1
Zirconium	5.1
Aluminum	7.8
Titanium	4.2
Iron	2.5
Fluoride	30
Rare Earths	1
Uranium	0.3
Thorium	0.6

Table 2-4
Typical Composition
Pond Nos. 8 and 9

Component	% Dry Weight Pond 8	% Dry Weight Pond 9
F	30	27
Ca	32	31
Ta	0.14	0.07
Nb	0.41	0.23
Al	0.83	0.94
Ti	1.06	1.32
Zr	0.1	0.09
U (ppm)	104	59
Th (ppm)	82	48
% Solids	30	30

Table 2-5
Dimensions and Construction of Settling Ponds
Muskogee, Oklahoma

Pond No.	Dimensions Length (ft)	Width (ft)	Approximate Depth (ft)	Liner Type	Leak Detection	Approximate Year Placed into Service
1S	90	80	10	Synthetic	No	1981
1N	80	80	10	Synthetic	No	1981
2	350	150	12	Clay, capped with one PVC sheet, one polyethylene sheet, and 6 to 12 inches of soil	No	1960
3	400	250	25	Synthetic	No	1979
5	200	100	9	Clay	No	1973
6	200	100	9	Clay	No	1973
7	250	150	7	Clay	No	1975
8	350	350	27	Synthetic	Yes	1978
9	600	250	25	Synthetic	Yes	1985

Figures

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: DRAWING NO. 6473420, FIGURE 2-1, SITE PLAN DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473420, FIGURE 2-1

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-01

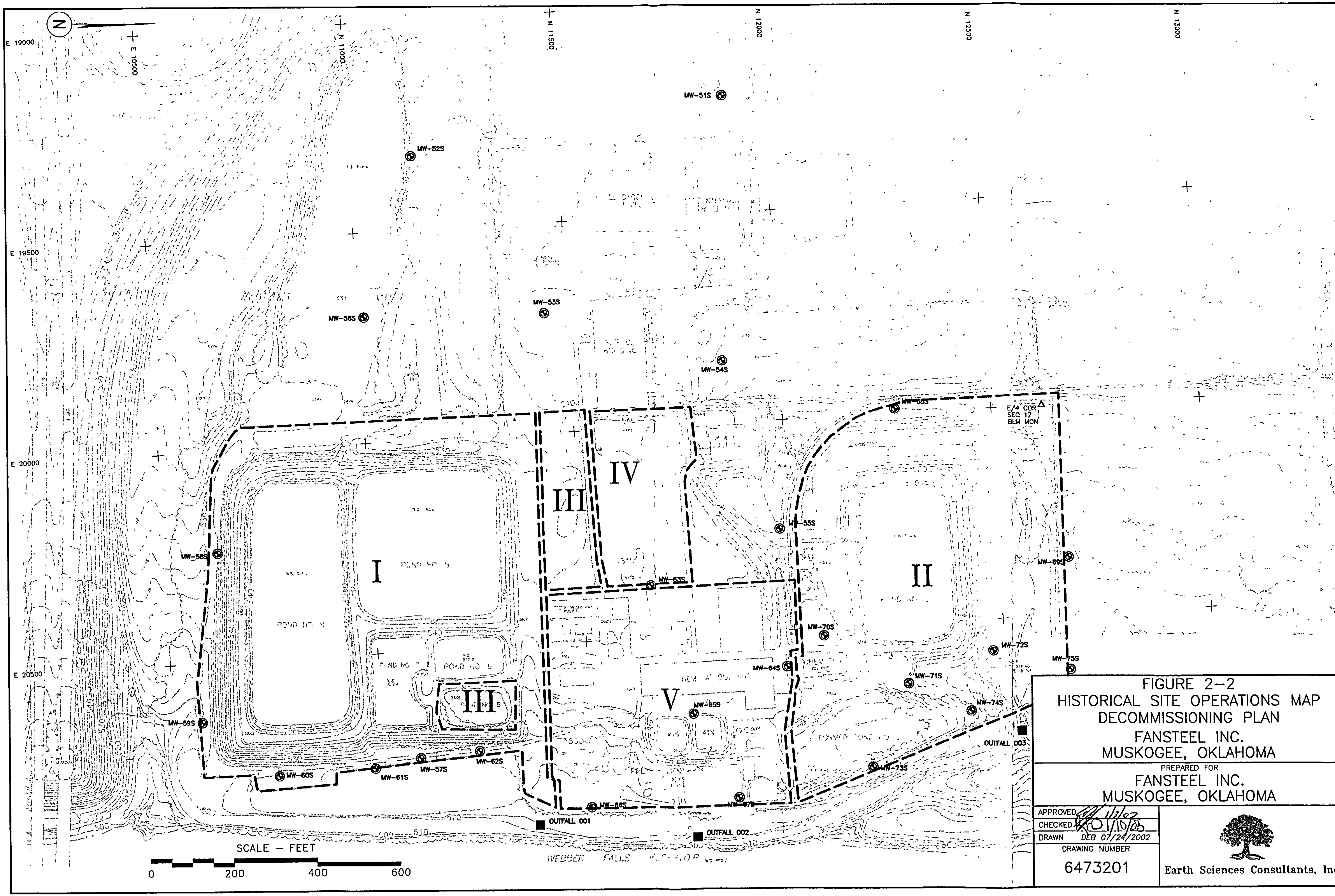

FIGURE 2-2
HISTORICAL SITE OPERATIONS MAP
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

APPROVED 1/13/03
CHECKED 1/10/03
DRAWN DEB 07/24/2002
DRAWING NUMBER
6473201

Earth Sciences Consultants, Inc.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: DRAWING NO. 6473428, FIGURE 2-3, PREVIOUS LOCATIONS OF RADIONUCLIDE USE DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473428, FIGURE 2-3

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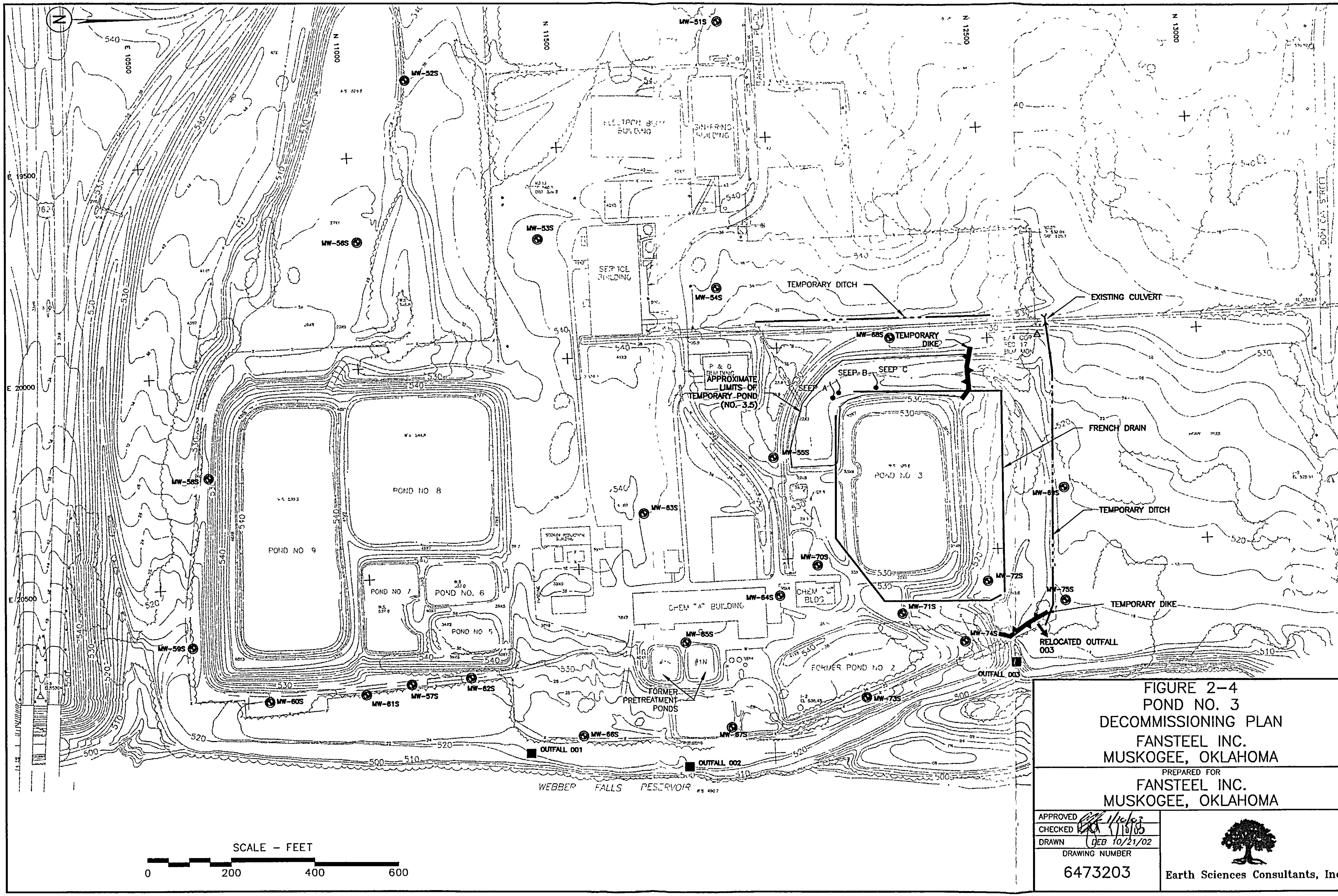

FIGURE 2-4
POND NO. 3
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

APPROVED 1/10/03
CHECKED 1/10/03
DRAWN DEB 10/21/02
DRAWING NUMBER
6473203

Earth Sciences Consultants, Inc.

3.0 Facility Description

3.1 Site Location and Description

The Fansteel Muskogee plant is located at Number Ten Tantalum Place in Muskogee, Oklahoma approximately 1 mile from the Muskogee Turnpike. It is situated in Muskogee County and occupies approximately 91 acres of land adjacent to the 406-acre Port of Muskogee Industrial Park, 2.5 miles northeast (Latitude 35.46.30, Longitude 095.18.15) of the Town of Muskogee, Oklahoma as shown in Figure 3-1. The site lies along the western edge of the Arkansas River (Webbers Falls Lock and Dam and Reservoir, part of the McClellan-Kerr Arkansas River Navigation System) and is bounded on the north by land owned by the Muskogee Port Authority, on the south by U.S. Highway 2, and on the west by Oklahoma State Highway 65 and a service road. A site vicinity map is shown in Figure 3-2.

The site is located in the unglaciated Osage Section of the Central Lowlands Physiographic Province (Earth Sciences Consultants, Inc, [Earth Sciences], 1993). The site topography ranges in elevation from 500 feet above mean sea level (msl) along the eastern border of the Arkansas River to 540 feet msl throughout the majority of the site. This is illustrated in Figure 3-3, Site Plan.

3.1.1 Distance to Nearby Cities

The following table lists nearby cities' direction and distance from Muskogee:

City	Direction from Muskogee	Distance from Muskogee
Wagoner	North	15 miles
Talequah	Northeast	24 miles
Okmulgee	Southwest	35 miles
Fort Gibson	Northeast	6 miles
Hyde Park	Northeast	4 miles
Summit	Southeast	4 miles
Taft	West	11 miles
Tulsa	Northwest	41 miles
Tullahassee	Northwest	8 miles
Braggs	Southeast	10 miles

3.1.2 Facility Description

The Fansteel site consists of 15 structures listed below and shown in Figure 3-4:

- Chemical "C" Building (Building No. 13)
- Chemical "A" Building (Building No. 16)
- Thermite Building (Building No. 9)

- Sodium Reduction Building (Building No. 11)
- R&D Laboratory Building (Building No. 15)
- Groundwater Treatment Facility (former Gunch House)
- Bertha Building (Building No. 12)
- Weir Building (Building No. 10)
- Ore Storage Pad
- New Maintenance Building (Machine Shop)
- Chemical Equipment Room (Building No. 17)
- Contractor's Tool Crib (Building No. 18)
- Pond No. 3 Pump Motor Control Center (Building No. 19)
- Chemical "C" Building Power Control Room (Building No. 20)
- White House (Building No. 7)

Ponds formerly used for WIP residue disposal and alkaline process water on the Fansteel site are listed below and shown in Figure 3-3:

- Pond No. 2 WIP residues
- Pond No. 3 WIP residues
- Pond No. 5 primarily CaF and wastewater treatment, short-term interim WIP residues
- Pond No. 6 CaF and wastewater treatment
- Pond No. 7 CaF and wastewater treatment
- Pond No. 8 CaF and wastewater treatment
- Pond No. 9 CaF and wastewater treatment

A groundwater collection trench exists along the southeastern and eastern border of the property. Four sumps are located along the trench as shown in Figure 3-3.

