DOE/OR/21548-264
CONTRACT NO. DE-AC05-86OR21548

WELDON SPRING QUARRY SUPPLEMENTARY ENVIRONMENTAL MONITORING INVESTIGATIONS SAMPLING PLAN

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

AUGUST 1992 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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DOE/OR/21548-264

Weldon Spring Site Remedial Action Project

Weldon Spring Quarry Supplementary Environmental Monitoring Investigations Sampling Plan

Revision 0

August 1992

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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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ABSTRACT

The Weldon Spring Quarry (WSQ) is part of the Weldon Spring Site Remedial Action Project (WSSRAP) and is operated by the U.S. Department of Energy (DOE). The WSQ is located in St. Charles county approximately 86 km (35 mi) west of St. Louis, MO. The contamination is the results of past quarry disposal practices and subsequent leakage. Radiologically and chemically contaminated building rubble, soil, sludge, and processing equipment were dumped into the quarry. Past investigations and ongoing environmental monitoring of groundwater, surface water, air, soil, and sediment have determined the approximate extent of the contamination.

The main contaminants of concern are uranium and nitroaromatics; contaminants of secondary concern include arsenic and sulfate. Environmental monitoring outlined in this plan, including background and contamination plume definition, is performed under the requirements of DOE Order 5400.1. This order establishes environmental protection program requirements for DOE controlled sites.

Sampling and monitoring activities proposed in this plan are: shallow seismic and EM34 geophysical surveying to determine the bedrock surface underneath the Missouri River alluvium between drill holes; installing three alluvium and three bedrock wells for additional groundwater monitoring; hydrological data gathering and gradient determination; collecting 200 in situ groundwater samples from 30 drill sites for determining the three dimensional distribution of uranium in the alluvium; and collecting 20 slough and stream sediment samples from the Femme Osage Slough. Deliverables generated from these investigations will include a detailed activity report showing all data, results, activities, interpretations, and analytical findings.

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1 INTRODUCTION

Remediation of the Weldon Spring site (WSS) was designated as a Major Project in May 1985. It has since been designated by the U.S. Department of Energy (DOE) as a Major System Acquisition. The program is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment, and to make surplus real property available for other uses to the extent possible. An environmental documentation approach has been developed that satisfies the requirements of both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) and the National Environmental Policy Act (NEPA). The result of this process will be a Record of Decision regarding the ultimate disposal of the WSS wastes.

Protection of the environment and the public are the primary objectives of DOE Order 5400.1. The DOE is firmly committed to ensuring the incorporation of national environmental protection goals in the formulation and implementation of DOE programs. The DOE is committed to good environmental management practices in the implementation of the Environmental Monitoring Program at the WSSRAP to correct existing environmental problems, to minimize risks to the environment or public health, and to anticipate and address potential environmental problems before they pose a threat to the environment or the public.

In addition to Order 5400.1, the DOE has established guidance for environmental radiological monitoring and environmental surveillance on DOE-controlled properties. Some of the activities covered under this guidance include characterization, pathway analysis, and background determinations of the anticipated contamination for all media.

The investigations described in this sampling plan will be performed to comply with DOE Order 5400.1 and DOE's surveillance guidance. This order establishes environmental protection program requirements and ensures compliance with all applicable Federal, State, and local environmental laws and regulations. Implementation of this sampling plan will provide additional groundwater monitoring data on the alluvial and bedrock formations surrounding the quarry, and on contamination in slough sediment and soils south of the quarry. Background data will also be collected from these media upgradient from the quarry. This additional data will enhance environmental monitoring capabilities and supplement the characterization of the quarry.

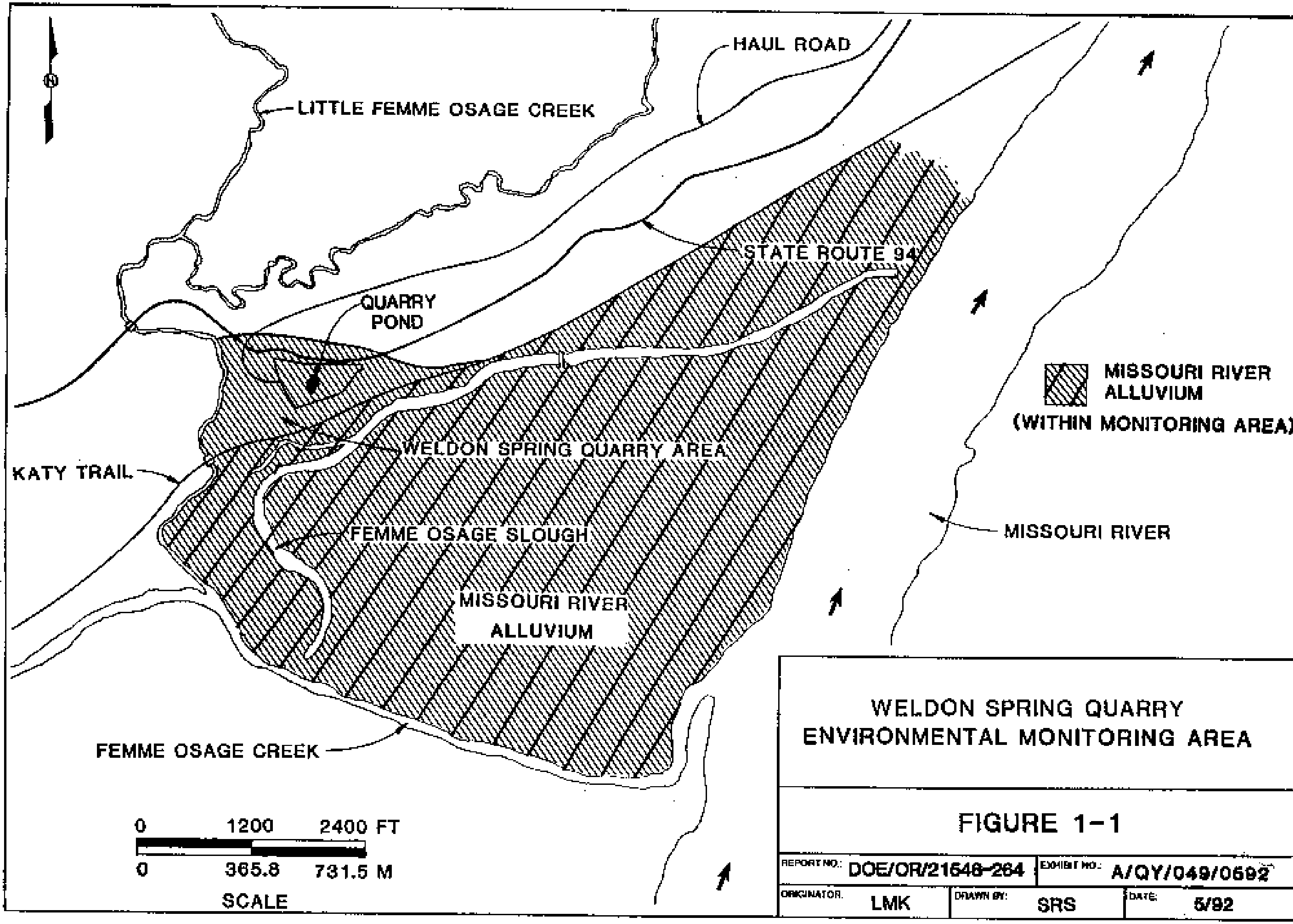
1.1 Purpose

The purpose of this document is to provide a site-specific sampling plan that includes rationale, procedures, locations, and other details involved in the environmental monitoring and contaminant characterization of the quarry. The sampling plan focuses on radiological and chemical environmental monitoring and characterization of the areas outside the quarry fence. Bulk wastes and quarry pond water inside the quarry fence have been characterized and addressed previously (BGA 1984, MKF and JEG 1989a). This plan will provide supplemental information on the nature and extent of contamination, and the data will be reviewed for use in the remedial investigation of the quarry residuals and affected surrounding areas.

The objective of this sampling program is to provide additional radiological and chemical monitoring of the groundwater, surface water, sediment and soil. Several monitoring and data gaps have been identified and are to be filled as this plan is implemented.

1.2 Scope

This sampling plan will provide documentation for field work necessary to provide a more thorough monitoring program of the quarry area. The quarry monitoring area includes, but is not limited to, the area shown in Figure 1-1. Media to be evaluated include: groundwater, surface water, sediment, and soil. The data collected from this and previous investigations will be used to evaluate present conditions and to predict future impacts. Information collected during this investigation may make additional monitoring and environmental surveillance necessary. Additional sampling plans will be developed, as necessary, to describe those efforts when they can be adequately scoped.



WELDON SPRING QUARRY
ENVIRONMENTAL MONITORING AREA

FIGURE 1-1

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2 BACKGROUND

This section describes the quarry area and summarizes the history, geologic setting, contaminant sources, and pertinent investigations performed before this investigation.

Previous investigations and routine monitoring of groundwater, surface water, air, and soils determined the presence of chemical and radiological contamination within and near the quarry. Contamination is the result of previous disposal practices when the Weldon Spring Ordnance Works and Uranium Feed Materials Plant were operational, and the subsequent leaching/migration of contaminated water.

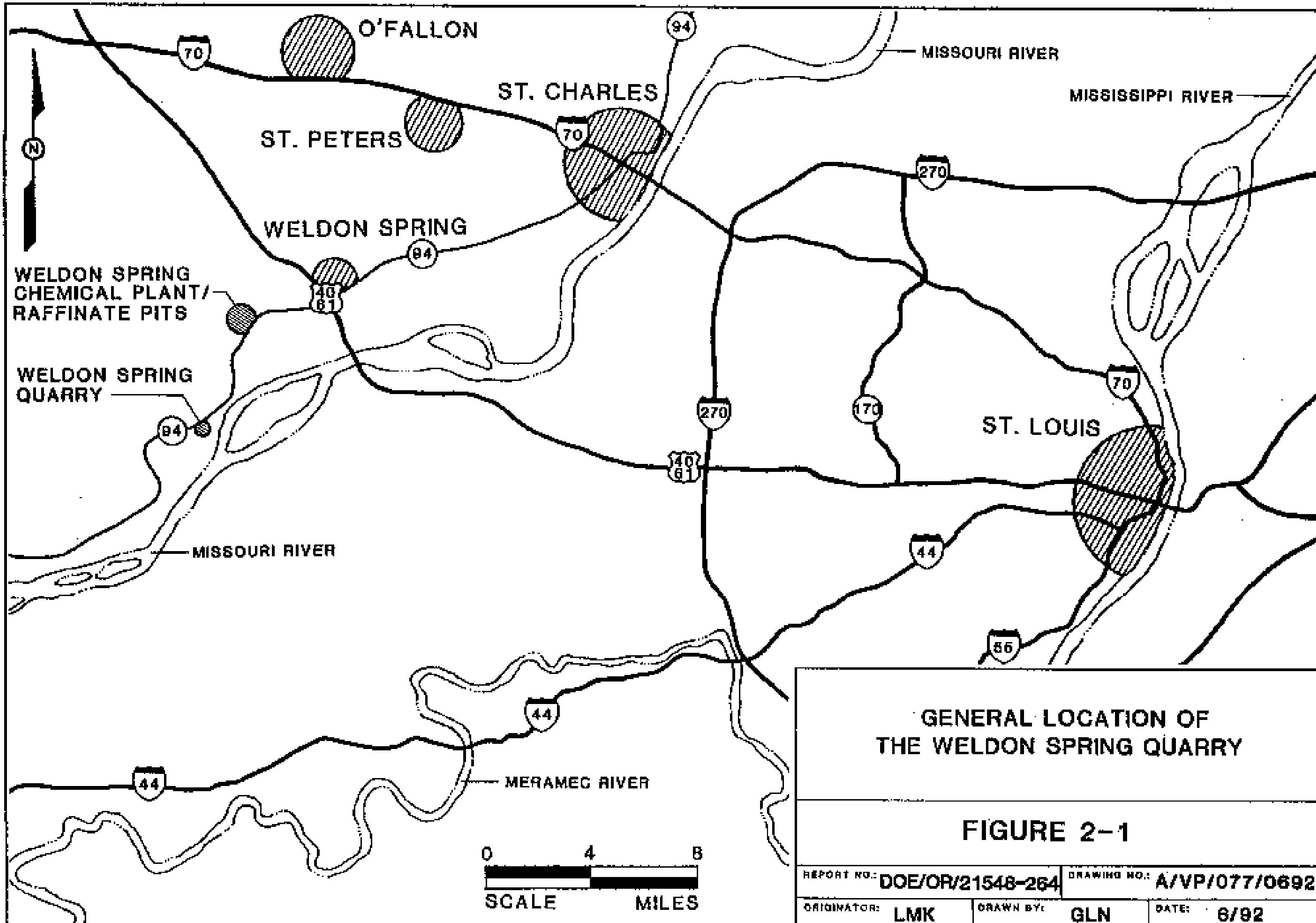
2.1 Location

The bulk waste of the quarry has been characterized. A decision has been made to begin removing material from the quarry property starting in late 1992 (EPA et al. 1990). Water from the quarry pond will be treated at an on-site treatment plant beginning in late 1992.