3.1.3 Off-Site Wells

An inventory of water wells located within a 1-mile radius of the Muskogee facility was conducted through an Oklahoma geographical information system website (http://virtuales.com/okgis/cfm/index.cfm; accessed October 2002). The inventory did not reveal the presence of any off-site wells within a 1-mile area of the site.

3.2 Population Distribution

The Fansteel Muskogee plant is located in Muskogee County that had a year 2000 population of 68,078. The plant site is adjacent to Cherokee County which had a year 2000 population of 42,521. Other counties adjacent to Muskogee County include Wagoner to the north with a year 2000 population of 57,491, Okmulgee to the west with a year 2000 population of 39,685, McIntosh and Haskell to the south with year 2000 populations of 19,456 and 11,792 respectively, and Sequoyah to the east with a year 2000 population of 38,972. The major population center is Muskogee (38,310). The geographical center of

Muskogee is located approximately 4 miles southwest of the site. Nearby cities and towns include Fort Gibson (4,054), Wagoner (7,669), and the regional population center of Tulsa (393,049).

The following tables summarize minority populations by the principal compass vectors, current and projected populations, and poverty estimates.

			Number of Minorities by Race						
County	Direction from Muskogee County	Total Population	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Hispanic or Latino	Two or more races	Other
Okmulgee	West	39,685	4,046	5,099	77	7	772	2,538	244
Wagoner	North	57,491	2,158	5,393	296	12	1,437	3,110	490
Cherokee	East	42,521	509	13,787	116	17	1,760	3,214	893
Sequoyah	East	38,972	725	7,654	86	13	793	3,658	288
Haskell	South	11,792	72	1,722	34	0	177	685	53
McIntosh	South	19,456	790	3,152	27	6	248	1,290	68
Muskogee	-	69,451	9,142	10,331	404	22	1,857	4,463	828

Source: U.S. Census Bureau, Census 2000 Redistricting (Public Law 94-171) Summary File.

County	Direction from Muskogee County	Current Population (yr. 2000)	Projected Population (yr. 2025)
Okmulgee	West	39,685	41,669
Wagoner	North	57,491	60,366
Cherokee	East	42,521	44,647
Sequoyah	East	38,972	40,921
Haskell	South	11,792	12,382
McIntosh	South	19,456	20,429
Muskogee	-	68,078	71,482

Source: U.S. Census Bureau, 2000 Census

County	Direction from Muskogee County	Estimate of People of All Ages in Poverty (yr. 1999) (%)
Oklahoma	-	14.7
Okmulgee	West	18.9
Wagoner	North	8.9
Cherokee	East	22.9
Sequoyah	East	19.8
Haskell	South	20.5
McIntosh	South	18.2
Muskogee	-	17.9

Estimates model 1999 income reported in the Census 2000 Summary File 3 (SF 3)

3.3 Current/Future Land Use

The Muskogee plant is sited in an area zoned for industrial use. This industrial use restriction is expected to persist in the future in accordance with the updated Master Plan for industrial properties issued by the Port of Muskogee (Master Plan of Development for the Muskogee Port and Industrial Park, Muskogee City-County Port Authority, November 28, 1967). Figure 3-4 is a 1995 aerial photograph depicting current land uses within the area. Land uses within the general area of the site include urban and built-up uses in the City of Muskogee, agriculture in the rural areas outside of Muskogee, and recreational use of the river. The City of Muskogee is a mixed urban area with commercial, residential, and industrial uses. The city has one college, two university branch campuses, one vocational technical school, two hospitals, and other amenities appropriate to a city of its size. Commercial use is largely related to food products and mineral production. The closest residence is located on the west side of State Highway 165, approximately one-quarter mile from the buildings on site (Earth Sciences, 1994).

Agricultural use of the land occurs outside of the City of Muskogee and is an important component of the economy of the area. Soybeans, hay, corn, and sorghum are the primary crops grown. Muskogee County is among the state's top six soybean-producing counties. Dairy cattle, beef cattle, hogs, and chickens are all raised in the area around the site. Most farms in the area are classified as livestock farms and dairy farms.

Recreational land uses are also important in the area of the site. Rolling scenic hills and man-made lakes are common. Fishing, hunting, and water sports are associated with the lakes.

3.4 Meteorology and Climatology

The Fansteel Muskogee plant is located in eastcentral Oklahoma. The terrain is generally rolling plains which slope downward from west to east with hilly areas to the east. There are no topographic features which significantly affect meteorological conditions.

This region exhibits a continental-type climate. The region lies in the zone of the prevailing westerly and is influenced by a regular progression of high- and low-pressure systems throughout the year. This system progression creates wide variations of temperature on both an annual and diurnal basis. These systems also produce precipitation throughout the year with relatively greater amounts occurring during the spring and autumn months. This precipitation pattern may be attributed to the influence of warm moist air from the Gulf of Mexico as evidenced by humidities that do not vary significantly on an annual basis and that are relatively high for an inland location. As a result, winters tend to be mild, although the influence of cold polar continental air masses is felt, especially during January and February (Earth Sciences, 1994).

3.4.1 Routine Weather

3.4.1.1 Wind

Wind characteristics are based on observations made at the National Weather Service (NWS) station at Tulsa, Oklahoma, 41 miles northwest of the Fansteel plant. This is the closest first-order NWS station to the plant that is located in similar terrain. The prevailing wind is generally from the south, except during January and February when northerly winds predominate. The annual average wind speed is 10.2 mph. Highest average wind speeds occur in the spring (11.9 mph), and lowest average wind speeds occur in the late summer (8.8 mph).

High winds may occur after the passage of intense cold fronts during the winter or may be associated with thunderstorm activity in the area. The fastest-mile wind speed observed at the Tulsa NWS station during the period of 1977 through 2001was 55 mph.

Meteorological dispersion data, found in Appendix A, are based on CAP88-PC Wind File Library Station Information from the Tulsa International Airport. The data represent the joint frequency distribution of wind speed, wind direction, and Pasquill stability class based on 5 years of observations from 1988 through 1992. The dataset assumes an average air temperature of 67.6°F, lid height of 1,000 meters (m), and average wind speed of 4.517 m per second (10.1 mph). The greatest frequency stability class is Class D at 51.72 percent.

3.4.1.2 Temperature

Table 3-1 lists climatological data found on the Oklahoma Climatological Survey website (http://climate.ocs.ou.edu/normals_extremes.html) including mean annual precipitation and temperature and monthly means for precipitation and temperature from 1971 through 2000. According to the National Climatic Data Center, the annual mean temperature is 60.0°F. Monthly mean temperatures range from 82.0°F in July to 36.2°F in January. The highest and lowest temperatures recorded are 114°F in July 1954 and -12°F in January 1996 respectively. On an annual basis, the average daily temperature ranges from a maximum of 71.4°F to a minimum of 50.1°F. This observed annual average temperature range (21.3°F) does not vary much on any given day.

3.4.1.3 Precipitation

The total precipitation averages 44.5 inches per year. Spring is the wettest season (30.3 percent of the total precipitation); winter is the driest season (16.4 percent of the total). The highest average monthly total precipitation is 5.8 inches in May with a secondary maximum of 5.0 inches in September. The lowest average monthly total, 2.0 inches, occurs in January. The greatest monthly precipitation total, 16.41 inches, was recorded in October 1941. The greatest daily total, 7.6 inches, was recorded in July 1963.

Snowfall averages 5.6 inches per year and occurs from October through March. The snow is usually light and only remains on the ground for brief periods. Most of the snow falls during January and February as cold Canadian air masses enter the region. The greatest daily snowfall, 12.0 inches, occurred on March 6, 1989. The greatest monthly snowfall, 17.5 inches, occurred in January 1977.

3.4.1.4 Relative Humidity

Relative humidity characteristics are based on observations made at the NWS station at Tulsa, Oklahoma, 41 miles northwest of the Fansteel plant. The average annual morning and afternoon relative humidities compiled from readings taken at 0600 hours and 1200 hours for the years 1960 through 2001 are 81 percent and 59 percent respectively. Monthly averages vary from 85 percent in May, June, and September to 54 percent in April.

3.4.1.5 Evapotranspiration

Evapotranspiration characteristics are based on observations made at the NWS station at Tulsa, Oklahoma, 41 miles northwest of the Fansteel plant. Average monthly potential evapotranspiration varies from 3 millimeters (mm) in January to 188 mm in July (Thornthwaite, 1964). During the months of February through May, the soil is at its maximum water-holding capacity and precipitation exceeds evapotranspiration. Therefore, a water surplus occurs during these 4 months.

During the June through September time frame, potential evapotranspiration exceeds actual evapotranspiration. This is due to the soil moisture content being below its maximum storage capacity, thereby limiting the water uptake of the vegetation. The amount of moisture removed from the soil by the vegetation during this time frame is dependent upon the ratio of the actual soil moisture content to the potential soil moisture content. In other words, actual evapotranspiration equals potential evapotranspiration, multiplied by the ratio of actual soil moisture content to potential soil moisture content. This exceedance of potential evapotranspiration to actual evapotranspiration results in a water deficit during June through September.

3.4.2 Severe Weather

Appendix B includes a list of the severe weather events that took place in the 51-year period from 1950 through June 30, 2001. In this period, a total of 37 tornadoes were observed in Muskogee County in which the Fansteel plant is located. Tornadoes strike most frequently in the spring (March 13.5 percent, April 18.9 percent, and May 43.2 percent). A tornado struck the Fansteel plant on June 1, 1999, damaging 6 buildings and causing up to $1.5 million damage there. A summary of the conditions that led to the damaging tornado is also included in Appendix B, along with summaries of other significant severe weather events impacting the City of Muskogee (National Climatic Data Center). Based on the method for estimating tornado strike probability as discussed in WASH-1300 (Markee et al., 1974, Pages 2, 8, and 9), the probability of a tornado striking the plant is 1.8×10^{-3} per year, with a recurrence interval of 560 years.

Other types of severe weather--thunderstorms, hail, freezing rain, and/or heavy snow--occur in the area. The area can expect thunderstorms, high winds, and/or lightning about 21 days per year; hail about 20 days per year; flash flooding about 4 days per year; and winter storms (ice and/or snow) about 2 days per year. Hail storms strike most frequently in the spring and early summer (March 14.5 percent, April 15.6 percent, May 33.3 percent, and June 18.8 percent). Thunderstorms occur more evenly throughout the spring through fall, but strike most frequently in the late spring through early summer (April 10.9 percent May 20.7 percent, June 20.7 percent, and July 9.8 percent).

3.4.3 National Ambient Air Quality Standards Category

The U.S. Environmental Protection Agency (USEPA) Office of Air Quality Planning and Standards (OAQPS) is responsible for the development of the National Ambient Air Quality Standards (NAAQS). NAAQS have been set for six criteria pollutants: carbon monoxide, nitrogen dioxide, ozone, lead, particulate (both PM 2.5 and PM 10), and sulfur dioxide. The NAAQS specify three area classifications as follows:

1. Attainment Areas – Areas in which the concentrations of each of the six criteria pollutants do not exceed the NAAQS.

2. Nonattainment Areas – Areas in which the concentration of each of the six criteria pollutants do exceed the standards.

3. Maintenance Areas – Areas which have previously been designated by the OAQPS as Nonattainment, but which have improved and are currently considered Attainment.