The Weldon Spring Quarry (WSQ) is located 56 km (35 mi) west of St. Louis in St. Charles County, Missouri (See Figure 2-1). The St. Louis metropolitan area has a population in excess of 2.5 million. The communities of Weldon Spring and Weldon Spring Heights are located approximately 8 km (5 mi) from the quarry and have a combined population of about 1,552. Francis Howell High School is located about 7 km (4.5 mi) east of the quarry on State Route 94. An estimated 2,300 persons are on campus daily during the school year. The largest city in St. Charles County is the city of St. Charles, which is located approximately 30 km (19 mi) northeast of the quarry and has a population of over 54,500. St. Charles County has been experiencing a rapid population growth in the last two decades. The 1990 population of approximately 212,900 represented a 50% increase over the 1980 population.

2.2 Site Description

The quarry is located in limestone and covers about 3.6 ha (9 acres) adjacent to the Missouri River floodplain (Figure 2-2). The deepest part is filled with water covering about 0.2 ha (0.5 acres) and is the only surface water body within the quarry proper which is a controlled area. The layout of the quarry is shown in Figure 2-3. The quarry was used for disposal of a variety of wastes at different times during the Weldon Spring site's operational



GENERAL LOCATION OF THE WELDON SPRING QUARRY

FIGURE 2-1

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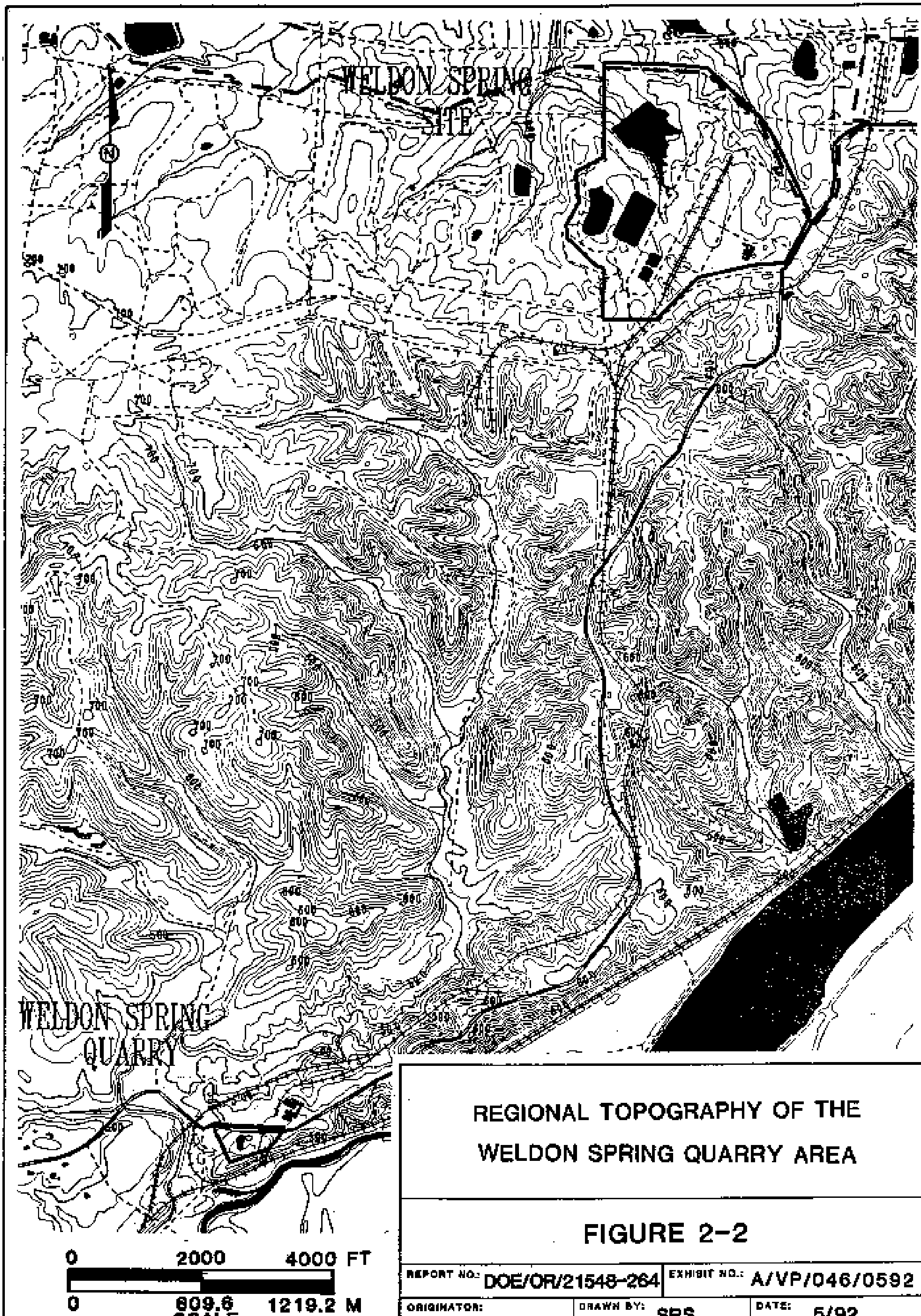

REGIONAL TOPOGRAPHY OF THE WELDON SPRING QUARRY AREA

FIGURE 2-2

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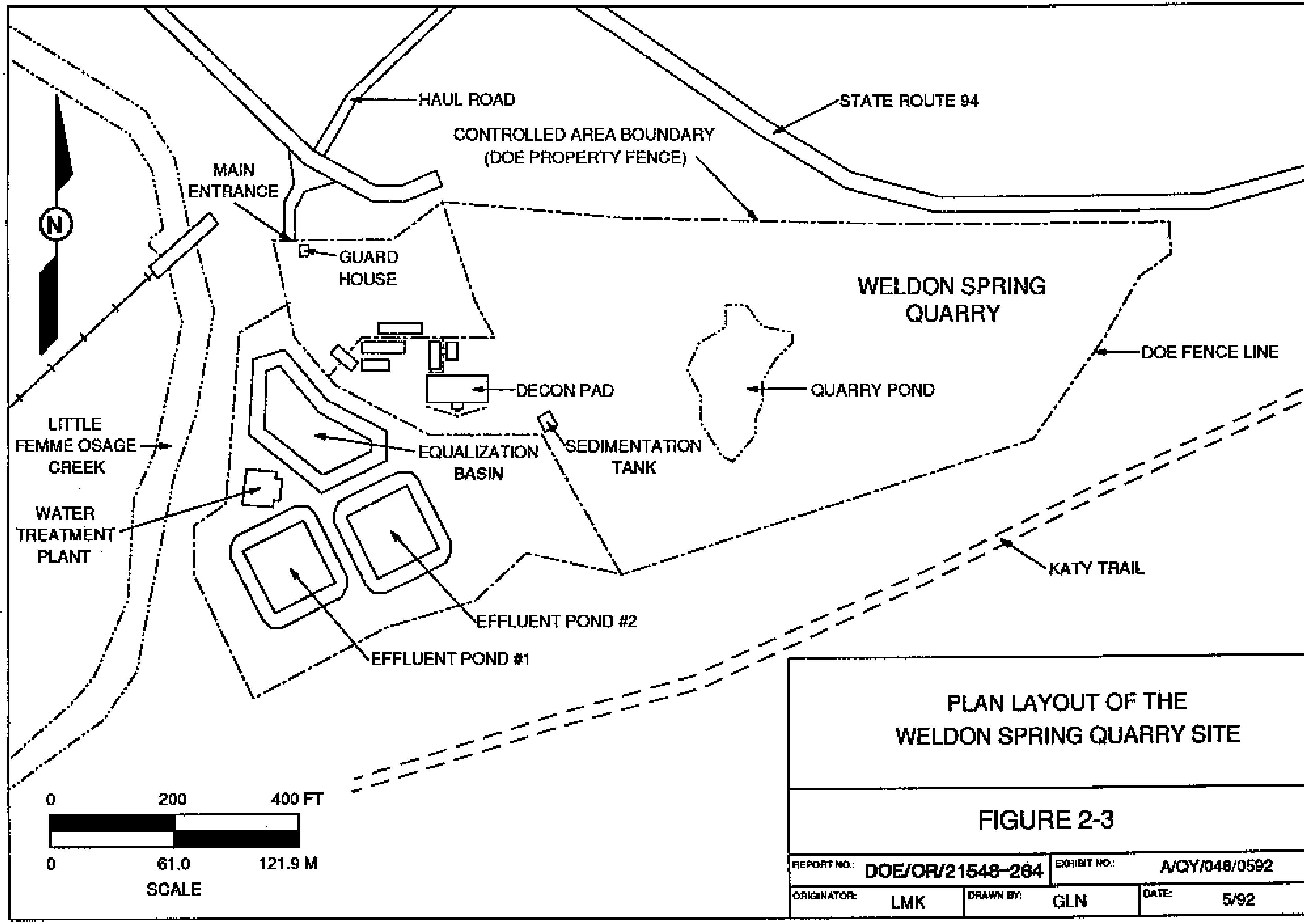

PLAN LAYOUT OF THE
WELDON SPRING QUARRY SITE

FIGURE 2-3

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period (MKF and JEG 1989a). A major source of potable groundwater in this area is the county well field located about 1.6 km (1 mi) southeast of the quarry in the Missouri River alluvium. The nearest active municipal well is located about 0.8 km (0.5 mi) from the quarry.

A considerable amount of information has been gathered from the groundwater southeast and west of the quarry, down gradient of the local flow direction. The areas of investigation are outside the DOE quarry fence.

2.3 Site History

The Army and the Atomic Energy Commission (AEC) used the Weldon Spring Quarry for waste disposal during their operations from 1941 to 1969. Before 1941, limestone aggregate was mined from the quarry and used to construct the Weldon Spring Ordnance Works, located about 6.4 km (4 mi) to the northeast.

Between 1941 and 1944, the Army used the quarry for disposal of wastes generated from manufacturing at the ordnance works. After 1944, rubble contaminated with trinitrotoluene (TNT) and other nitroaromatic compounds was dumped into the quarry until 1957. The ordnance works produced dinitrotoluene (DNT) in addition to TNT, and operated until 1944. The property was declared as surplus two years later. By the end of 1949, most of the land around the ordnance works and the quarry had been transferred to the state of Missouri and the University of Missouri. Later most of this land was converted to the Weldon Spring Wildlife and the August Busch Memorial Wildlife areas.

In 1956, portions of the ordnance works area were transferred to the AEC. This agency constructed and operated a uranium feed materials plant, now known as the chemical plant, which processed uranium and thorium ore concentrates. Two years later, in 1958, the AEC assumed custody of the quarry for use as a disposal site for radioactively contaminated wastes. The feed materials plant operated until 1966. Radioactive waste materials and rubble was disposed in the quarry during this period.

In 1975, the AEC contracted with National Lead Company of Ohio (NLO) to perform environmental monitoring and maintenance at the quarry. This responsibility was transferred to Bechtel National Inc. (BNI) in 1981, under contract to the Department of Energy (DOE), the AEC's successor. MK-Ferguson Company (MKF), DOE's Project Management Contractor

(PMC), has been active at the site since 1986. In 1987, the Weldon Spring Quarry was placed on the National Priorities List under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980.

The area within the quarry fence, including quarry bulk waste, has been approved for clean up (EPA et al 1990).