No Nonattainment or Maintenance areas are located in the State of Oklahoma. The nearest Nonattainment area to the facility is located in Collin County, Texas (ozone) which is approximately 200 miles southwest of the facility (http://ecfr.access.gpo.gov/otcgi/cfr/otfilter.cgi?DB=3&query=40000000081&region=BIBSRT&action=view&SUBSET=SUBSET&FROM=1&SIZE=10&ITEM=1#Sec.%2081.344).

3.5 Geology and Seismology

3.5.1 Regional Geology

The City of Muskogee, Oklahoma is located in the unglaciated Osage Section of the Central Lowlands Physiographic Province (Earth Sciences, 1993). The eastern boundary of the section is delineated by the lapping of westward-dipping Pennsylvanian rocks onto the western edge of the Ozark and the Ouachita uplifts. On the south, the Osage Section abuts the Arkansas Valley and Ouachita Mountains. Much of the Osage Section can be described as scarped plains. The topography ranges from nearly featureless plain and low escarpments to bold escarpments that rise as much as 600 feet above the adjacent plains. Lowlands or plains mark the weak rock belts and hills or escarpments the areas of resistant rock.

Bedrock in the southeastern portion of the Osage Section consists of mostly thin- to massive-bedded sandstone, shale, siltstone, and limestone of Pennsylvanian Age. The sandstone beds are hard and well cemented and the shales and siltstones are compact and dense. Units identified in the Muskogee area include the Hartshorne Sandstone, the McCurtain Shale, and the Warner Sandstone, in ascending order. Permeability in this type of bedrock is generally low and groundwater movement depends on secondary porosity (joints and fractures) rather than primary porosity (intergranular).

Although the Muskogee site is physically located in the Osage Section, the regional structural geology is influenced by its proximity to the Boston Mountains Section of the Ozark Plateau Physiographic Province and the Arkansas Valley Section of the Ouachita Physiographic Province. The Boston Mountains form a fairly narrow east-west belt at the extreme southern margin of the Ozark Dome (uplift). Rocks of the Boston Mountains Section are early and middle Pennsylvanian in age and are predominantly sandstone and shale. Faulting is conspicuous in the Boston Mountains, particularly in Cherokee and Adair counties of Oklahoma. However, the number and magnitude of these faults rapidly subside until they are eventually unrecognizable west of the Arkansas River. On the southern margin of the Boston Mountains, near the subject site, bedrock dips steepen rapidly as the strata descend into the synclinorium in the Arkansas Valley to the south.

The Arkansas Valley Section is an east-west belt that extends from Oklahoma to the Coastal Plain in Arkansas. The Arkansas Valley is a trough both topographically and structurally. It is transitional between the essential homoclinal structure of the south flank of the Boston Mountains to the north and the complexly folded strata of the Ouachita Mountains to the south. Intensity of folding increases from the Ozark Uplift (north) to the Ouachita Mountains (south). Closed folding with an east-west trend characterizes the Arkansas Valley. The structures and associated ridges commonly overlap one another en echelon. Rocks in the Arkansas Valley, with the exception of a few igneous intrusions, are Carboniferous in age and belong mainly to the Atoka, Stanely, and Jackfork groups. The Atoka Group that consists mostly of shale and thin sandstone forms an erosional scarp located approximately 4 miles from the Arkansas River (and the Muskogee site) and is the closest bedrock outcrop. The Muskogee site is located on the northern flank of the Arkansas Valley. Bedrock dips typically are to the south toward the axis of the basin.

Bedrock in the area of the Muskogee site is nearly entirely overlain by alluvial deposits. The general regional topography of the bedrock beneath the alluvial deposits is relatively uniform with minor variations due to differential erosion. Terrace deposits having upper surfaces ranging from 20 to 120 feet above the floodplain border the alluvial deposits in segments on both sides of the Arkansas River. These deposits are composed predominantly of silt, fine sand, coarse sand, and gravel near the base. The City of Muskogee is on a terrace segment that extends north and east of the city to the bank of the Arkansas River.

Alluvium is formed in lenticular segments along the Arkansas River from 1 to 3 miles wide and 3 to 11 miles long which roughly parallel the river flow direction. Deposits of alluvium underlying the floodplain consist of clay, silt, sand, and gravel in proportions that vary locally. A general feature of the alluvium is the gradation in grain size from gravel or coarse-grained sand near the base of the deposit to silt and clay near the surface. Its total thickness averages 42 feet and its saturated thickness is approximately 25 feet.

3.5.2 Site Geology

In February 1991 (revised July 1992), Earth Sciences submitted a Remedial Assessment (RA) Work Plan (Earth Sciences, 1992) for the Fansteel Muskogee facility in its entirety. Earth Sciences' personnel conducted a background literature search to obtain regional geologic and hydrogeologic information concerning rock units and unconsolidated deposits in the vicinity of the Fansteel Muskogee facility. Information obtained during this search was used to postulate geologic and hydrogeologic conditions underlying the Fansteel Muskogee facility and develop a site-specific work plan to evaluate such conditions. Hydrogeologic information is presented in Section 3.7.

The RA Work Plan proposed to define geologic conditions of the subsurface through an extensive drilling program that included collection of continuous split-spoon samples of the unconsolidated materials and obtaining core samples of the underlying bedrock.

A total of 96 soil borings were advanced at the subject property as specified in the RA Work Plan (Earth Sciences, 1993). Twenty-five of these soil borings were converted into shallow groundwater monitoring wells (MW-51S through MW-75S) and 4 into deep monitoring wells (MW-151D, MW-161D, MW-167D, and MW-174D). The locations of the soil borings and monitoring wells are shown in Figure 3-5.

In addition, three observation wells (OW-1, OW-2, and OW-3) were installed as part of the pumping tests performed at the Muskogee site. The shallow monitoring wells were installed to the top of bedrock, fully penetrating the unconsolidated materials. The deep monitoring wells were installed into the McCurtain Shale that represents the first bedrock unit encountered beneath the site. The remaining soil borings not converted into monitoring wells were also drilled into unconsolidated materials to determine the depth to groundwater in these locations and to provide additional information regarding the chemical character of the sediments beneath the site. However, because these three borings were not fully advanced to bedrock, the thickness of the water-bearing zone at these locations was unquantifiable.

Unconsolidated deposits underlying the Fansteel site range in thickness from approximately 8.75 feet (MW-75S) to approximately 34.5 feet (OW-1). These unconsolidated materials consist of natural soils and heterogeneous fill material. The fill is probably a heterogeneous mixture of man-made materials and reworked natural soils used during the grading of the site. Fill material was not identified in most of the soil borings; however, where encountered, thicknesses ranging from 0.5 foot (MW-58) to 24 feet (OW-2) were observed.

The natural soils observed at the Muskogee site are alluvial terrace deposits composed predominantly of silty and sandy clay, silt, fine sand, and coarse sand. It is typical of alluvial deposition for the more coarse-grained deposits to be found near the base of the materials.

The alluvial soil deposits observed beneath the subject property can be divided into two units. At the base of the unconsolidated deposits and overlying bedrock is a medium- to-coarse-grained sand unit ranging in thickness from approximately 1.5 feet (MW-56S) to 17.5 feet (MW-54S). This sand unit is generally saturated throughout its entirety with few exceptions.

Additionally, at the base of the lower coarse-grained unit, a sand and gravel layer was observed in seven of the soil borings. This very coarse-grained layer, where observed, ranged in thickness from 0.5 foot (B-20) to 5.0 feet (B-64). Except for the occurrence in OW-2, the sand and gravel layer appears to be confined to the northeastern portion of the subject property.

Overlying the sand unit and comprising the major portion of the unconsolidated materials is a series of finer-grained deposits. These fine-grained materials range from 3 feet (MW-69S) to 27 feet (OW-1) in thickness and consist of predominantly silty and sandy clay at the top grading to clayey sand toward the bottom. As is evidenced at Well MW-51S, occasional coarse-grained lenses of materials may be found within the predominantly finer-grained matrix.

The bedrock encountered beneath the facility is the McCurtain Shale. Site Monitoring Wells MW-151D, MW-161D, MW-167D, and MW-174D were designed to monitor hydrogeologic conditions in the McCurtain Shale. As part of the monitoring well installation process, rock cores of the McCurtain Shale were retrieved and logged in detail. Monitoring Well MW-174D had the deepest penetration of the McCurtain Shale, 56.3 feet. Based on the boring logs for Monitoring Wells MW-151D, MW-161D, MW-167D, and MW-174D, the McCurtain Shale encountered at this location is predominantly medium to dark gray, siliceous, and moderately hard. Few relatively intense zones of horizontal fracturing were observed which included the presence of a few fractures on a 45-degree plane from horizontal. Rock Quality Designation (RQD) values ranged from 0 to 100 percent. In general, the lower RQD values were recorded near the top of bedrock surface and typically increased with increasing depth corresponding to lessening degrees of weathering. Some of the fractures in the basal 30 feet of shale are clay filled, indicating groundwater flow through fractures in this portion of the shale. Due to the injection of water during coring activities, zones of saturation within the shale were detected using secondary identification indicators such as staining, contact features, and fracture/filling characteristics.

Although encountered at different portions of the Fansteel Muskogee site during other remediation assessment activities, the strike and dip of the McCurtain Shale beneath the facility were not able to be calculated from drilling information because the unit was not fully penetrated and the uppermost surface represents an erosional surface. However, a strike and dip measurement from an outcrop of the

McCurtain Shale on the west bank of the Arkansas River east of the Fansteel property boundary indicated the strike to be N20°W with a dip of 14 degrees to the southwest.

Based on drill hole data, the top of bedrock consists of the McCurtain Shale with no detectable lithologic boundaries. The top of bedrock surface slopes from west to east over the majority of the Fansteel Muskogee site. However, along the southern boundary of the Fansteel Muskogee site, the bedrock surface begins to rise slightly. Consequently, the overall morphology of the bedrock surface beneath the Fansteel Muskogee site resembles an elongate swale with a north-south axis. A depression occurs on the bedrock surface in the northeast quadrant of the site roughly centered on Monitoring Well MW-72S. This depression in the bedrock surface most likely is a result of construction activity associated with the installation of the french drain circumventing Pond No. 3, rather than natural erosional or depositional processes.

3.5.3 Regional Geologic Structures and Tectonics

The Fansteel Muskogee plant is regionally located on the west-plunging faulted nose of the Ozark Uplift (Earth Sciences, 1994). The Ozark Uplift is a major tectonic feature extending from eastcentral Missouri to northwest Arkansas and northeast Oklahoma. The bedrock is Pennsylvanian Age, consisting of mostly sandstone and shales. Most of the region is comprised of cuestas overlooking broad shale planes. Movements of the Ozark and Ouachita provinces have influenced the development of the structure of the area creating folding and very pronounced faulting.

Quaternary river deposits of fluvial silts, sands, and gravels rest on the Upper Paleozoic shales. In general, the surface is covered by 3 to 4 feet of reddish-brown silty sand and represents typical Arkansas River bottom land. The texture of the soils is defined as fine sand, very fine sandy loam, silty loam, and clay loam. The upper strata of silty clays, silty and sand clays, and fine to medium sands are deposits of the Arkansas River.

The plant site is located on the west bank of the Arkansas River which has a low relief but reaches a topographic difference of 50 to 60 feet above the river channel. Geomorphically, this is the cut bank of the Arkansas River at this location. The east side of the river is 40 to 50 feet lower in elevation than the plant site and represents the slip-off slope of the river course at this location (Crest Engineering, 1975).

The subsurface geology of the study area is characterized by a downward vertical gradation of finer-grained alluvial materials into coarser-grained unconsolidated sediments which bottom in shale. The majority of the alluvial deposits is fine grained and appears as varying combinations of clay, silt, and fine sand. The coarser-grained unconsolidated sediments are mostly sand with some interstitial silt, fine sand, and gravel.

The bedrock material, as previously indicated by the lithographic information, is the McCurtain Shale. The trends that are discernable from the contour of the top of bedrock elevations are as follows:

- A relatively steep drop-off of the top of bedrock elevation at the northeast corner of the site. The elevation at the northeast corner reaches a minimum of 494.12 feet.
- An overall increase in the bedrock elevation from east to west.
- A ridge that trends east-west through the northcentral portion of the site. There is a decrease in bedrock elevation in both a north-northeast and south-southeast direction from this ridge.