2.4 Contaminant Sources

Wastes placed in the quarry by the U.S. Department of the Army (DA) and the AEC comprise the primary contaminant source for this investigation. These wastes consist of chemically and radioactively contaminated soil, sludge, drummed waste, building rubble and contaminated building rubble including process equipment and machinery. Table 2-1 present a summary of historical waste disposal activities. Additional information on the characteristics of the bulk wastes is available in the *Remedial Investigation for Quarry Bulk Waste Removal* (MKF and JEG 1989a).

The quarry is a closed basin and precipitation falling in the quarry percolates through the bulk wastes. As a result, contaminants have dissolved and migrated via groundwater to areas outside of the quarry perimeter. Environmental monitoring and other characterization efforts have detected the presence of chemical and radiological contaminants in groundwater, surface water, soils, sediment, and air.

2.5 Geologic Setting

This section outlines the general geology and the hydrogeology of the quarry area. For a more detailed description, the *Remedial Investigations for Quarry Bulk Waste* (MKF and JEG 1989a) should be consulted.

TABLE 2-1 History of Disposal Activities at the Weldon Spring Quarry

Time Period	Waste Type	Estimated Volume[a] m³	yd³
1942-1945	TNT and DNT waste.	---[a]	---[a]
1946	TNT and DNT waste.	[b]	[b]
1946-1957	TNT and DNT residues and contaminated rubble from cleanup of the ordnance works (in deepest part and in northeast corner of quarry).	---[a]	---[a]
1959	3.8% thorium residues (drummed, currently below water level).	150	200
1960-1963	Uranium- and radium-contaminated rubble from demolition of the St. Louis Destrehan Street feed plant (covering 0.4 ha [1 acre] to a 9-m [30 ft] depth in deepest part of quarry).	38,000	50,000
1963-1966	High-thorium-content waste (in northeast corner of quarry)[c].	760	1,000
1963-1966	Uranium and thorium residues from the chemical plant and off-site facilities; building rubble and process equipment (both drummed and uncontained).	---[a]	---[a]
1966	3.0% thorium residues (drummed, placed above water level in northeast corner of quarry); TNT residues from cleanup of the ordnance works (placed to cover the drums).	460	600
1966-1969	Uranium- and thorium-, rubble and equipment from interiors of some chemical plant buildings (101, 103, and 105).	4,600	6,000

Source: MKF and JEG 1989a.

---

[a] A hyphen indicates that the waste volume estimate is not available.

[b] An estimated 90 tons of TNT/DNT waste was disposed of in 1946.

[c] This was a portion of the waste originally stored at the Army arsenal in Granite City, Illinois; most of this material was subsequently removed from the quarry for the purpose of recovering rare earth elements.

2.5.1 Geology

Soil/Alluvium

Two distinct types of surficial deposits are present in the quarry area. Loess and residual soils cover the upland surfaces to thicknesses of up to 9 m (30 ft), while major alluvial deposits are present along the Missouri River and its tributaries.

Upland areas in the vicinity of the WSQ generally consist of Paleozoic bluffs with a dissected topography, the result of stream erosion. These areas are covered with upland soils which are topographically higher than the quarry. Upland soils are generally not saturated.

Alluvial deposits south of the quarry in the Missouri River floodplain are composed of up to 33 m (110 ft) of Quaternary Missouri River alluvium. Local tributaries, i.e., the Femme Osage and Little Femme Osage Creeks, contain thinner alluvium with a higher clay content than the Missouri River alluvium.

The Missouri River alluvium north of the Femme Osage Slough is up to 15 m (50 ft) thick and generally consists of fine-grained silty clay and clayey organic silt to a depth of about 6 m (20 ft). The silt and clay are overbank deposits associated with flooding of the Missouri River and the Femme Osage Creek. Below a depth of 6 m (20 ft) silty sands predominate. Toward the south and the deeper section of the Missouri River bedrock channel, fine-grained alluvium diminishes with depth and the grain size increases (BGA 1984). The coarse-grained fraction of alluvium south of the slough is up to 18 m (60 ft) thick.

Bedrock

The bedrock units in the quarry and vicinity are predominantly Ordovician limestone and dolomite overlying sandstone and shale. Bedrock exposures exist as quarry walls and steep bluffs which compose the northern wall of the Missouri River valley.

The uppermost bedrock unit in the vicinity of the WSQ is the Ordovician Kimmswick Limestone. The Kimmswick is underlain by other units of Ordovician age which include, in descending order, the Decorah Group (shale and limestone), the Plattin Limestone, the Joachim Dolomite, and the St. Peter Sandstone. Table 2-2 shows the stratigraphic relationships and

TABLE 2-2 Generalized Description of the Lithologic and Hydrologic Properties of the Aquifers

Stratigraphic Unit	Regional Thickness (ft)	Typical WSQ Thickness (ft)	Physical Characteristics	Hydrologic Properties
Alluvium (Holocene)	0-65	10-30	Gravelly, silty loam over occasionally gravelly, silty clay loam.	Deposits underlie tributaries to Missouri and Mississippi rivers.
Alluvium (Holocene)	65-120	70-110	Silty loam, clay, and sand over sand and gravelly sand.	Deposits underlying Missouri and Mississippi river flood plains generally yield large quantities of water to wells. (600-2,600 gal/min)
Loess and glacial drift (Pleistocene)	0-150	5-30 30-80	Silty clay, silty loam, clay, or loam over residuum and bedrock, or both.	Yields little water to wells (<5 gal/min).
Undifferentiated (Pennsylvania)	0-75	--	Partly silty red shale with purplish-red to light gray clay (Residuum).	Limited occurrence. Yields small quantities of water to wells (<1-10 gal/min)
Kimmswick Limestone*	0-140	90-100	Limestone; white to light gray, coarsely crystalline, medium to thickly bedded. Cherty near base.	Yields small to moderate quantities of water to wells (10-50 gal/min). Leaky confined layer.
Decorah Group*	0-35	30	Interbedded green and yellow shale with thin beds of limestone.	Yields small to moderate quantities of water to wells (10-50 gal/min). Leaky confined layer.
Plattin Limestone*	0-195	100-125	Limestone; light to dark gray, finely crystalline. Thinly bedded; weathers with pitted surface.	Yields small to moderate quantities of water to wells (10-50 gal/min). Leaky confined layer.
Joachim Dolomite*	0-135	90-110	Dolomite; yellowish-brown, silty, thin-to thickly bedded. Grades into siltstone, shales common.	Yields small to moderate quantities of water to wells (10-50 gal/min). Leaky confined layer.
St. Peter Sandstone*	0-250	120-150	Quartz sandstone, yellowish-silt to white, fine to medium grained, massively bedded.	Yields small to moderate quantities of water to wells (10-140 gal/min). Everton Formation discontinuous.†

* Middle Ordovician
† Deep bedrock aquifer
Source: Adapted and Modified From: (Kleeschulte and Emmett 1987)

hydrological properties of the major stratigraphic units present in the vicinity of the quarry. The original floor of the quarry was excavated about 4.5 m (15 ft) into the Decorah. The strata overlying the Kimmswick are generally eroded in the vicinity of the quarry. The general relationship of the quarry, bedrock, and unconsolidated material is shown in Figure 2-4.

Bedrock in the study area is virtually flat lying, having a regional dip of about 0.5° to the northeast and striking N60W. The strata of the region have been broadly uplifted by Ozark doming resulting in a northeast sloping monoclinal structure (BNI 1987).

Local joint and fracture sets strike N65±5°W (major) and N30±5°E (minor) (Figure 2-5). The joint planes for both sets are nearly vertical.

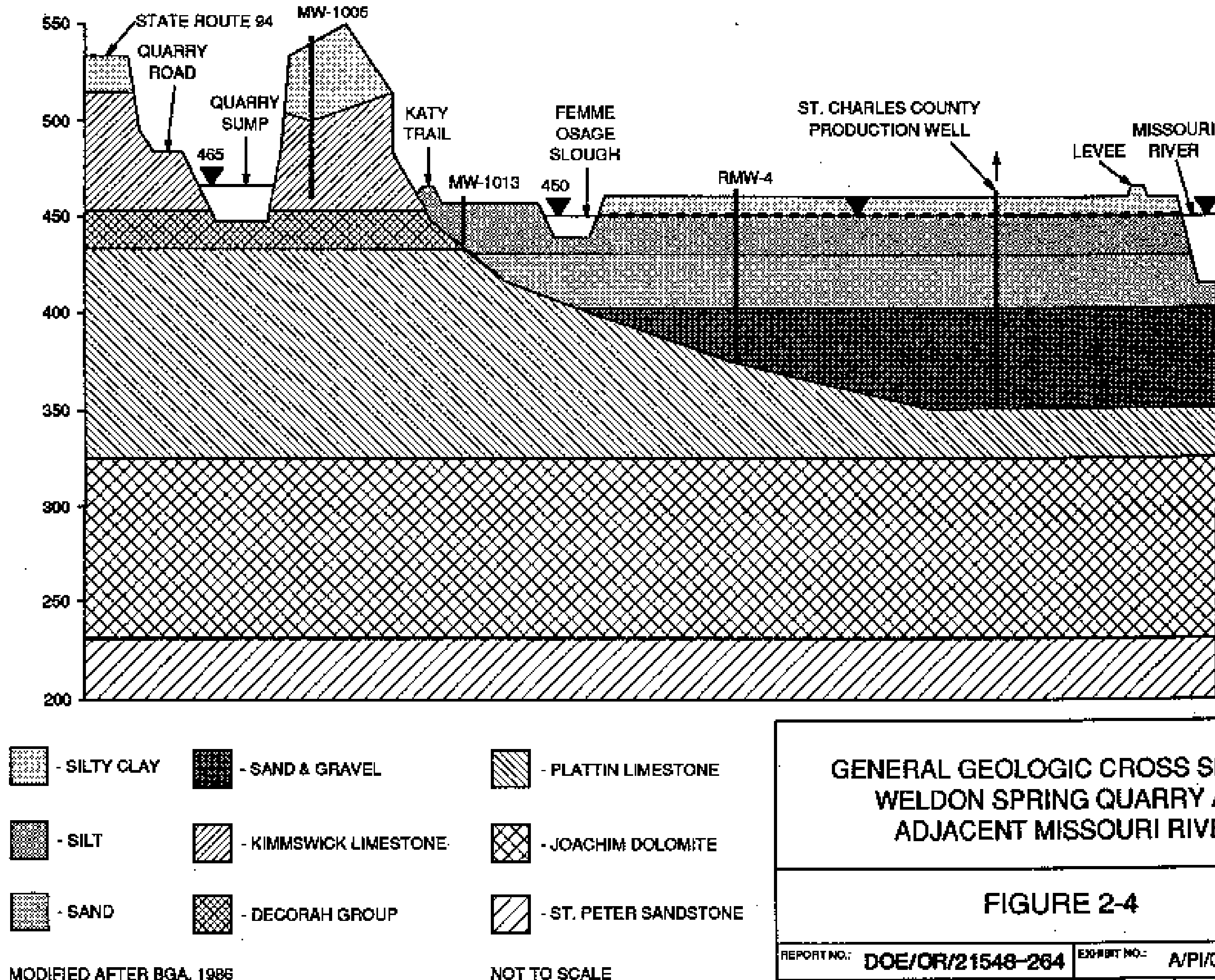
2.5.2 Hydrogeology

Soil and Alluvium

The upland soils are generally unsaturated; however, the upland soil may provide a portion of recharge to the bedrock aquifer during precipitation events.

The vadose zone in the alluvium generally is between 1.5 m (5 ft) to 7.6 m (25 ft) thick. Depth to groundwater varies with season and position in the alluvium. The alluvial aquifer is mostly recharged by infiltration from precipitation and the Missouri River. Minor recharge comes from the adjacent bedrock. As stated previously, the alluvium south of the slough provides a major source of drinking water in St. Charles County. Figure 2-5 shows active alluvium wells and the piezometric surface.

The groundwater flow direction from the quarry is mainly toward Missouri River alluvium to the south and to a lesser extent towards the west towards Little Femme Osage Creek. Groundwater levels in the alluvium near the slough have measured up to 3.0 m (10 ft) lower than groundwater levels in the bedrock near the south rim of the quarry (MKF and JEG 1988b). South of the slough groundwater flow is affected by pumping and river stage.



GENERAL GEOLOGIC CROSS SECTION WELDON SPRING QUARRY AND ADJACENT MISSOURI RIVER

FIGURE 2-4

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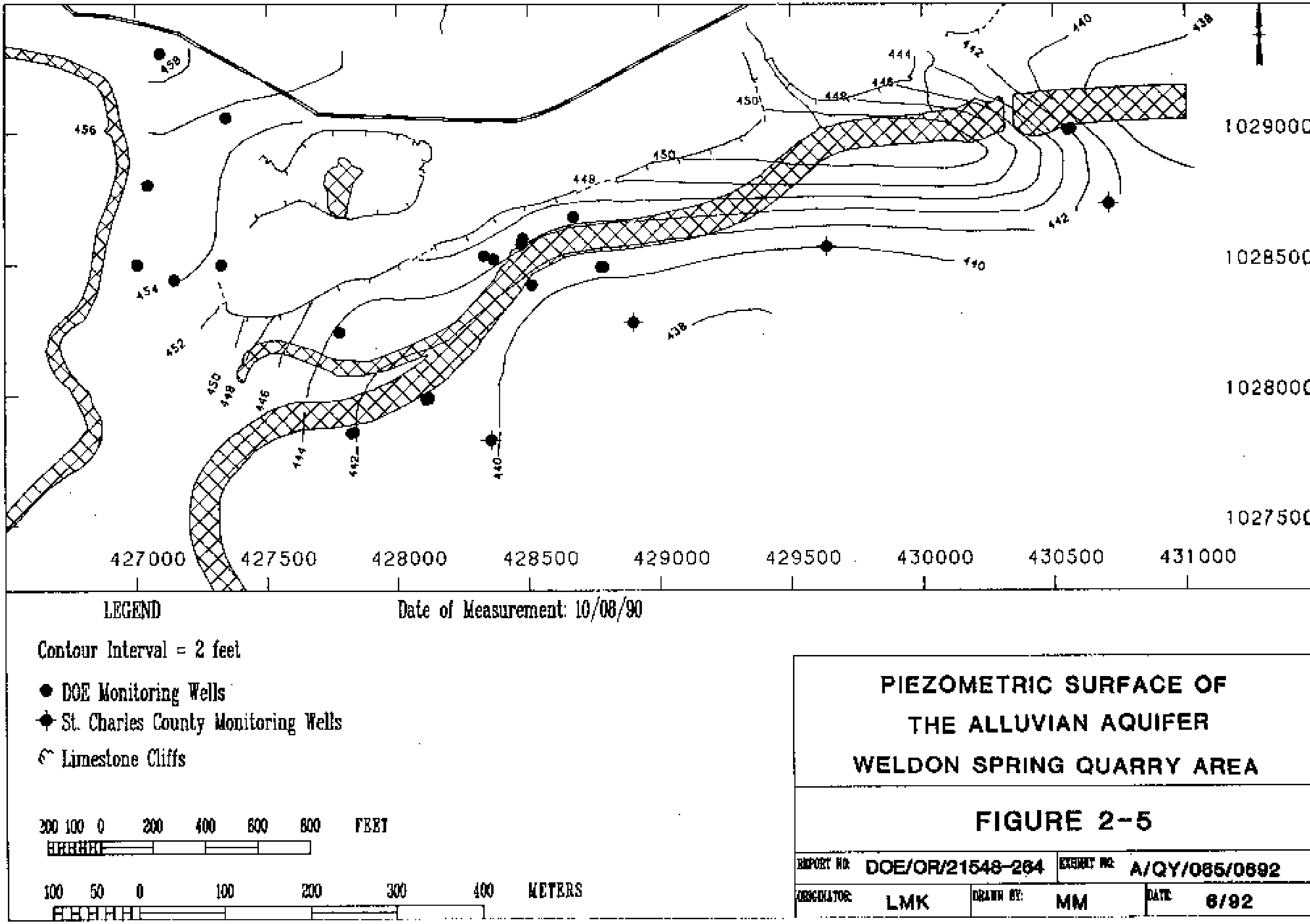

PIEZOMETRIC SURFACE OF THE ALLUVIAN AQUIFER WELDON SPRING QUARRY AREA

FIGURE 2-5

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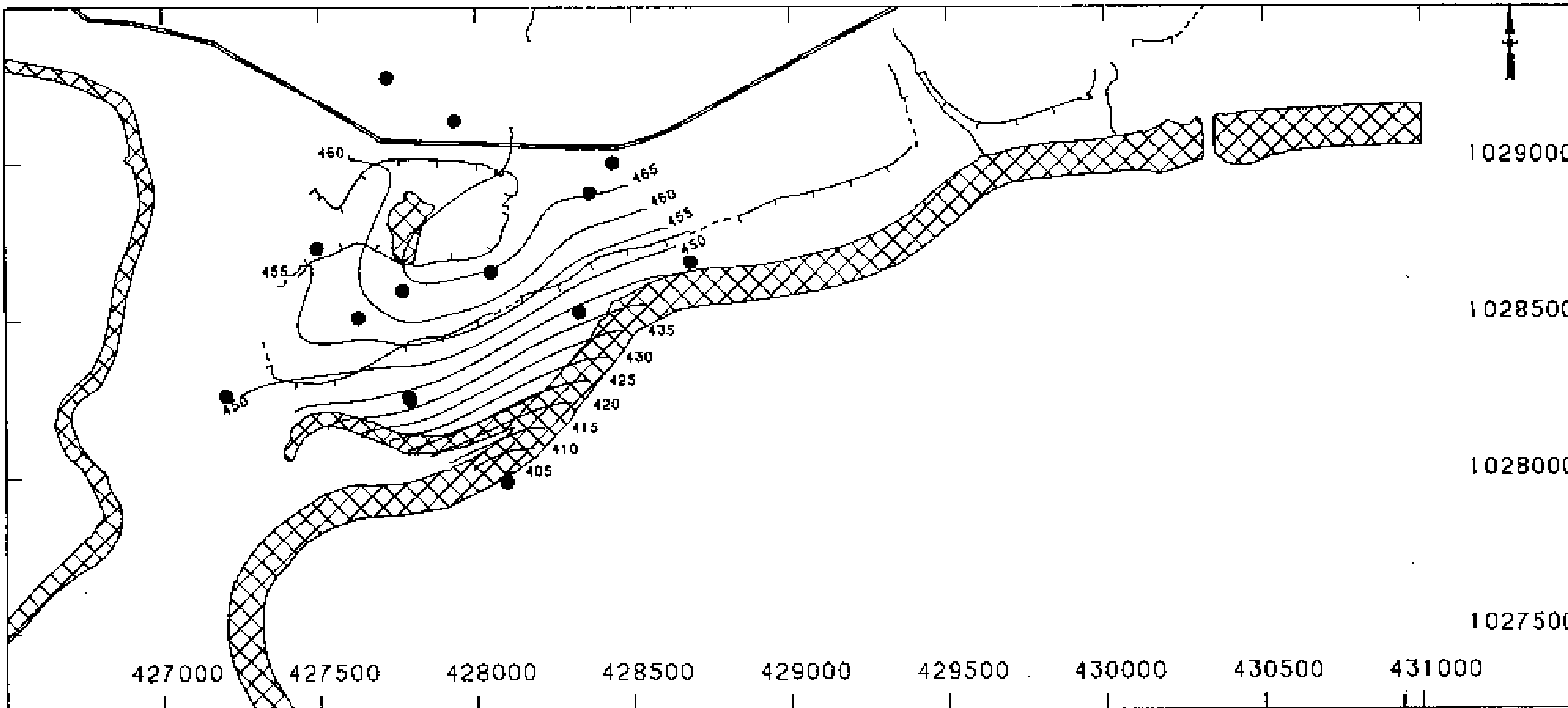
Bedrock

Near-surface groundwater occurs at the base of the Kimmswick Limestone and within the Decorah Group and Plattin Limestone. This groundwater is in hydraulic connection with the quarry, as is evident by the presence of contaminants. Porosity in the carbonate bedrock is primarily a function of fractures, joints, bedding planes, solution enhanced cavities, and other discontinuities. Figure 2-6 shows active bedrock wells and the piezometric surface (BGS 1984) of the quarry.

Figure 2-7 identifies joints and lineaments of the Weldon Spring Quarry walls and cliffs, respectively. Fracture patterns observed at the surface in the Kimmswick Limestone extend vertically. In contrast, fractures within the Decorah Group are predominantly horizontal as determined from core logs.

The Plattin Limestone appears massive with very little evidence of fracturing. Presently, water levels within the Plattin do not appear to correlate with the fracture-system in the Kimmswick-Decorah units; therefore, the Plattin is considered locally a separate hydrostratigraphic unit. Specific hydrological data of the Joachim Dolomite, which contains siltstone and shale lenses, are lacking. The Joachim-Plattin units are likely the same hydrostatic unit.

The St. Peter Sandstone is the uppermost bedrock aquifer of regional significance beneath the quarry. The formation is the youngest unit within the deep bedrock aquifer (Ordovician-Cambrian) as described by Kleeschulte and Emmett (1987). The upper contact for the St. Peter Sandstone is estimated to be 76 m (250 ft) in the quarry area. Groundwater in the St. Peter Sandstone in the quarry area may exhibit artesian behavior based on conditions encountered during monitoring of this formation in the vicinity of the Weldon Spring Chemical Plant (WSCP).



LEGEND

Contour Interval 5 feet

● DOE Monitoring Wells

Limestone Cliffs

200 100 0 200 400 600 800 FEET

100 50 0 100 200 300 400 METERS

Date of Measurement: 10/08/91

PIEZOMETRIC SURFACE OF THE BEDROCK AQUIFER WELDON SPRING QUARRY AREA

FIGURE 2-6

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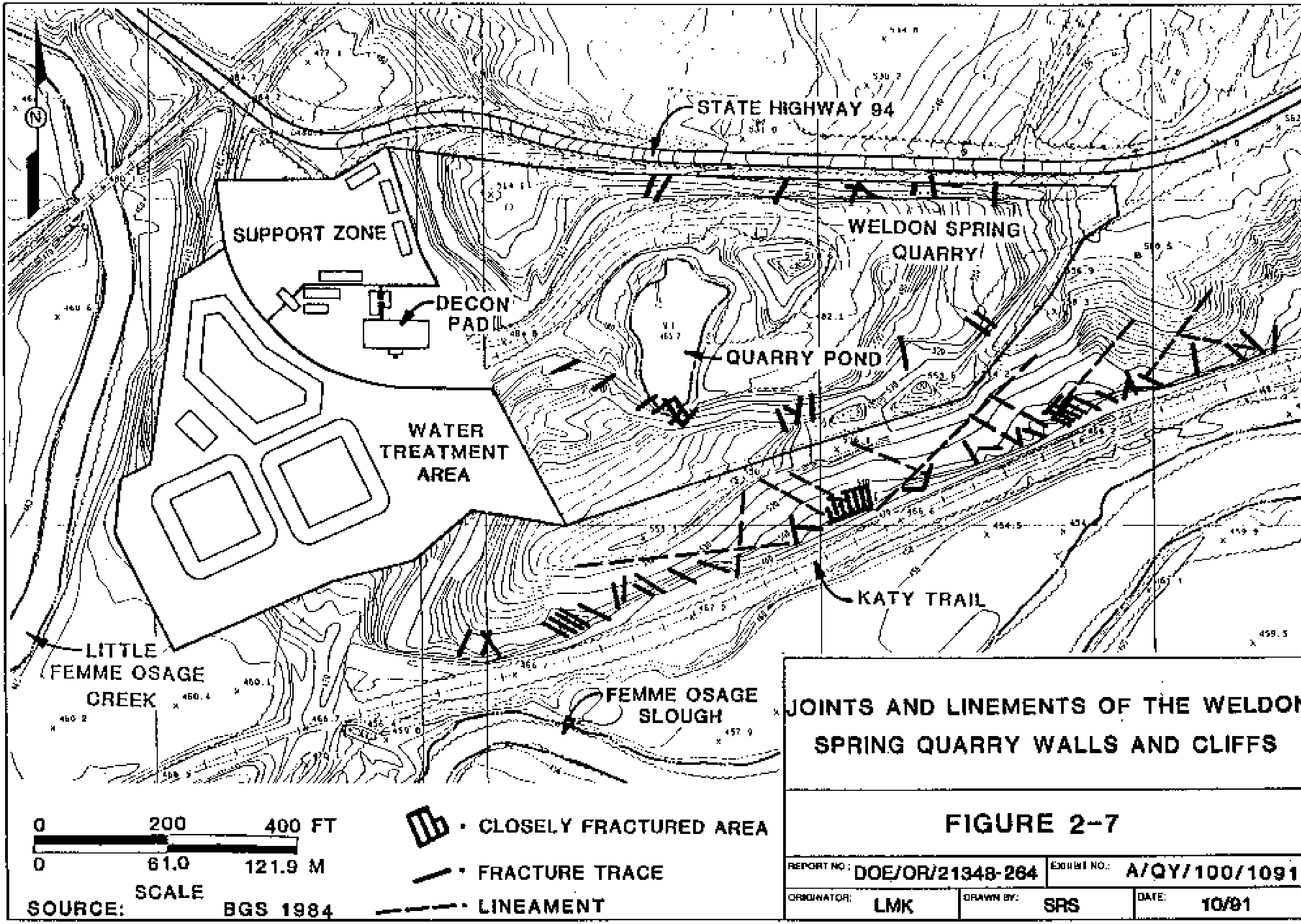