Figure 3-6 presents the regional tectonic map showing the site location and its proximity to tectonic structures (Oklahoma Geological Survey, http://www.ou.edu/special/ogs-pttc/faults.gif).

Arkola Division Muskogee Glass Sand Plant is dredging a feldspathic sand from the Arkansas River at Muskogee. These sands are used for glassmaking, foundry sands, ceramics, and the manufacture of sodium silicate. Muskogee is also home to industrial sand and gravel production at the Muskogee Sand Plant. Both sites are operated by APAC Arkansas Inc. The only other mining operation near Muskogee is Global Stone St. Claire, Inc. marble mine and plant in Sequoyah County (U.S. Geological Survey [USGS], http://minerals.usgs.gov/minerals/pubs/mapdata/documnt1.pdf).

3.5.4 Seismology

The Fansteel Muskogee plant is located in a quiet seismic region of the United States considered to be of minor seismic risk (Earth Sciences, 1994). The regional structure of the area is the west-plunging faulted nose of the Ozark Uplift. Many minor folds are mapped on this major feature and an echelon block faulting, placing rocks of Pennsylvanian Age in contact with rocks of Mississippian Age and older, is common. The fault blocks are prominent to the east of the Arkansas River, but become less so westerly since the small displacements and the thicker Pennsylvanian sediment layers leave similar beds opposing each other on opposite sides of the faults (Crest Engineering, 1975). A probabilistic acceleration map of the contiguous United States indicates that the horizontal acceleration in the region of the Fansteel Muskogee plant, with a 90 percent probability of not being exceeded in 50 years, is less than 5 percent of gravity which could produce only a small earthquake, approximate intensity 5 on the Mercalli Scale (Earth Sciences, 1994). Table 3-2 includes a complete list of all Oklahoma earthquakes since 1882 that had a magnitude 3.5 or more (Oklahoma Geological Survey, http://156.110.192.25/level2/okeqcat/largest.1897.1999.html).

3.6 Surface Water Hydrology

The Muskogee plant site is in the Middle Arkansas Basin, Basin One, as defined by the Oklahoma Department of Pollution Control. Major tributaries in Basin One are the Verdigris and Neosho rivers (Earth Sciences, 1994). Waters of the Arkansas River at Muskogee are generally well regulated by upstream flood protection facilities on the main stem of the Arkansas River as well as its major tributaries. The Arkansas River above Muskogee is impounded by Keystone Reservoir, 15 miles upstream from Tulsa, Oklahoma. The Verdigris River Basin is generally well regulated by upstream flood protection structures at Elk City, Fall River, Hulah, and Oologah reservoirs. The Neosho River is controlled through its entire length in Oklahoma. Controlling reservoirs include Grand Lake O' the Cherokees, Lake Hudson, and Lake Fort Gibson. Lake Fort Gibson is the main regulating impoundment on the Neosho River and provides Muskogee, Oklahoma, only 12 miles downstream, with a good water supply. In the study area, the Arkansas River is impounded as Webbers Falls Reservoir above Webbers Falls Lock and Dam. The Webbers Falls Dam impoundment extends all the way to the mouth of the Verdigris River (U.S. Army Corps of Engineers [USCOE], 1976).

Streamflow data for the Arkansas River at Muskogee were compiled by USGS from 1898 through 1970 (USGS, http://ok.waterdata.usgs.gov/nwis/sw). Peak streamflow and gauge height are given in Table 3-3, annual mean streamflow is given in Table 3-4, and monthly mean streamflow is given in Table 3-5. During the period of record, peak streamflow ranged from 63,000 cubic feet per second (cfs) on June 16, 1931 and May 3, 1954 to 384,000 cfs in May 1898 and 366,000 cfs on May 26, 1957. Mean annual streamflow for the period of record ranged from 1,902 cfs in 1956 to 42,120 cfs in 1961. Monthly streamflow records averaged over the period of record show that streamflow is lowest in December (9,327 cfs) and highest in May (38,647 cfs), with an average flow rate of approximately 20,000 cfs. Surface water users in the area include: Public Water Supply OK2005104-00003 in Braggs, in southeastern Muskogee County; Surface Water Intakes at Camp Gruber and Greenleaf State Park on Greenleaf Lake, and Public Water Supplies OK4120408_TP001 and OK1021772_TP001, also in southeastern Muskogee County; Surface Water Intake at Birdena's Brushy Mt. Spring, downstream on the Arkansas River; and Surface Water Intake at Ft. Gibson Grand River and Public Water Supply OK1021622_TP001, northeast of the site (Oklahoma Department of Environmental Quality [ODEQ], http://virtuales.com/okgis/cfm/index.cfm).

Figure 3-3 is a topographic map of the site that shows natural drainages and man-made features. Figure 3-4 is an aerial photograph of the site and adjacent drainage areas. The maximum probable flood level has been determined to be at 525 feet msl (Muskogee Engineering Company, 1978); the Fansteel plant facilities are located above this elevation. In addition, the waters of the Arkansas River are well regulated by upstream flood protection facilities. The 100-year floodplain zone is shown in Figure 3-3 at approximately 517 feet msl; the Fansteel plant facilities are located above this elevation.

3.7 Groundwater Hydrology

3.7.1 Regional Hydrogeology

Shale bedrock permeability is generally low and, therefore, does not readily transmit groundwater in the Muskogee area. However, a small amount of water is produced from bedrock aquifers throughout the area for domestic and stock use, presumably from fractures or joints with the bedrock. Depths to water measured in wells completed into the bedrock average approximately 30 feet below ground surface (bgs) (Earth Sciences, 1993).

Alluvial deposits are the most important aquifer in the Muskogee area and along the Arkansas River in general. Precipitation is the primary recharge, averaging approximately 36 to 40 inches per year (Todd, 1983). Natural discharge is mainly by seepage into streams and evapotranspiration. Quantities of groundwater adequate for domestic or stock use are available almost everywhere on the alluvial floodplain. Wells completed into the alluvium have been recorded to yield between 300 and 5,000 gallons per minute (gpm).

Groundwater in the alluvium is predominantly a hard, calcium, magnesium bicarbonate type (Earth Sciences, 1993). Precipitation, geology, water movement, and hydraulics of the alluvium affect the observed groundwater quality. The water is suitable for irrigation and for domestic, stock, and limited industrial purposes. The most important source of groundwater in the region is the shallow alluvial aquifer found along the Arkansas River (USCOE, 1976). The alluvial deposits consist of sand and gravel which are typically highly permeable and often relatively thick. Generally, the thicker and more laterally continuous the alluvium, the more water is available to wells which are completed in these zones. Thickness of the alluvium along the Arkansas River bed ranges from 30 feet at Tulsa, Oklahoma to 55 feet at Webbers Falls, Oklahoma. Wells yield from 20 to 400 gpm or more, and a properly built well should yield 100 gpm anywhere along this stretch of river.

Terrace deposits along the Arkansas River constitute another favorable source of groundwater (Earth Sciences, 1994). These aquifers consist of clayey silt near the surface and coarse gravel and/or sand in the lower 5 to 10 feet. Deposits range from 60 feet at Tulsa, Oklahoma to 90 feet at Braggs, Oklahoma, southeast of Muskogee, Oklahoma. Typical regional well yields in this zone can range from 20 to 125 gpm in these deposits. These terrace deposits constitute the shallow flow medium beneath groundwater at the Fansteel Muskogee site.

3.7.2 Site Hydrogeology

In February 1991 (revised July 1992), Earth Sciences submitted an RA Work Plan (Earth Sciences, 1992) for the Fansteel Muskogee facility in its entirety. Earth Sciences' personnel conducted a background literature search to obtain regional geologic and hydrogeologic information concerning rock units and unconsolidated deposits in the vicinity of the Fansteel Muskogee facility. Information obtained during this search was used to postulate geologic and hydrogeologic conditions underlying the Fansteel Muskogee facility and develop a site-specific work plan to evaluate such conditions. Geologic information is presented in Section 3.5.

The hydrogeologic conditions of the Fansteel property were to be defined by observing water inflow zones during drilling, slug tests, and static water level measurements (Earth Sciences, 1993). The following sections present a detailed summary of the site geologic and hydrogeologic conditions at the Fansteel Muskogee facility based on these activities. Groundwater flow through the unconsolidated materials at the Fansteel Muskogee site can be characterized as follows:

- The general direction of groundwater flow across the majority of the site is toward the east and the Arkansas River. There is an east-west divide in the direction of groundwater flow in the northwest corner of the facility which results in radial flow to the northeast, southeast, and southwest. Shallow groundwater flow across the southernmost portion of the site is toward the south parallel to the flow direction of the river.
- The Arkansas River is an effluent stream in regard to the alluvial aquifer at the Fansteel site.
- The principal component of groundwater flow is in a horizontal direction parallel to the bedrock surface. The flow of groundwater is concentrated in the basal sand and gravel deposits of the alluvial aquifer.

- The hydraulic gradient across the facility is very low. Gradients calculated across the site varied according to the flow direction.

Twenty-nine groundwater monitoring wells were installed to communicate with two distinct zones of saturation. Monitoring Wells MW-51S through MW-75S were installed to communicate with the unconsolidated zone of saturation and Monitoring Wells MW-151D, MW-161D, MW-167D, and MW-174D were installed to communicate with a water-bearing zone within the shale bedrock.

Groundwater within the unconsolidated deposits is located at the base of the sediments within the coarse-grained materials. The unconfined saturated sand unit overlying bedrock is laterally persistent across the Muskogee site. The saturated thickness of this unit ranges from approximately 1.5 feet at Monitoring Well MW-56S to 17.5 feet at MW-54S. Perched zones of saturation were not encountered. In the instance where a coarse-grained lens of material was encountered overlying a finer-grained material, the lens was dry.

A groundwater contour map (Figure 3-7) was constructed based on groundwater elevation data for wells communicating with this unit across the entire Muskogee site. As indicated in Figure 3-7, a groundwater divide in the unconsolidated zone of saturation in the Northwest Property Area results in radial flow northeast, southeast, and southwest to other portions of the facility at hydraulic gradients of 0.0076, 0.003, and 0.0064 respectively.

3.7.2.1 <u>Single-Well Aquifer Characterization</u>

Slug tests were conducted in each well to determine the hydraulic conductivity and transmissivity of the unconsolidated zone of saturation (Earth Sciences, 1993). The hydraulic conductivity of the northeast water-bearing zone ranged from 1.32×10^{-2} centimeter per second (cm/s) at Well MW-65S to 5.95×10^{-3} cm/s at Well MW-63S. The mean hydraulic conductivity for the northeast water-bearing zone was calculated as 5.43×10^{-3} cm/s. The hydraulic conductivity of the southwest water-bearing zone ranged from 5.15×10^{-3} cm/s at Well MW-56S to 3.12×10^{-3} cm/s at Well MW-54S. The mean hydraulic conductivity for the southwest water-bearing zone was calculated as 4.18×10^{-3} cm/s. The hydraulic conductivity of the southeast water-bearing zone ranged from 3.86×10^{-3} cm/s at Well MW-59S to 7.21×10^{-3} cm/s at Well MW-58S. The mean hydraulic conductivity for the southeast water-bearing zone was calculated as 5.56×10^{-3} cm/s.

Average linear groundwater velocity calculations were calculated for the shallow aquifer using effective porosity values of 15 and 20 percent for variations of sand, gravel, and some silty clay. The average linear velocity for the northeast and the southeast flow direction was consistent across the area ranging from 1.77×10^{-4} cm/s to 2.74×10^{-4} cm/s. However, average linear velocity for the southwest direction was slightly lower, ranging from 6.27×10^{-5} cm/s to 8.36×10^{-5} cm/s.

The volume of groundwater flow through the unconsolidated zone of saturation in the Muskogee site was calculated for the three flow directions--the southeast, southwest, and northeast. Groundwater flow associated with these areas was estimated to be 0.53, 0.4, and 0.52 gpm respectively.