JOINTS AND LINEMENTS OF THE WELDON SPRING QUARRY WALLS AND CLIFFS

FIGURE 2-7

REPORT NO.: DOE/OR/21348-264	EXHIBIT NO.: A/QY/100/1091	
ORIGINATOR: LMK	DRAWN BY: SRS	DATE: 10/91

3 ENVIRONMENTAL SETTING

Previous investigations and routine environmental monitoring of the groundwater, surface water, sediment, soil, and air have partially characterized the Weldon Spring Quarry (WSQ) and surrounding area and determined that contamination is present outside the quarry proper. Table 3-1 identifies previous major investigations. Data gaps have been identified, as outlined in this section. Also, data collected prior to 1987 are generally not verifiable because quality assurance (QA) and quality control (QC) information are absent or are lacking. In addition, data on specific chemical constituents, notably nitroaromatics, are missing. A defendable, accurate, and complete contamination data base is necessary to assess potential risks to the public and the environment.

3.1 Overview of Contamination

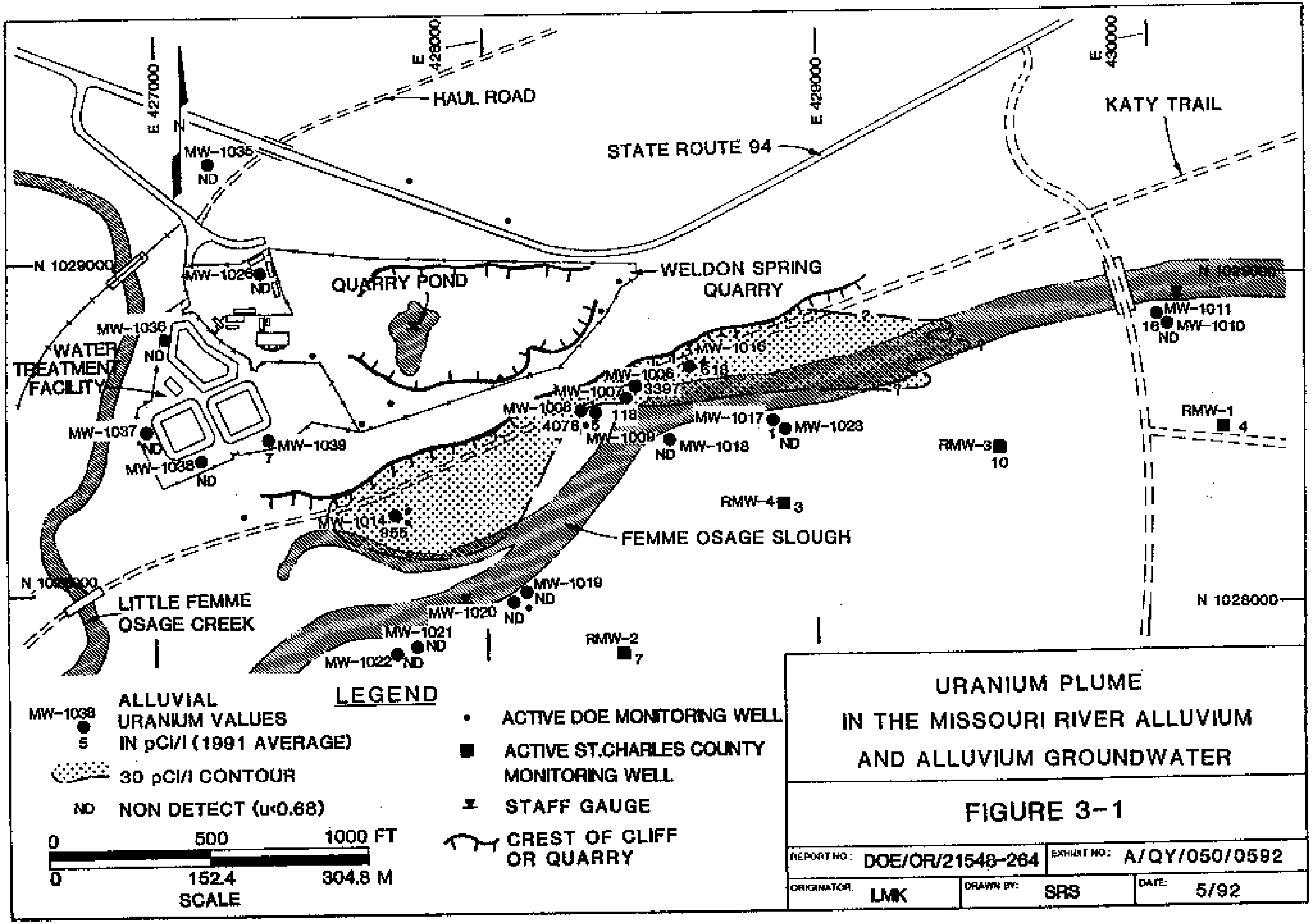
Ongoing monitoring and previous investigations have determined that minor radon contamination is present in the air near the quarry rim; uranium, nitroaromatics, and miscellaneous chemical constituents are also present in groundwater, surface water, stream sediments, and soils. This contamination is the result of disposal practices after the aggregate had been mined from the quarry. Leaching of percolating rain water, subsequent infiltration into the groundwater, and subsurface migration are the greatest threats to the environment outside of the quarry proper. Specifically, the contaminated groundwater plumes have moved south of the quarry into the fine-grained upper Missouri River alluvium, and to a limited extent into the underlying bedrock, but are absent in the coarser, gravelly section of the well field (Figures 3-1 through 3-3).

The disposal history of the quarry, quarry waste characterization work, and water monitoring have determined that natural uranium is the most perversive contamination and is of primary concern. Contaminants of secondary consideration that are currently monitored include barium, arsenic, nitroaromatics, and sulfate. Contamination levels of this group are generally at, or below, U.S. Environmental Protection Agency (EPA) primary and secondary drinking water standards. Other components currently monitored are of tertiary concern and include the radionuclides Ra-226, Ra-228, Th-230, Th-232, and nitrate, all of which are below secondary drinking water standards or are not detected (MKF and JEG 1992a).

TABLE 3-1 Summary of Major Geological, Hydrological and Environmental Investigations

Date	Lead Agency*	Contractor* (author/reference)	Main Activity
1944	DA	USGS (Fishel and Williams 1944)	Regional geology and hydrology.
1951	AEC	USGS (Robert & Theis 1951)	Regional geology and hydrology.
1960-1961	AEC	USGS (Richardson 1960a and b)	Monitoring wells and aquifer testing.
1976-1977	AEC	NLO (Huey 1978)	Monitoring wells - groundwater quality.
1979-1984	DOE	LBL (BGA 1984)	Geologic characterization and aquifer testing.
1982-1986	DOE	BNI (BNI 1985)	Rejuvenating and installing monitoring wells.
1983-1986	DOE	USGS (Kleeschulte and Emmett 1987)	Regional hydrogeology and summary of previous data.
1986	St. Charles County	Layne-Western 1986	Aquifer testing.
1987-1991	DOE	PMC (MKF and JEG 1988a)	Monitoring wells, water level contour maps.
		PMC (MKF and JEG 1989a)	Monitoring wells.
		PMC (MKF and JEG 1990b)	Geotechnical holes, piezometers.
		PMC (MKF and JEG 1991a, 1991b)	Monitoring wells.

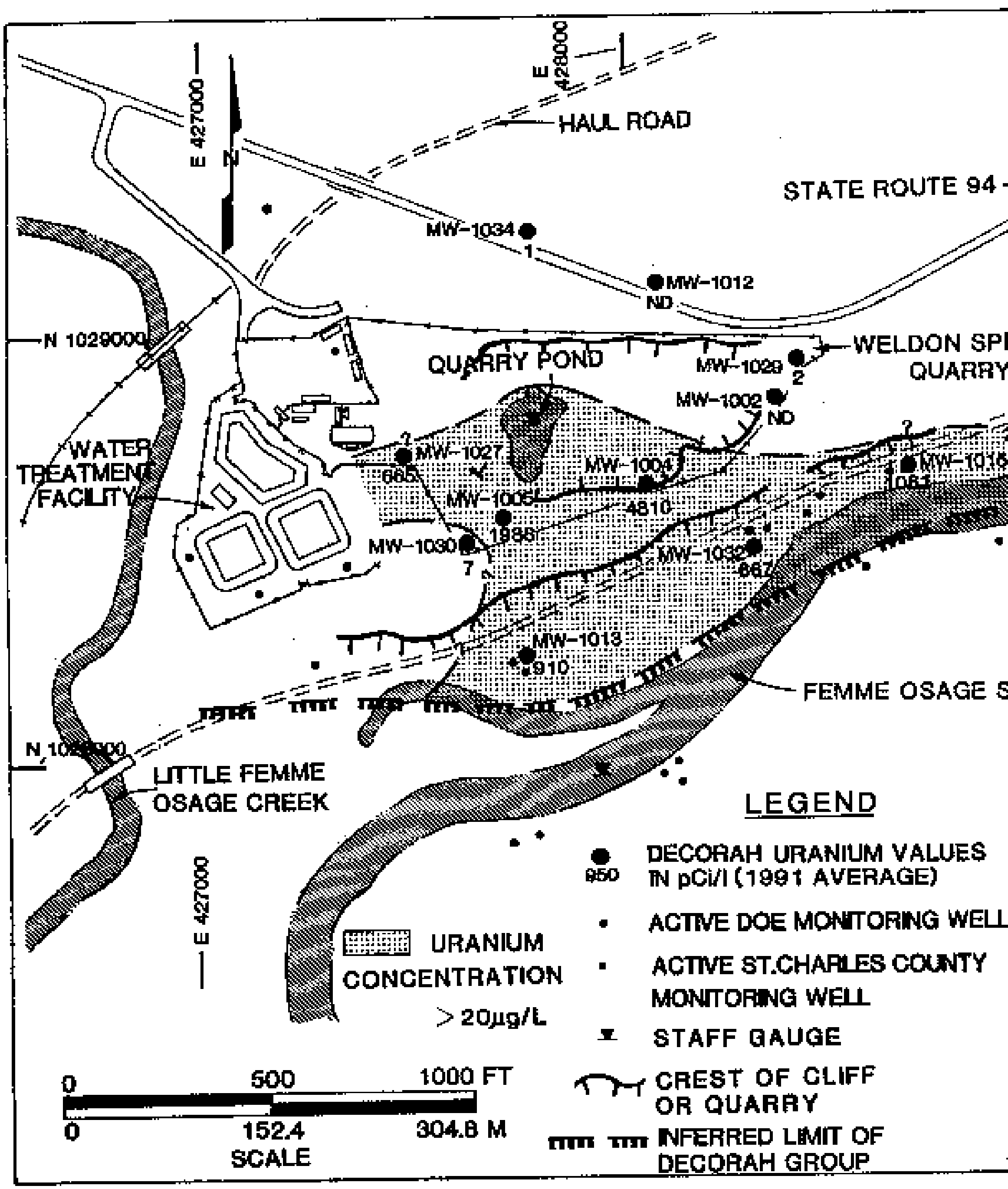
* Refer to the list of Acronyms and to References.



URANIUM PLUME
IN THE MISSOURI RIVER ALLUVIUM
AND ALLUVIUM GROUNDWATER

FIGURE 3-1

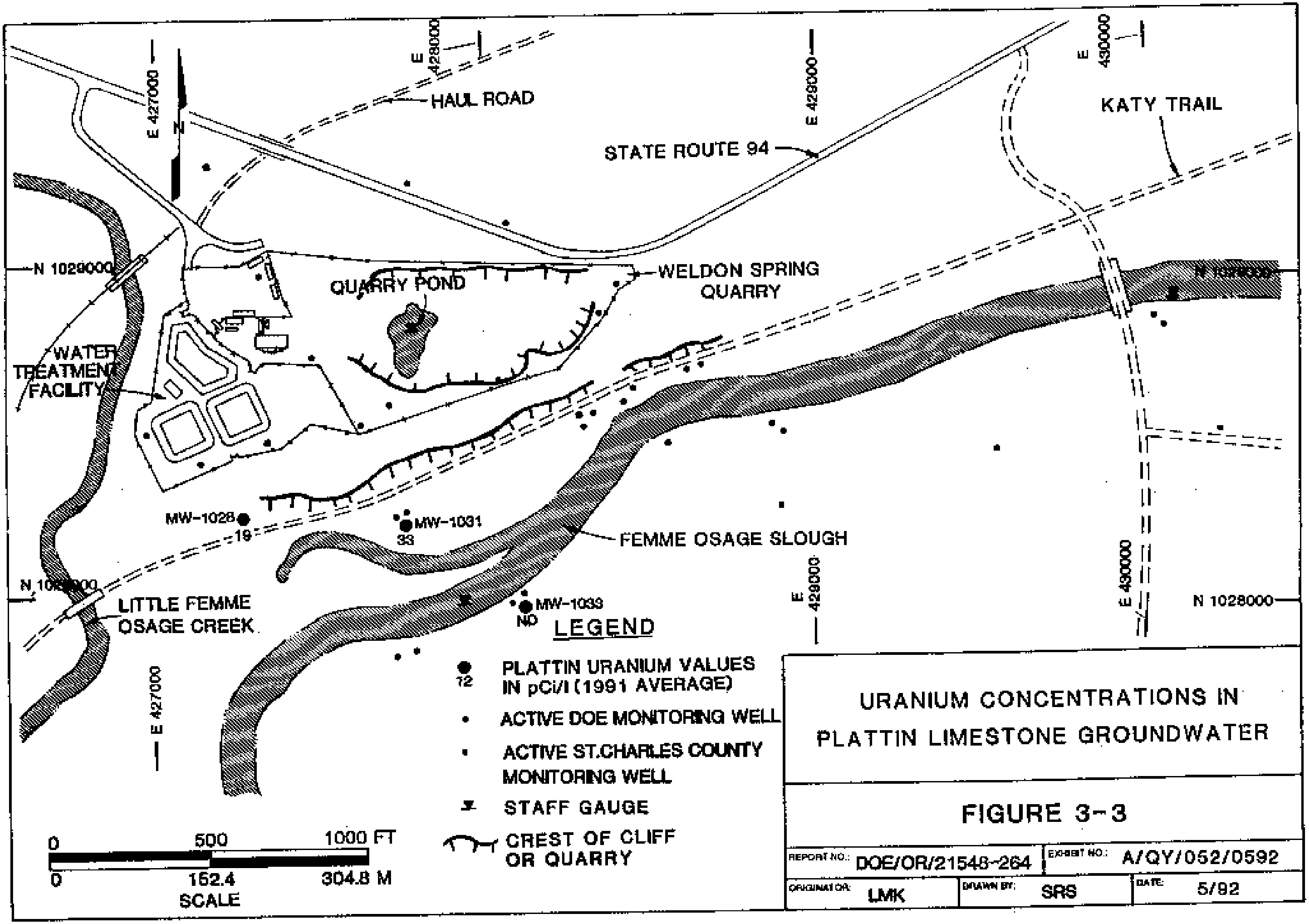
REPORT NO: DOE/OR/21548-264		EXHIBIT NO: A/QY/050/0592
ORIGINATOR: LMK	DRAWN BY: SRS	DATE: 5/92



URANIUM CONCENTRATIONS IN DECORAH GROUP GROUNDWATER

FIGURE 3-2

REPORT NO.: DOE/OR/21548-264	EXHIBIT NO.: A/QY/051/0592	
ORIGINATOR: LMK	DRAWN BY: SRS	DATE: 5/92



URANIUM CONCENTRATIONS IN PLATTIN LIMESTONE GROUNDWATER

FIGURE 3-3

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/QY/052/0592	
ORIGINATOR: LMK	DRAWN BY: SRS	DATE: 5/92	

3.2 Characteristics of Media

The following subsections describe the environmental setting and the extent of contamination in the different media.

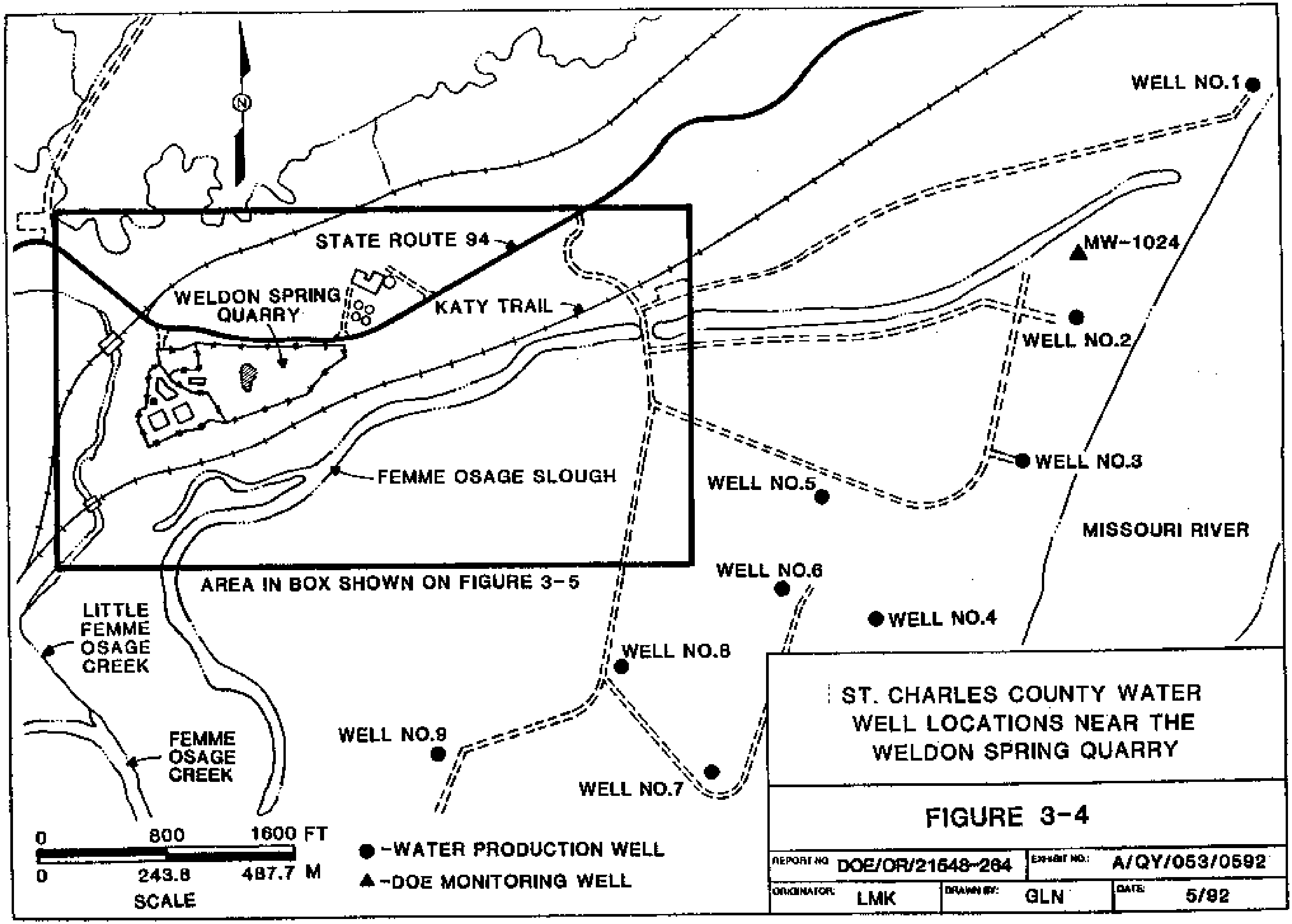
These sections are described in order of importance, e.g., groundwater poses the biggest environmental threat to man and the environment. In contrast, once the quarry wastes have been removed, the air pathway will likely have no detrimental effect on the surrounding environment media. The following subsections provide a summary of data collected from previous studies and on-going monitoring.

3.2.1 Groundwater

Prior to 1987, water quality testing was performed primarily for radionuclides, nitrate, and chloride. In 1987, new monitoring wells were installed and water quality parameters were expanded. Since this time the monitoring program has been reviewed and revised annually. Current analytical parameters include radionuclides, nitroaromatics, inorganic anions, and metals. All existing monitoring wells, including the St. Charles County well field, are shown in Figures 3-4 and 3-5. Currently 36 monitoring wells are active including the four St. Charles County wells (RMW series) and five wells recently installed to satisfy Resource Conservation Recovery Act (RCRA) monitoring requirements for the water treatment facility. Monitoring wells MW-1029 through MW-1039 were installed in 1991; therefore, data from these wells are limited. Wells MW-1035 through MW-1039 were installed in the alluvium to detect possible leakage from the treatment plant area.

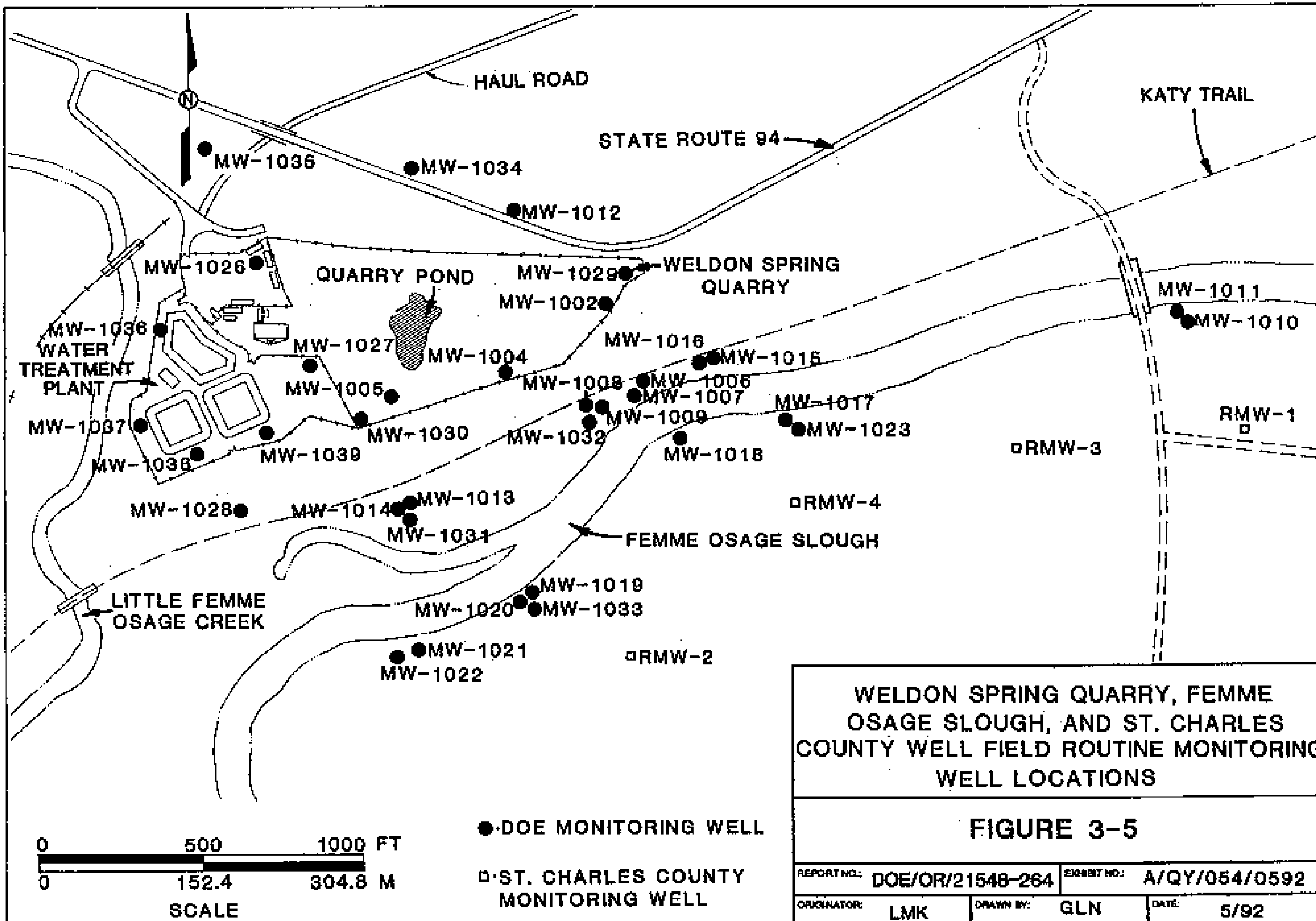
Routine monitoring of existing wells provides some background and contamination data for radiological and chemical constituents, the most important of which is uranium (See Table 3-2). Most of the uranium contamination is present south and southeast of the quarry, but contamination is also present in two monitoring wells located west of the quarry. For additional details on the contamination, consult *Annual Site Environmental Reports* (ASER) (MKF and JEG 1988a, MKF and JEG 1989a, MKF and JEG 1990a and MKF and JEG 1991c) or the references listed in Table 3-1.