Groundwater within the McCurtain Shale was encountered at Wells MW-151D, MW-161D, MW-167D, and MW-174D in the Muskogee site. These deep monitoring wells were installed to communicate with a zone of fractured shale that was determined to produce a measurable quantity of water. The rock core above and below this fractured sequence was determined to be dry based on core inspection. Groundwater in this zone of saturation was encountered under confined conditions and is separated from the overlying unconsolidated zone of saturation by approximately 30 feet of shale bedrock. The significant difference in static groundwater elevation observed between nested Monitoring Wells MW-51S, MW-67S, and MW-74S (designed to communicate with the overlying unconsolidated material) and Monitoring Wells MW-151D, MW-161D, and MW-174D (designed to communicate with the shale bedrock) indicates that these pairs of monitoring wells communicate with two distinct zones of saturation.

A potentiometric surface map (Figure 3-8) was constructed based on groundwater elevations obtained from all site monitoring wells communicating with the McCurtain Shale. As shown in Figure 3-8, groundwater in the shale bedrock unit beneath the Muskogee site has bidirectional flow directions; one component of flow is to the west-northwest and the second to the east. The flow to the northwest has a hydraulic gradient of 0.017. The hydraulic gradient of the easterly flow is 0.00565.

3.7.2.2 Single-Well Aquifer Characterization Tests

Slug tests were performed at Monitoring Wells MW-151D, MW-161D, MW-167D, and MW-174D to determine the hydraulic conductivity and transmissivity of the shale bedrock zone of saturation at this location (Earth Sciences, 1993). The hydraulic conductivities of bedrock Monitoring Wells MW-151D, MW-161D, MW-167D, and MW-174D were 3.82×10^{-6}, 1.54×10^{-5}, 1.08×10^{-3}, and 9.72×10^{-6} cm/s respectively. However, it should be noted that the saturated zone in MW-167 was 17 feet compared to 5.5, 6.0, and 7.25 feet in the other three bedrock monitoring wells. This may account for the anomolously high hydraulic conductivity at this location. Based on these hydraulic conductivities, mean conductivities were calculated for the two bedrock flow directions. The mean conductivity for the westerly flow is 8.30×10^{-6} cm/s. The mean conductivity for the easterly flow (includes MW-167D) is 5.45×10^{-5} cm/s.

An average linear groundwater velocity was calculated using effective porosities of 5 and 10 percent. Five percent was assumed to account for little fracturing within the saturated zone and 10 percent was assumed to account for moderate fracturing within the saturated zone. Based on an effective porosity of 5 percent, the average linear groundwater velocity was calculated to be 9.38×10^{-7} and 1.85×10^{-5} cm/s for the westerly and easterly flow directions respectively. Based on an effective porosity of 10 percent, the average linear groundwater velocity was calculated to be 4.69×10^{-7} and 9.27×10^{-6} cm/s for the westerly and easterly flow directions respectively.

The volume of groundwater flow through the McCurtain Shale zone of saturation in the eastern portion of the Muskogee site was determined to be 5.18×10^{-5} gpm. The volume of groundwater flow through the shale in the western portion of the Muskogee site is 8.30×10^{-6} gpm.

3.7.2.3 Multiwell Aquifer Characterization Test

A 65-hour pumping test was conducted in the southwestern quadrant of the Muskogee site to further characterize the unconsolidated aquifer (Earth Sciences, 1993). Because no impacts were observed to the McCurtain Shale, a pumping test was not required for this aquifer. Monitoring Well MW-53S was utilized as the pumping well for the unconsolidated aquifer while Monitoring Wells MW-52S, MW-54S, MW-61S, and MW-68S, and Observation Wells OW-1, OW-2, and OW-3 were used as observation points.

A step test performed on the pumping well indicated that the well could not sustain pumping rates more than 1.0 gpm. A rate of 0.5 gpm produced a slight decrease in hydraulic head over time. Consequently, a rate of 0.1 gpm was determined to be the highest rate at which the pumping well could be pumped in order to retain its yield for the duration of the pump test. Based on water level measurements made at the designated observation points, it does not appear that the pumping test produced a measurable response in the unconsolidated aquifer. Although Observation Wells OW-1 and OW-2 were located only 40 and 35 feet respectively from the pumping well, no effects of the pumping were observed. Consequently, the zone of influence produced by the pumping appears to be confined to a radius of less than 35 feet.

3.8 Natural Resources

3.8.1 Mineral and Hydrocarbon Resources

In 2000, the estimated value of nonfuel mineral production for Oklahoma was $453 million (USGS, http://minerals.usgs.gov/minerals/pubs/state/984001.pdf). This was a 2.7 percent increase from that of 1999, following a 4.1 percent decrease from 1998 to 1999. For the third consecutive year, Oklahoma was the 31st in rank among the 50 states in total nonfuel mineral production value, accounting for more than 1 percent of the United States total. In 2000, crushed stone continued to be Oklahoma's leading nonfuel mineral commodity, followed by cement (masonry and portland), construction sand and gravel, industrial sand and gravel, gypsum, iodine, and lime. In 1999, the most substantial changes in nonfuel mineral value were those of Grade A helium and crude helium which were down a combined $25 million.

Oklahoma's mines exclusively produced industrial minerals; no metals were mined in the state. Based upon USGS production estimates during 2000, Oklahoma remained the only state that produced iodine, first in gypsum, second of four states that produced tripoli, third of three states in crude helium, and fifth in feldspar. Additionally, significant quantities of crushed stone, masonry and portland cements, common clays, and gemstones were produced (in descending order of value) in Oklahoma. Minerals produced in Muskogee County include clay, feldspar, sand, and gravel. Surrounding counties (Wagoner, Cherokee, Sequoyah, and Haskell) also produced sand, gravel, crushed stone, and lime.

The USGS Central Energy Team provides periodic assessments of the oil and natural gas endowment of the United States. The first assessment was completed in 1995. According to the 1995 National Oil and Gas Assessment (USGS, http://certmapper.cr.usgs.gov/data/noga95/prov60/txt/prov60.pdf), Muskogee County, belonging to the Cherokee Platform, Province 60, is associated with five geological plays with varying probabilities for production of oil and/or natural gas. Table 3-6 shows the estimated number of undiscovered oil and gas accumulations in each play and their estimated volumes. The undiscovered accumulations in these plays, which extend to the northwest of Muskogee County, total 67.2 million barrels of oil and 163.2 billion cubic feet of natural gas.

3.8.2 Water

Oklahoma has experienced several periods of drought since statehood, some lasting several years (USGS, http://water.usgs.gov/pubs/FS/FS-037-99). Major droughts in Oklahoma occurred in 1929-1941, 1951-1957, 1961-1972, and 1975-1982. A significant but more localized drought occurred during 1984-1986. The most recent short-term droughts have occurred during 1995-1996 and 1998.

A severe drought began about April 1998 in southern and western areas of Oklahoma. From April 1, 1998 to January 10, 1999, southwestern Oklahoma received only 55 percent of the normal rainfall. Rains during September 1998 helped many areas, but several lakes in the south remained low into the winter. In January 1999, southwestern Oklahoma continued in a moderate drought; 15 reservoirs still were operating at less than full capacity. Conditions improved in March and early April, with above-normal rainfall for most of the state; however, storage in 5 reservoirs in the state still was below full capacity; storage in 2 reservoirs in the southwest was only about 70 percent of capacity in early April.

Oklahoma uses about 98 million gallons of surface water per day for irrigation and about 101 million gallons per day of surface water to water livestock, based on estimates in 1995. Most of the aquifers in Oklahoma are recharged during the winter when vegetation uses less water and steady rainfall soaks the ground. A description of water sources in the site vicinity is included in Section 3.6, Surface Water Hydrology.

3.8.3 Ecology

This section discusses terrestrial and aquatic biota including endangered and threatened species found in the area of the Fansteel Muskogee plant site. Data presented in this section are based on literature received from and telecommunication with the Oklahoma Department of Wildlife Conservation.

3.8.3.1 Terrestrial

3.8.3.1.1 Flora

There are four potential vegetation types within the general site region (Earth Sciences, 1994). These are bottom land forest, post oak-blackjack oak forest, oak-hickory forest, and tallgrass prairie. The former two types are likely to typify the original vegetation of the immediate site vicinity. Of the latter two types, oak-hickory forest is found to the east of the site, while tallgrass prairie is found to the west.

Bottom land forest in the site region is characterized by cottonwood, black willow, American elm, green ash, sycamore, slippery (red) elm, river birch, water oak, overcup oak, post oak, blackjack oak, black walnut, bitternut hickory, shagbark hickory, hackberry, hawthorn, redbud, boxelder, red maple, and silver maple. Major understory plants are Virginia creeper, poison ivy, greenbriar, river cane, buckrush, poke-weed, switchgrass, Johnsongrass, purpletop, and big bluestem.

The post oak-blackjack oak forest represents the forested grassland of Oklahoma. The overstory is composed of post oak, blackjack oak, black hickory, and eastern red cedar. The understory is generally composed of little bluestem, big bluestem, broomsedge, flameleaf sumac, smooth sumac, blackberry, black raspberry, and dewberry. A complete list of flora found in the Muskogee area is contained in Appendix C.

3.8.3.1.2 Fauna

Expected wildlife which could occur in the site vicinity are reported by the Oklahoma Department of Wildlife (August 2002). Mammals include the swamp rabbit; opossum; skunk; coyote; fox; bobcat; white-tail deer; and several species of mice, rats, and bats. Due to the proximity of the Arkansas River, a diverse avifauna would also be expected. Species likely to be seen near the Fansteel site include mourning doves, ducks, geese, vultures, hawks, crows, sparrows, bluejays, woodpeckers, mocking birds, and cardinals. Birds of prey reported in the area include several species of hawks and owls, bald eagles, osprey, and peregrine falcons. Reptiles reported on the general site area include several species of turtles and terrapins, numerous snakes, and lizards. Species of amphibians in the area include toads, frogs, and common bullfrog. A complete list of wildlife for the Muskogee area is contained in Appendix D.

3.8.3.2 Aquatic

The Fansteel Muskogee plant is next to the Webbers Falls Reservoir. Webbers Falls Reservoir is a 4,411-hectare (10,900 acres) mainstem reservoir designated as Lock and Dam 16 of the McClellan-Kerr Arkansas River Navigation System (Oklahoma Department of Wildlife Conservation, 1986). The reservoir was built by the USCOE and was opened to navigation traffic in 1970.

According to the Oklahoma Department of Wildlife (August 2002), common species of fish found in Webbers Falls Reservoir are spotted bass, blue catfish, flathead catfish, bullhead, striped bass, sauger, buffalo fishes, fresh-water drum, and paddlefish. A complete list of fish located in the Muskogee area is contained in Appendix E.

3.8.3.3 Threatened and Endangered Species

Oklahoma has 20 animal species and 3 plant species that are listed as endangered or threatened under either federal or state guidelines (Table 3-7) (ODEQ, http://www.wildlifedepartment.com/endanger.htm). However, several species are on the increase such as the gray bat, peregrine falcon, whooping crane, and the bald eagle. The bald eagle has undergone such a population increase nationwide that it was down-classed from Endangered status to a Threatened status. In July 1999, procedures were begun to remove the bald eagle from the Endangered Species List. The peregrine falcon, a former endangered species, was removed from the list in August 1999 because its population had increased to 1,425 breeding pairs.