Arsenic has been found in anomalous quantities in monitoring wells south of the slough, but is absent or present at background concentrations in the bedrock and alluvium in wells north



ST. CHARLES COUNTY WATER WELL LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-4



WELDON SPRING QUARRY, FEMME OSAGE SLOUGH, AND ST. CHARLES COUNTY WELL FIELD ROUTINE MONITORING WELL LOCATIONS

FIGURE 3-5

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/QY/054/0592	
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92	

TABLE 3-2 Annual Averages for Total Uranium in Groundwater Around the Weldon Spring Quarry

WSSRAP ID	Uranium-Total pCi/l 1990	Uranium-Total pCi/l 1991
ALLUVIUM AND SURFICIAL MATERIAL WELLS		
MW-1006	3226	3397
MW-1007	100	118
MW-1008	5134	4076
MW-1009	5	5
MW-1010	2	ND
MW-1011	10	16
MW-1014	816	955
MW-1016	173	618
MW-1017	1	1
MW-1018	6	ND
MW-1019	5	ND
MW-1020	3	ND
MW-1021	7	ND
MW-1022	10	ND
MW-1023	1	ND
MW-1024	1	ND
MW-1026	ND	ND
MW-1035	NOL	ND
MW-1036	NOL	ND
MW-1037	NOL	ND
MW-1038	NOL	ND
MW-1039	NOL	7
MW-RMW1	4	ND

TABLE 3-2 Annual Averages for Total Uranium in Groundwater Around the Weldon Spring Quarry (Continued)

WSSRAP ID	Uranium-Total pCi/l 1990	Uranium-Total pCi/l 1991
MW-RMW2	7	5
MW-RMW3	10	ND
MW-RMW4	3	3
MW-RAWW	2	ND
MW-FINW	1	ND
MW-PW02	2	ND
MW-PW03	2	ND
MW-PW04	2	ND
MW-PW05	4	ND
MW-PW06	3	ND
MW-PW07	6	1
MW-PW08	1	ND
MW-PW09	6	ND
DECORAH GROUP WELLS		
MW-1002	2	ND
MW-1004	5167	4810
MW-1005	2481	1988
MW-1012	2	ND
MW-1013	918	910
MW-1015	575	1081
MW-1027	619	665
MW-1030	NOL	7
MW-1032	NOL	666
MW-1034	NOL	1

TABLE 3-2 Annual Averages for Total Uranium in Groundwater Around the Weldon Spring Quarry (Continued)

WSSRAP ID	Uranium-Total pCi/l 1990	Uranium-Total pCi/l 1991
PLATTIN LIMESTONE WELLS		
MW-1028	6	19
MW-1029	NOL	2
MW-1031	NOL	33
MW-1033	NOL	ND

Source: (MKF and JEG 1991c and 1992)

Uranium Total	Rounded to full decimal
ND	Non Detected
NOL	Not on Line on Sample Date
MW-RAWW	Untreated Water From St. Charles County Water Treatment Plant
MW-FINW	Treated Water From St. Charles County Water Treatment Plant

of the slough. This metal was recently added to the analytical parameter list in 1991, and additional upgradient background data are needed. Nitroaromatic compounds (1,3,5-TNB; 1,3-DNB; 2,4,6-TNT; 2,4-DNT; 2,6-DNT and nitrobenzene) are found in non-detect (ND) values as high as 174 μg/l for 1,3,5-TNB for MW-1002. Non-detect values predominate; however, values may vary for specific compounds and laboratories between 0.010 μg/l to 0.500 μg/l. Anomalous and contaminated values are mostly present in wells known to also contain uranium contamination.

Sulfate contamination exceeding the EPA's drinking water standard (250 mg/l) are encountered in six wells also contaminated with uranium.

Some contamination may also have entered the Femme Osage Slough from the quarry area. The original contamination source at the quarry proper is scheduled to be moved to the Weldon Spring Chemical Plant (WSCP) site between late 1991 and the end of 1994. Consequently, the remaining contamination will be material that has leached from the quarry to adjacent areas.

Present monitoring wells provide insufficient data to fully understand migration routes and the extent of contamination, and do not provide adequate background data for all aquifers. Previous studies indicate that the alluvium west of the quarry is not contaminated. However, MW-1027, screened within the bedrock (Decorah) immediately west of the quarry, contains anomalous uranium and nitroaromatic contamination; bedrock further west has not yet been monitored. Two bedrock wells (Decorah and Kimmswick) north of the quarry are void of contamination. However, additional data is needed from Plattin Limestone to provide upgradient background information. Groundwater within the Plattin Limestone south of the quarry, but north of the slough, contains anomalous uranium and nitroaromatic contamination. Groundwater south of the slough (within the Plattin) remains at background. All other chemical compounds and radionuclides have remained below detection limits or within background ranges. Some information is available on the chemical and radiological characteristics of groundwater within bedrock (Kimmswick and Decorah) east of the quarry, but additional data are needed to thoroughly define and monitor the extent of contamination, both vertically and horizontally, in this area.

Alluvium and Surficial Material

Contaminants present in groundwater pose the greatest potential threat due to the proximity of contaminated groundwater to the St. Charles County public water supply wellfield (see Figure 3-1). The U.S. Department of Energy (DOE) is currently monitoring 22 DOE wells and four St. Charles County monitoring wells (RMW series; see Figure 3-5). Based on 1991 annual averages, a total of six monitoring wells contain uranium above the proposed maximum contaminant level (PMCL) for drinking water. All of these wells are located south and southeast of the quarry, but north of the slough. The extent of contamination to east is unknown, and additional data are required, especially north of RMW-3. Additional water quality data are also required southwest of MW-1014.

Decorah Group

Within the Decorah Group a total of 10 wells currently monitor groundwater chemistry, six of which contain more than the proposed drinking water standard for total uranium (Figure 3-2). All of these contaminated wells are south of the quarry except MW-1027 which is located west of the source. The Decorah Group unconformably contacts the Missouri River alluvium to the south of the quarry. The strike of this contact is approximately N60E, parallel to the limestone cliffs and generally parallel to the Femme Osage Slough. Seepage of contamination is through fractures, joints, and bedding planes that discharge into the Missouri River alluvium. At this time no additional wells are required in this formation.

Plattin Limestone

Three monitoring wells are completed in this unit south of the slough (see Figure 3-3). MW-1028 is screened across the contact between the lower Decorah Group and upper Plattin Limestone. Anomalous total uranium occurs in two monitoring wells, with the highest concentration closest to the quarry. Upgradient monitoring wells are lacking. Additional data are needed to the west, south, and upgradient, or north, of the quarry.

3.2.2 Surface Water

As of 1991, routine monitoring of surface water in the WSQ area includes the following parameters: (1) radionuclides (total uranium, thorium, radium); (2) nitroaromatics; (3) metals

(As, Ba); and (4) anions (sulfate, fluoride, nitrate). Background values for total uranium in surface water are considered to be reflected in data obtained from the Little Femme Osage Creek and the Missouri River. Uranium is the primary source of contamination in the quarry area. Other components are at, or near background levels with the possible exception of arsenic. Current routine surface water sample locations are shown in Figures 3-6 and 3-7.

As expected, the quarry pond water contains relatively high annual average levels of uranium (969 pCi/l and 2,401 pCi/l; see Table 3-3). Average 1991 levels for the Little Femme Osage Creek and Missouri River range from 3.5 pCi/l to 5.4 pCi/l total uranium. Within the Femme Osage Slough values range from 15 pCi/l to 129 pCi/l. Generally, higher levels of contamination occur west of the culvert, near routine surface water sampling location SW-1005 indicating uranium contaminated groundwater is discharging into the slough. Other radionuclides are not pressent in surface water in the Femme Osage Slough.

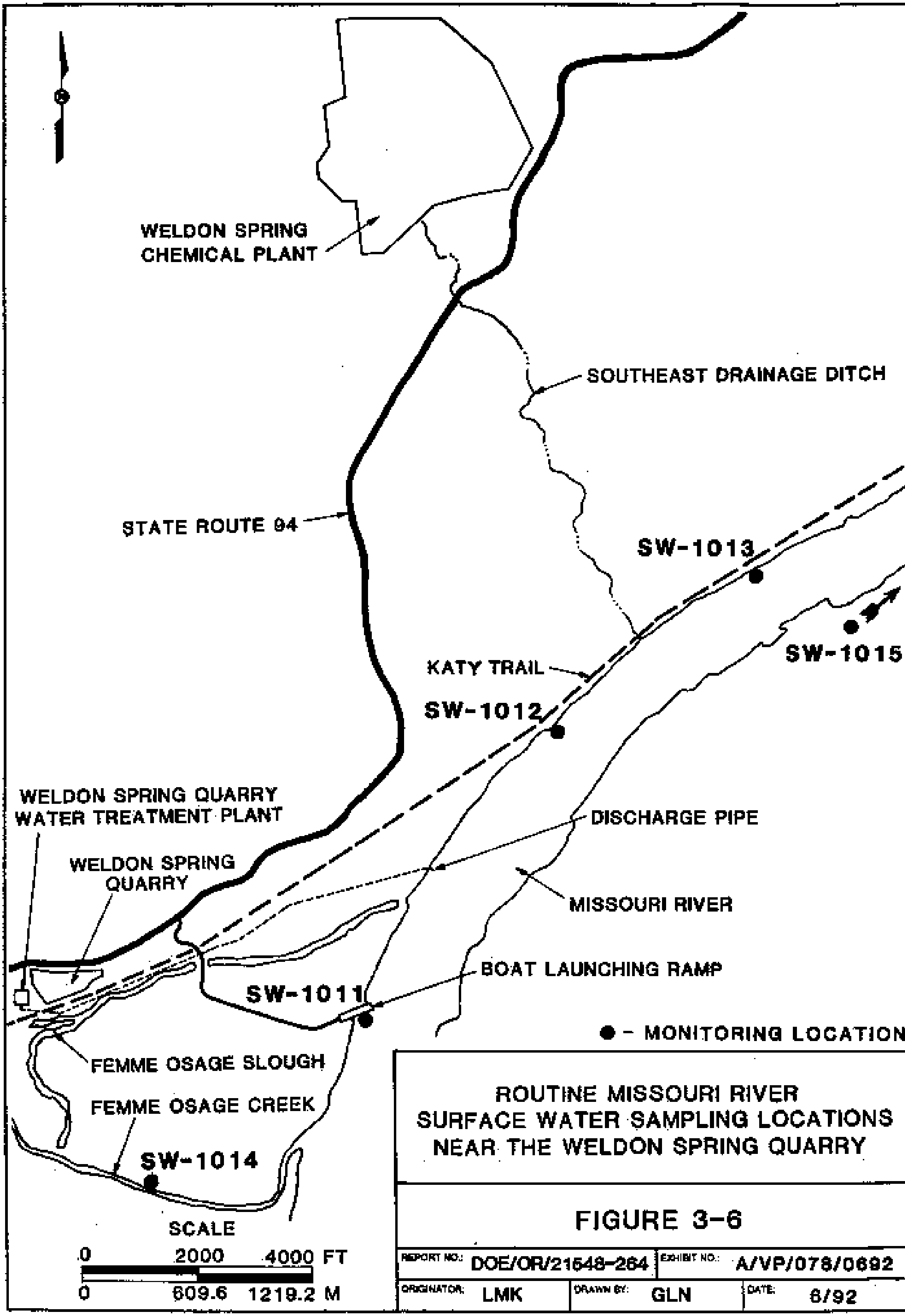
Sulfate (SO_4) occurs at low levels in the Femme Osage Slough (80 μg/l), while the average sulfate level in Missouri water is 122 μg/l (MKF and JEG 1990a). Nitroaromatics and radionuclides are not present in the Femme Osage Slough. Arsenic and barium are present at background levels.