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Tables

Table 3-1
Climatological Information for Muskogee County, Oklahoma

Climate Division	6 (East Central)
Mean Annual Precipitation	44.5 Inches
Mean Annual Temperature	60.0°F
Population (2000 Census)	69,451
Total Area	839 square miles
Land/Water Area	97.0% land / 3.0% water
Tornadoes: 1950-2000	38

Monthly Means from 1971-2000	January	February	March	April	May	June	July	August	September
Precipitation (inches)	2.0	2.3	3.8	3.9	5.8	4.8	2.8	2.7	5.0
Temperature (F)	36.2	41.7	50.5	59.7	68.5	76.6	82	80.9	73.1

Monthly Means from 1971-2000	October	November	December
Precipitation (inches)	4.2	4.2	3.0
Temperature (F)	62.1	49.4	39.8

Reference http://climate.ocs.ou.edu/county/muskogee.html 10/14/02

Table 3-2
Oklahoma Earthquakes Magnitude 3.5 or Greater

Date	Time (GMT)	County	Maximum Intensity (Modified Mercalli)	Magnitudes (3 Hz)	Magnitudes (bLg)	Magnitudes (DUR)	Latitude (deg N)	Longitude (deg W)	Depth (km)	Agency	Earth Model
10/22/1882	afternoon	NE I.T.	8	-	?	-	Near Ft. Gibson?		-	-	-
11/08/1915	-	Rogers	F	-	3.9	-	36.2000	95.8000	-	T	-
06/20/1926	14:20:00.00	Sequoyah	5	-	4.3	-	35 6000	94.9000	-	D	-
12/28/1929	00:30:00.00	Canadian	6	-	4.0	-	35.5000	98.0000	-	U	-
03/14/1936	17:20:00.00	McCurtain	5	-	3.6	-	34.0000	95.0000	-	U	-
06/08/1937	14:26:00.00	Pottawatomie	4	-	3.6	-	35.3000	96.9000	-	D	-
06/01/1939	07:30.00.00	Hughes	4	-	4.4	-	35.0000	96.4000	-	U	-
06/12/1942	05:50:00.00	Garfield	3	-	3.7	-	36.4000	97.9000	-	U	-
04/09/1952	16:29:15.00	Canadian	8	-	5.0	-	35.4000	97.8000	-	U	-
04/11/1952	20:30:00.00	Canadian	4	-	3.8	-	35.4000	97.8000	-	U	-
04/16/1952	05:58:00.00	Canadian	F	-	3.8	-	35.4000	97.8000	-	U	-
04/16/1952	06:05:00.00	Canadian	5	-	3.8	-	35.4000	97.8000	-	U	-
03/17/1953	14:25:00.00	Canadian	6	-	3.8	-	35.4000	98.0000	-	U	-
04/02/1956	16:03:18.00	Pushmataha	5	-	3.8	-	34.2000	95.6000	-	U	-
10/30/1956	10:36:21.00	Rogers	7	-	4.1	-	36.2000	95.8000	-	U	-
06/15/1959	12:45:00.00	Pontotoc	5	-	4.0	-	34.8000	96.7000	-	U	-
06/17/1959	10:27:07.00	Comanche	6	-	4.2	-	34.5000	98.5000	-	U	-
01/11/1961	01:40:00.00	Latimer	5	-	3.8	-	34.8000	95.5000	-	U	-
04/27/1961	07:30:00.00	Latimer	5	-	4.1	-	34.9000	95.3000	-	U	-
010/14/1968	14:42:54.00	Bryan	6	3.5	-	-	34.0000	96 4000	-	OGS	-
05/02/1969	11:33:22.50	Okfuskee	F	-	3.5	-	35.5000	96.2000	-	OGS	-
11/29/1975	14:29:41.20	Garvin	5	-	3.6	-	34.6500	97.5300	5.00R	OGS	-
04/19/1976	04:42:43.90	Roger Mills	5	-	3.5	-	35.8700	99.9700	5.00R	OGS	-
07/11/1981	21:09:21.84	Grady	5	2.9	3.5	3.0	34.8530	97.7320	5.00R	OGS	N
12/08/1987	01:42:40.28	Kingfisher	6	-	3.7	3.6	36.0550	98.0240	5.00R	OGS	N
10/11/1990	11:07:22.14	Garvin	-	3.6	3.0	1.9	34.7770	97.5030	5.00R	OGS	N
11/15/1990	11:44:41.63	Garvin	6	4.0	3.9	3.0	34.7610	97.5500	10.00R	OGS	N

Table 3-2
Oklahoma Earthquakes Magnitude 3.5 or Greater

Date	Time (GMT)	County	Maximum Intensity (Modified Mercalli)	Magnitudes (3 Hz)	Magnitudes (bLg)	Magnitudes (DUR)	Latitude (deg N)	Longitude (deg W)	Depth (km)	Agency	Earth Model
12/17/1992	07:18:05.65	Garvin	5	3.8	3.5	3.1	34.7300	97.5410	5.00R	OGS	N
01/18/1995	15:51:39.90	Garvin	6	4.1	4.2	-	34.7120	97.5420	5.00R	OGS	N
09/15/1995	00:31:33.05	Woods	6	3.7	3.8	3.0	36.8700	98.7260	5.00R	OGS	N
09/06/1997	23:31:08.58	Coal	F	-	4.4	-	34.6340	96.4200	5.00R	OGS	N
04/28/1998	14:13:02.30	Comanche	6	-	4.2	-	34.7830	98.4120	5.00R	OGS	N
10/30/1998	17:41:23.90	Grant	4	-	3.5	-	36.7710	97.6230	7.80	OGS	C
02/08/2002	16:07:13.60	Comanche	5	-	3.8	-	34.7270	98.3610	5.00R	OGS	C
06/20/2002	12:14:18.00	Cimarron	-	-	3.6	-	36.5420	102.9180	5.00R	-	-
10/19/2002	02:18:00.00	Atoka	-	-	3.4	-	34.3300	95.8000	-	-	-

Notes:
In "Depth" column, "R" stands for restrained depth.
In "Agency" column, "OGS" stands for Oklahoma Geological Survey.
In "Earth Model" column, "N" stands for Nuttli and "C" stands for Chelsea.
Earthquakes from 1882 to 1942 are known mainly from felt effects.
Earthquakes beginning 1952 are known from felt effects plus seismograms.
Earthquakes beginning 1977 are located by the Oklahoma Geological Survey's Oklahoma Seismograph Network.

Reference http://156.110.192.25/ 10/25/02 and http://156.110.192.25/level2/okeqcat/largest.1897.1999.html 10/16/02

Table 3-3
Annual Peak Streamflow
Arkansas River Near Muskogee, Oklahoma

Year	Date	Gauge Height (ft)	Streamflow (cfs)
1898	May	39.50	384,000**
1923	June	34.70	295,000**
1926	September 7	23.40	142,000
1927	April 15	36.50	325,000
1928	June 22	27.90	197,000
1929	May 15	31.50	249,000
1930	June 17	22.70	136,000
1931	June 16	16.00	63,000
1932	November 25	19.20	95,300
1933	May 16	25.10	165,000
1934	April 9	14.90	57,200
1935	June 9	30.80	243,000
1936	September 29	19.54	98,000
1937	June 13	23.25	141,000
1938	May 26	24.79	149,000
1939	May 14	18.20	77,800
1940	September 5	24.68	161,000
1941	April 21	32.72	248,000#
1942	October 31	37.23	304,000#
1943	May 21	48 20	700,000#
1944	April 27	27.64	189,000#
1945	April 18	36.65	326,000#
1946	October 1	30.67	231,000#
1947	April 16	27.31	196,000#
1948	June 24	30.25	224,000#
1949	May 20	28.27	208,000#
1950	August 3	25 10	157,000#
1951	July 15	30.83	242,000#
1952	November 17	17.71	83,000#
1953	April 25	15.99	66,600#
1954	May 3	15 83	63,000#
1955	May 29	18.16	87,200#
1956	October 6	20.28	110,000#
1957	May 26	39.03	366,000#
1958	July 14	22.66	138,000#
1959	July 18	22.04	125,000#
1960	October 7	34.00	286,000#
1961	May 9	32.70	295,000#
1962	November 5	23.82	158,000#
1963	October 3	15.38	60,300#
1964	June 16	18.87	96,400*
1965	April 8	20.25	109,000*
1966	October 1	11.80	28,900*
1967	July 1	17.59	76,400*
1968	May 30	17.12	73,000*
1969	June 27	18.72	94,900*
1970	April 30	19 29	92,400*

Notes:
Discharge affected to unknown degree by Regulation or Diversion
* Discharge affected by Regulation or Diversion.
** Discharge is a Historic Peak.

Reference http://waterdata.usgs.gov/ok/nwis/peak?site_no=07194500&agency_cd=USGS&format=html 10/21/02

Table 3-4
Calendar Year Streamflow Statistics
Arkansas River Near Muskogee, Oklahoma

Year	Annual Mean Streamflow (cfs)
1926	19,380
1927	41,710
1928	25,860
1929	32,390
1930	13,550
1931	10,660
1932	10,710
1933	11,880
1934	8,199
1935	28,630
1936	7,693
1937	13,719
1938	18,090
1939	5,411
1940	5,386
1941	35,350
1942	30,930
1943	29,550
1944	29,480
1945	38,100
1946	13,990
1947	20,840

Year	Annual Mean Streamflow (cfs)
1948	24,180
1949	31,050
1950	24,050
1951	39,800
1952	11,470
1953	4,909
1954	3,567
1955	8,972
1956	1,902
1957	35,310
1958	20,840
1959	25,600
1960	21,630
1961	42,120
1962	17,160
1963	5,840
1964	8,698
1965	17,100
1966	6,060
1967	12,140
1968	19,730
1969	27,730

Reference http://waterdata usgs.gov/ok/nwis/annual/?site_no=07194500&agency_cd=USGS 10/21/02

Table 3-5
Monthly Streamflow Statistics
Arkansas River Near Muskogee, Oklahoma

Year	Monthly Mean Streamflow (cfs)											
	January	February	March	April	May	June	July	August	September	October	November	December
1925	-	-	-	-	-	-	-	-	-	5,872	9,587	3,627
1926	5,619	4,829	5,709	19,180	6,714	19,960	5,037	6,977	42,430	84,480	13,440	17,310
1927	19,300	19,250	26,889	175,700	31,400	54,200	13,130	77,610	17,900	45,310	10,430	10,210
1928	9,449	16,560	20,070	39,180	22,080	89,750	25,350	25,910	5,608	3,806	30,540	23,410
1929	27,820	11,970	20,060	89,950	113,600	67,330	34,620	6,260	3,519	4,220	4,603	3,917
1930	5,976	23,300	5,107	3,980	55,410	33,050	4,337	2,317	10,940	3,854	4,928	10,310
1931	3,855	6,148	6,866	16,000	18,140	16,189	6,254	6,118	3,014	3,620	27,560	14,390
1932	30,180	12,800	6,172	5,207	4,403	22,000	20,080	8,462	1,807	1,893	1,258	13,960
1933	9,184	4,334	9,068	23,830	36,390	5,842	2,909	11,240	17,110	8,805	6,932	6,375
1934	9,095	2,844	2,881	16,850	10,630	3,410	873	566	14,050	10,330	19,650	7,379
1935	8,974	7,673	30,640	10,060	61,270	156,300	18,250	3,194	5,578	7,531	18,080	16,500
1936	4,223	2,881	2,894	1,792	8,756	12,040	2,310	532	12,440	29,950	11,200	3,190
1937	25,430	23,790	11,000	13,330	11,090	44,140	12,600	6,572	12,260	2,596	1,417	1,870
1938	2,985	19,430	17,390	27,060	56,920	62,510	9,416	11,560	4,979	1,416	2,960	1,405
1939	1,655	2,917	3,459	8,475	21,790	11,730	8,102	3,459	1,057	636	674	744
1940	618	1,184	1,378	6,596	8,541	6,892	5,033	4,119	14,120	1,152	9,566	5,665
1941	18,000	16,770	5,356	54,720	20,790	54,190	9,025	5,135	29,609	114,900	81,510	14,879
1942	8,527	17,790	13,900	87,850	37,410	67,770	20,730	15,470	35,200	22,530	21,630	23,950
1943	19,120	11,990	11,160	12,960	210,000	48,490	11,800	4,737	2,596	8,780	5,115	4,518
1944	5,375	9,660	39,540	99,010	65,259	30,300	11,890	9,435	10,570	32,660	9,044	30,780
1945	10,250	11,930	61,860	137,500	45,280	34,500	35,740	9,635	28,040	70,390	6,603	4,673
1946	29,199	23,940	18,250	12,820	25,250	14,710	8,198	3,363	4,046	4,736	11,860	12,120
1947	5,027	4,036	10,930	97,980	62,800	36,530	15,270	4,929	3,667	3,461	2,894	2,817
1948	3,210	4,039	23,310	12,120	13,310	50,690	103,500	49,340	8,166	4,988	8,458	7,193
1949	27,580	77,150	32,040	24,080	81,550	56,389	28,280	10,500	14,990	11,330	6,575	5,901
1950	10,450	10,310	10,370	7,661	35,930	30,280	50,790	70,710	35,870	13,310	6,002	5,042
1951	5,215	15,129	17,870	12,880	61,539	61,720	166,900	20,340	45,700	16,650	34,310	16,850
1952	12,580	17,150	35,320	29,130	16,890	12,200	3,914	3,432	2,854	1,232	1,328	1,905
1953	1,995	2,100	6,412	14,270	13,139	4,217	5,614	3,264	2,226	1,521	2,066	1,917
1954	1,547	1,171	1,468	2,276	19,220	7,184	2,496	454	397	2,490	1,874	1,913
1955	4,574	3,403	5,797	4,107	23,980	20,540	11,190	3,525	3,547	19,890	2,854	3,568
1956	1,870	1,681	1,699	1,868	4,471	4,282	2,998	1,864	301	286	637	829
1957	878	3,045	3,146	39,920	130,000	153,000	58,720	6,622	10,890	5,030	6,478	5,038
1958	4,817	6,483	46,530	38,550	22,060	17,360	63,320	19,660	14,790	5,667	5,361	3,867

Table 3-5
Monthly Streamflow Statistics
Arkansas River Near Muskogee, Oklahoma

Year	Monthly Mean Streamflow (cfs)											
	January	February	March	April	May	June	July	August	September	October	November	December
1959	3,493	7,571	11,640	9,825	23,760	10,350	47,770	13,450	14,670	123,700	21,670	16,089
1960	16,700	24,220	32,240	32,250	45,330	26,029	16,730	18,170	11,410	8,926	14,950	12,730
1961	5,210	8,421	17,320	32,229	139,300	37,030	38,810	25,200	66,260	39,500	62,670	31,180
1962	17,090	26,939	18,160	16,000	5,773	31,169	14,210	8,375	26,760	25,069	9,848	7,907
1963	8,512	4,443	12,170	5,078	3,374	6,697	10,520	4,975	8,669	2,693	1,736	1,045
1964	1,183	1,607	1,523	8,642	6,342	22,360	5,875	6,434	9,093	1,426	27,770	12,730
1965	9,581	4,609	9,708	48,600	13,810	47,060	20,010	5,091	29,220	10,650	3,142	4,407
1966	5,553	10,710	7,445	6,834	11,690	8,017	3,551	5,905	5,945	3,503	1,697	2,258
1967	1,674	1,254	1,748	6,778	4,666	19,990	40,780	13,469	11,100	16,910	17,520	8,907
1968	10,300	23,400	26,870	32,379	19,920	27,039	11,970	17,710	8,067	10,050	23,930	25,750
1969	24,000	27,789	29,270	43,620	49,250	57,990	34,580	9,981	15,680	22,420	10,090	8,670
1970	6,645	4,376	6,938	45,720	59,900	36,830	10,160	3,464	11,790	-	-	-
Mean Monthly Streamflow	9,878	12,067	15,324	31,885	38,647	36,450	22,970	12,212	14,199	18,226	12,943	9,327

Reference http://waterdata.usgs.gov/ok/nwis/monthly/?site_no=07194500&agency_cd=USGS 10/21/02

Table 3-6
Mean Estimates of Conventional Undiscovered Accumulations
1995 Nation Oil and Gas Assessment
U.S. Geological Survey

Cherokee Platform Plays	Mean Number of Undiscovered Oil Accumulations	Mean Size of Undiscovered Oil Accumulations (MM Bbl)	Mean Estimate of Undiscovered Oil Accumulations Volume (MM Bbl)	Mean Estimate of Undiscovered Associated Gas Volume (B cf)	Mean Estimate of Undiscovered Associated Gas Liquids Volume (MM Bbl)
6001 Pre-Woodford Paleozoic	4.7	3.1	14.7	13.3	0.9
6003 Mississippian	4.6	3.3	15.3	21.4	1.5
6004 Pennsylvanian Structural	1	2.1	2	3.8	0.3
6005 Pennsylvanian Stratigraphic	6.3	4.5	28.3	70.9	5.4
6007 Internal Arbuckle/Reagan	1.7	4	6.9	6.9	0.5

Note:

Only accumulations greater than or equal to 1 million barrels of oil or 6 billion cubic feet of gas are included in this part of the assessment.

Reference http://certmapper.cr.usgs.gov/data/noga95/prov60/tabular/conv60out.txt 10/22/02

Table 3-6
Mean Estimates of Conventional Undiscovered Accumulations
1995 Nation Oil and Gas Assessment
U.S. Geological Survey

Cherokee Platform Plays	Mean Number of Undiscovered Nonassociated Gas Accumulations	Mean Size of Undiscovered Nonassociated Gas Accumulations (B cf)	Mean Estimate of Undiscovered Nonassociated Gas Accumulations Volume (B cf)	Mean Estimate of Undiscovered Nonassociated Gas Liquids Volume (MM Bbl)
6001 Pre-Woodford Paleozoic	1.8	12.3	22.2	0.5
6003 Mississippian	0	0	0	0
6004 Pennsylvanian Structural	0	0	0	0
6005 Pennsylvanian Stratigraphic	2	12.3	24.7	0.8
6007 Internal Arbuckle/Reagan	0	0	0	0

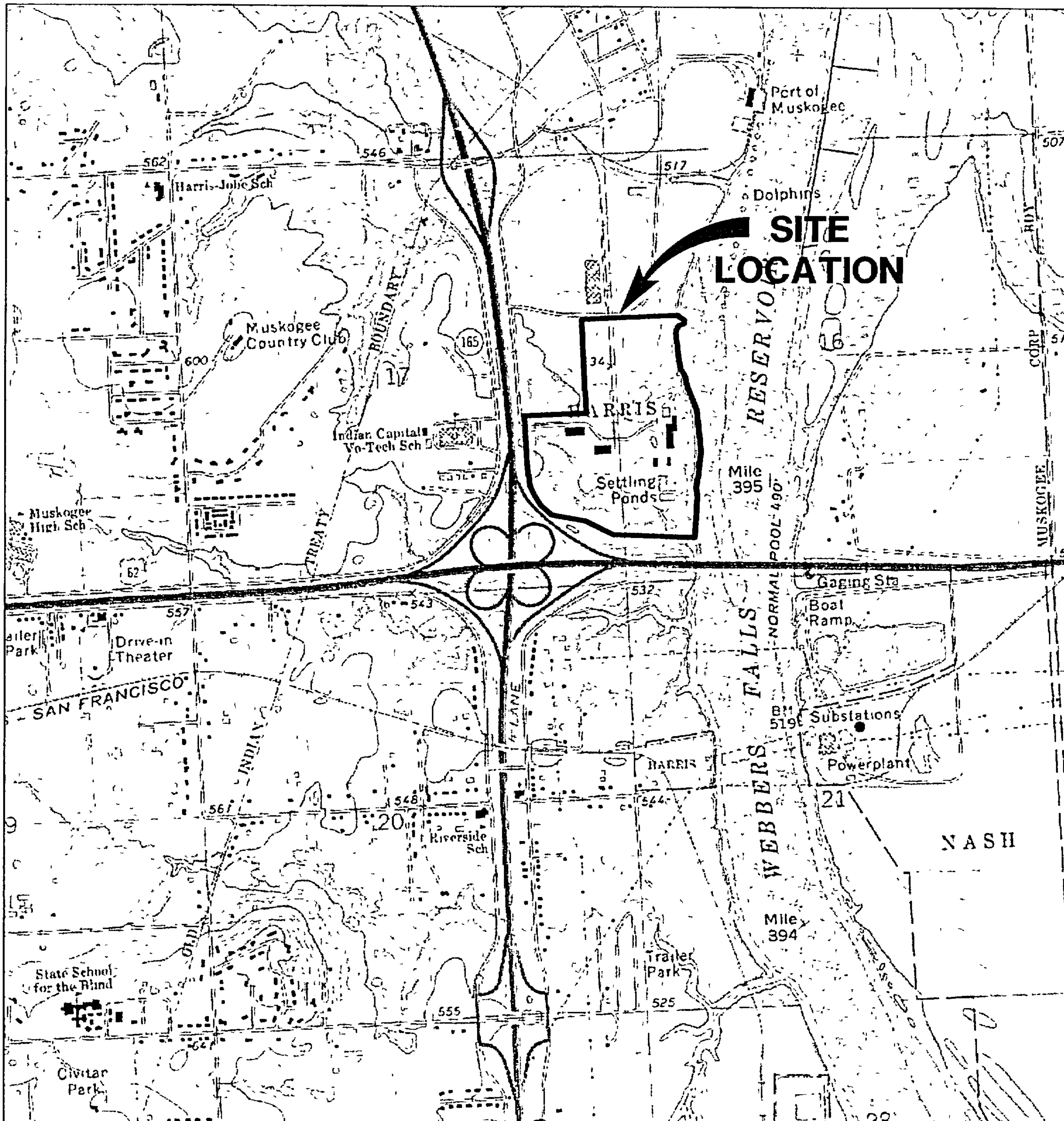
Table 3-7
Threatened and Endangered Species of Oklahoma

Common Name	Species Name	Federal Status	State Status
Gray Bat	Myotis grisescens	Endangered	Endangered
Indiana Bat	Myotis sodalis	Endangered	Endangered
Ozark Big-Eared Bat	Plecotus townsendii ingens	Endangered	Endangered
Whooping Crane	Grus americana	Endangered	Endangered
Black-Capped Vireo	Vireo atricapillus	Endangered	Endangered
Bald Eagle	Haliaeetus leucocephalus	Threatened	Threatened
Interior Last Tern	Sterna antillarum	Endangered	Endangered
Piping Plover	Chadradrius melodus	Threatened	Threatened
Red-Cockaded Woodpecker	Picoides borealis	Endangered	Endangered
American Alligator	Alligator mississippiensis	Threatened	Threatened
Longnose Darter	Percina nasuta	N/A	Endangered
Neosho Madtom	Noturus placidus	Threatened	Threatened
Ozark Cavefish	Amblyopsis rosae	Threatened	Threatened
Leopard Darter	Percina pantherina	Threatened	Threatened
Blackside Darter	Percina maculata	N/A	Threatened
Arkansas River Shiner	Notropis girardi	Threatened	Threatened
Cave Crayfish	Cambarus tartarus	N/A	Endangered
Ouschita Rock Pocketbook	Arkansia wheeleri	Endangered	Endangered
Neosho Mucket	Lampsilis rafinesqueana	N/A	Endangered
American Burying Beetle	Nicrophorus americanus	Endangered	Endangered
Western White-Fringed Prairie Orchid	Platanthera praeclara	Threatened	N/A
Winged Mapleleaf	Quadrula fragosa	Endangered	Endangered
Eastern White-Fringed Prairie Orchid	Platanthera leucophaea	Threatened	N/A

Notes:
Endangered - Native species whose prospects of survival or recruitment within the state is in imminent jeopardy.
Threatened - Native species that, although not presently in danger of extinction, is likely to become endangered in the foreseeable future in the absence of special protection and management efforts.

Reference http://www.wildlifedepartment com/endanger.htm 10/24/02

Figures



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REFERENCE
USGS 7.5-MIN TOPOGRAPHIC QUADRANGLE
NORTHEAST MUSKOGEE, OK
DATED 1974
SCALE 1:24000.

FIGURE 3-1
SITE LOCATION MAP
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

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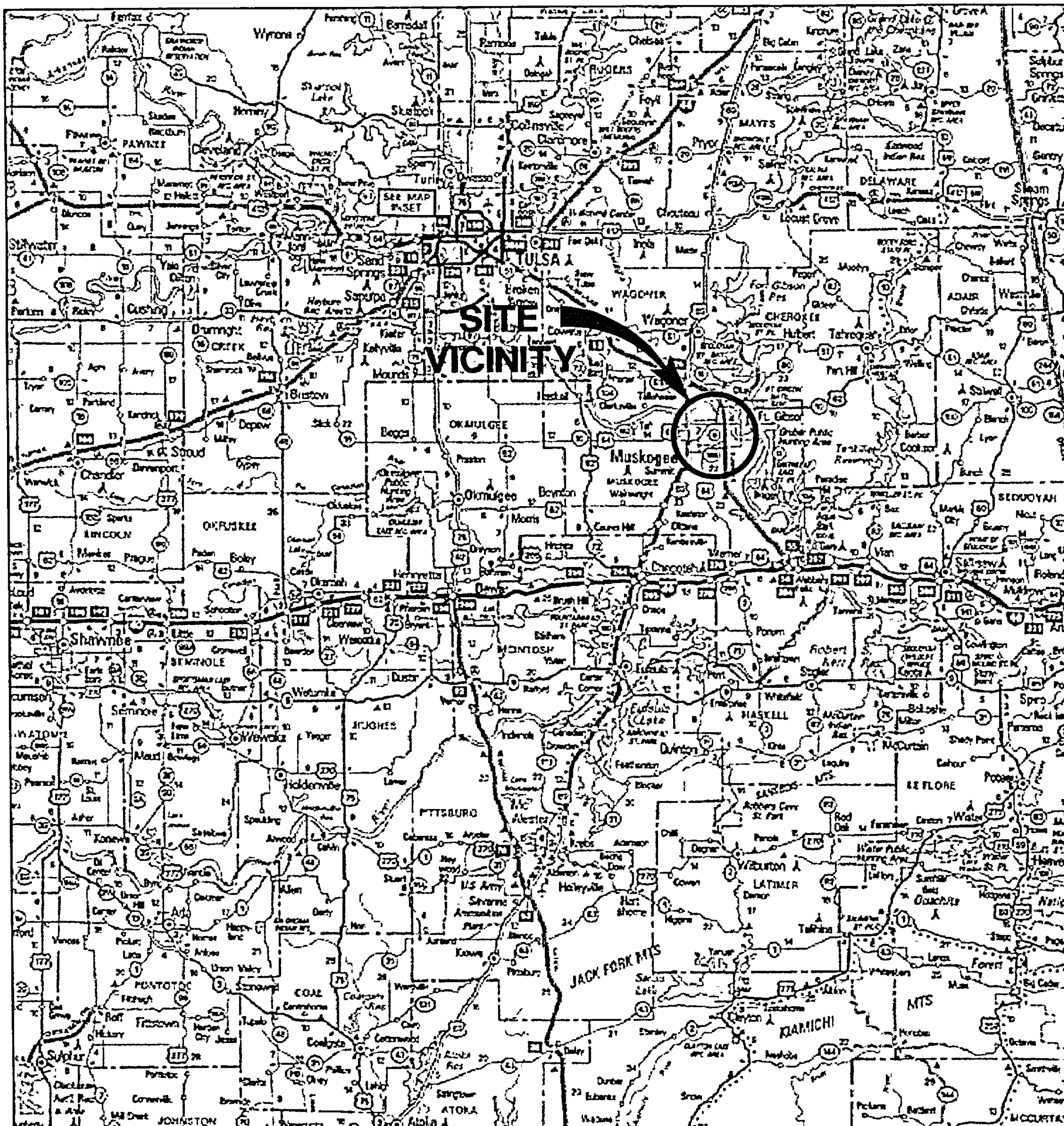

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FIGURE 3-2
SITE VICINITY MAP
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

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PAGE 83 OF THE 1999 RAND McNALLY ROAD ATLAS.

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D-03

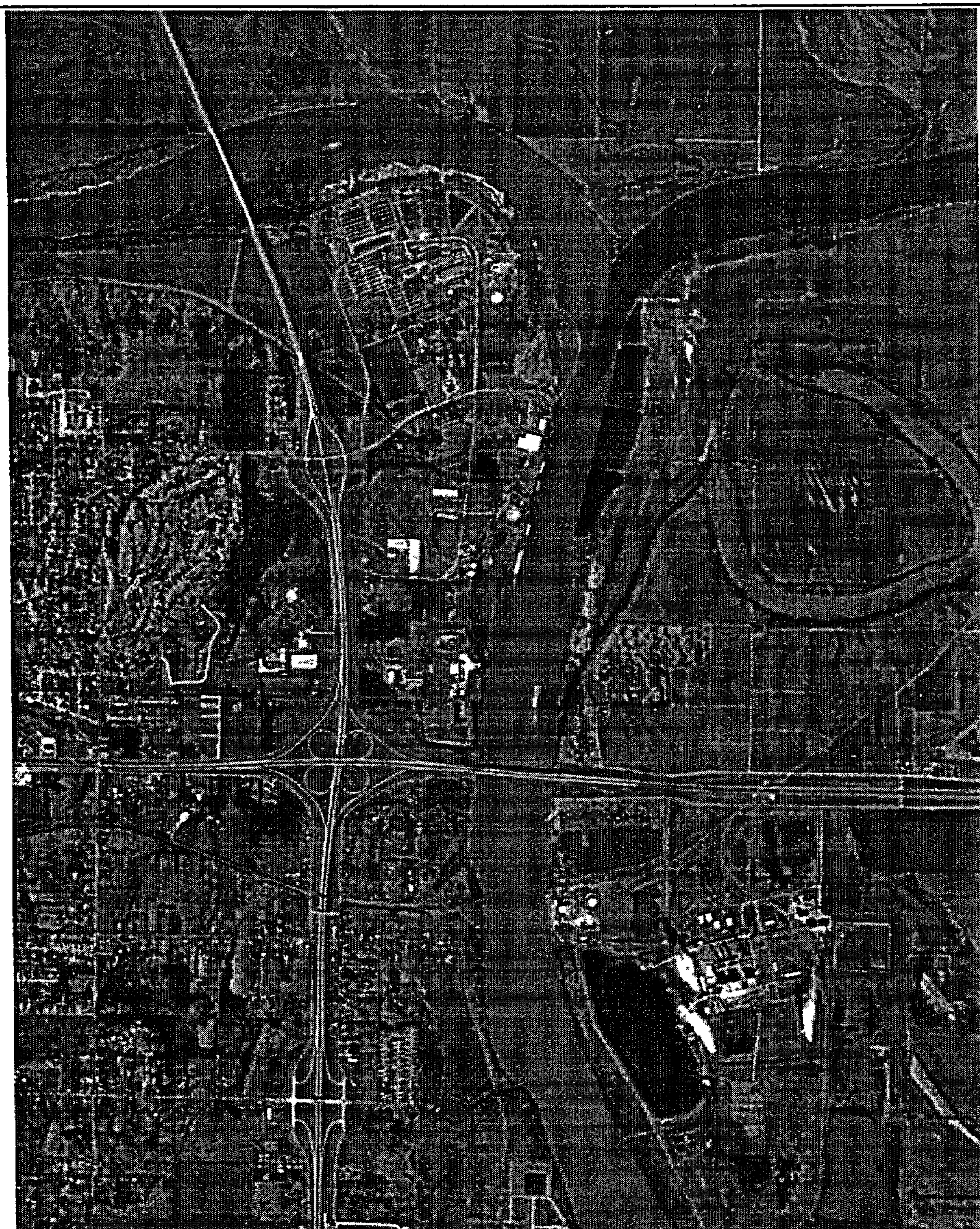

FIGURE 3-4
AERIAL PHOTOGRAPH
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

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U S GEOLOGICAL SERVICE
PHOTO TAKEN MARCH 1995

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D-04

MAJOR GEOLOGIC PROVINCES AND SUBPROVINCES

1 ***Anadarko Basin***
② Anadarko Shelf
③ Cimarron Arch
④ Cyril Basin

5 ***Ardmore Basin***

6 ***Arkoma Basin***
⑦ Franks Graben
⑧ Wapanucka Graben

9 ***Cherokee Platform***
⑩ Semonole Structure

11 ***Hollis Basin***

12 ***Marietta Basin***

13 ***Arbuckle Uplift***
⑭ Arbuckle Mountains
⑮ Tishomingo-Belton Horst
⑯ Pauls Valley-Hunton Horst
⑰ Clarita Horst
⑱ Ada High
⑲ Lawrence Horst

20 ***Nemaha Uplift***

21 ***Ouchita Mountain Uplift***
㉒ Broken Bow Uplift
㉓ Ouachita Central Region
㉔ Ouachita Frontal Thrust Belt
㉕ Potato Hills

26 ***Ozark Uplift***

27 ***Wichita Uplift***
㉘ Criner Uplift
㉙ Waurika-Muenster Uplift
㉚ Wichita Frontal Fault Zone

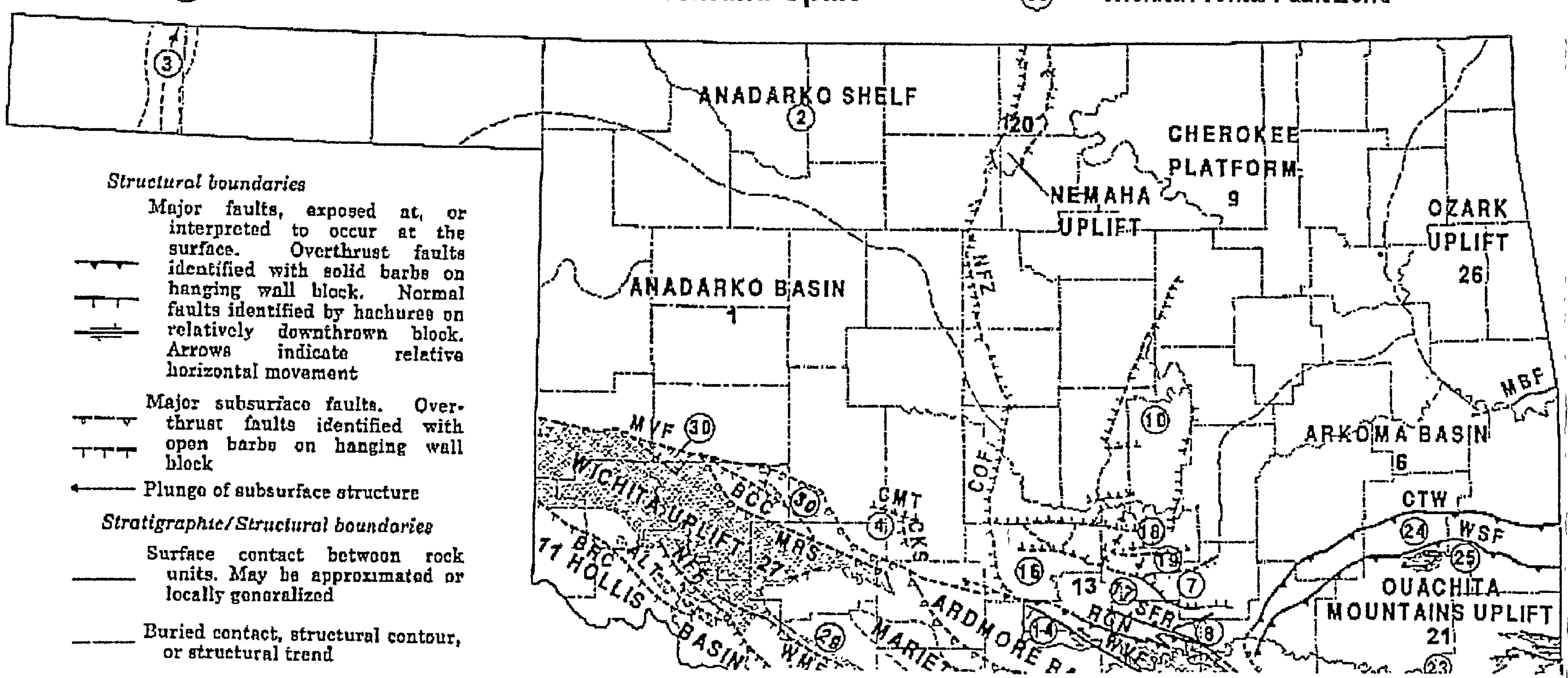

FIGURE 3–6
MAJOR GEOLOGIC PROVINCES AND SUBPROVINCES OF OKLAHOMA
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

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D-05

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D-06

Appendices