Results of routine monitoring for surface water are included in the *Annual Site Environmental Report* (ASER). Additional characterization of surface water bodies near the quarry is not proposed at this time.

3.2.3 Slough Sediments

The Femme Osage Slough is located 152 m (500 ft) south of the quarry and was created in the late 1950's when a protective levee was build around the well field (Richardson 1960b). Prior to the levee construction the slough was part of the Femme Osage and Little Femme Osage Creeks. Hydrologically, the slough is downgradient from the quarry.

In 1988, slough sediment samples were collected from 10 sites at 6 in. intervals (Figure 3-8) (Geotechnology 1989). All samples were analyzed for total uranium and three sample locations also for Ra-226, Th-230 and Th-232 (Table 3-4). Most samples contain low uranium levels (1.1 pCi/g to 9.0 pCi/g) which are in, or slightly above, the natural background range. Ra-226 was not detected, while Th-230 and Th-232 are at, or slightly above background



ROUTINE MISSOURI RIVER SURFACE WATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 3-6

REPORT NO: DOE/OR/21548-264		EXHIBIT NO: A/VP/078/0692	
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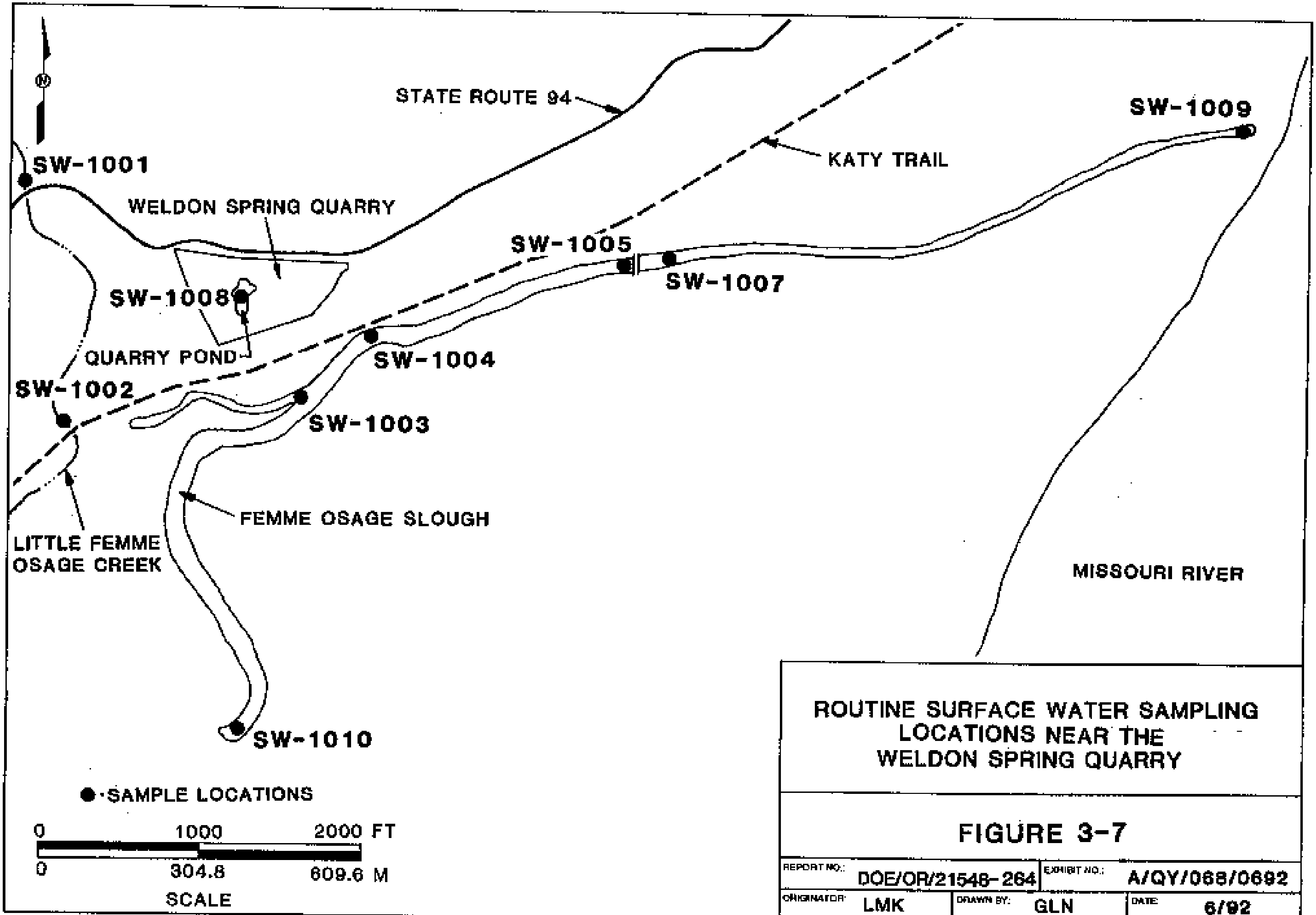


ROUTINE SURFACE WATER SAMPLING
LOCATIONS NEAR THE
WELDON SPRING QUARRY

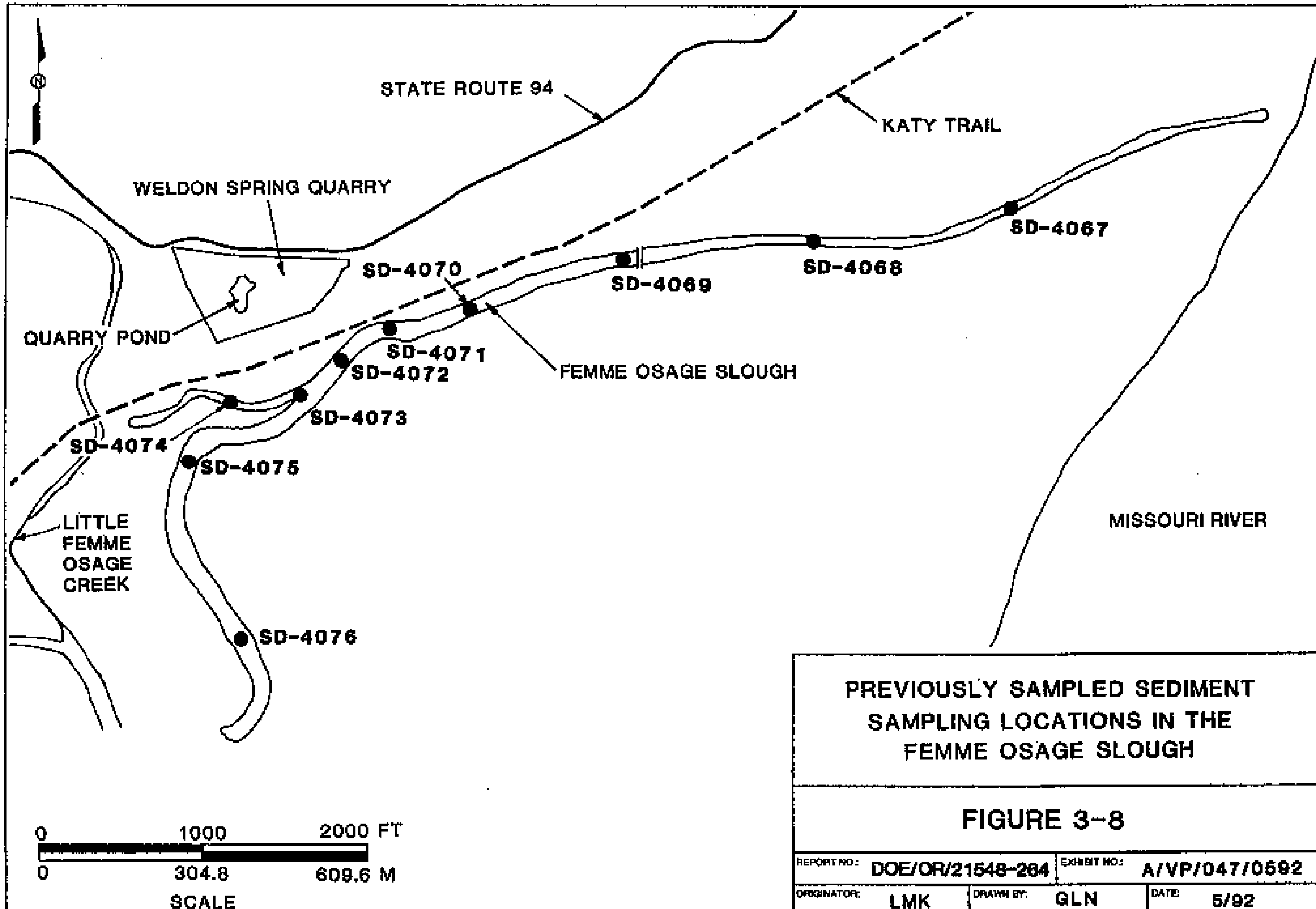
FIGURE 3-7

REPORT NO.: DOE/OR/21548-264	EXHIBIT NO.: A/QY/068/0692	
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 6/92

TABLE 3-3 Annual Average Uranium Concentrations for Surface Water Near the Weldon Springs Quarry

WSSRAP ID	Uranium - Total pCi/l 1990	Uranium - Total pCi/l 1991
STREAM AND RIVER WATER		
SW-1001	4.5	2.3
SW-1002	6.8	3.1
SW-1011	4.3	4.0
SW-1012	5.7	3.9
SW-1013	5.9	3.1
SW-1014	NS	1.8
SLOUGH WATER		
SW-1003	45.7	92.6
SW-1004	47.6	128.0
SW-1005	19.9	47.5
SW-1007	17.2	15.4
SW-1009	15.9	15.1
SW-1010	34.4	77.5
QUARRY POND		
SW-1008	2400.7	968.8

NS Not sampled
Source: MKF and JEG, 1991c
MKF and JEG, 1992a



PREVIOUSLY SAMPLED SEDIMENT SAMPLING LOCATIONS IN THE FEMME OSAGE SLOUGH

FIGURE 3-8

REPORT NO.:	DOE/OR/21548-264	EXHIBIT NO.:	A/VP/047/0592		
ORIGINATOR:	LMK	DRAWN BY:	GLN	DATE:	5/92

TABLE 3-4 Total Uranium in the Femme Osage Slough Sediments

WSSRAP ID	Total Uranium in pCi/g - Depth Interval in Inches			Sa. Site Average
	0-6	6-12	12-18	
SD-4067	3.0	4.1	ND	2.53
SD-4068*	ND	ND	1.9	.97
SD-4069*	3.1	1.4	1.7	2.07
SD-4070	5.6	9.0	8.4	7.67
SD-4071	2.3	9.0	1.5	4.27
SD-4072	ND	4.8	1.8	2.37
SD-4073	1.2	ND	NS	2.03
SD-4074	3.8	5.1	4.2	4.37
SD-4075*	2.4	1.5	1.1	1.67
SD-4076	7.2	5.0	3.9	5.37
INTERVAL AVERAGE	**2.96**	**4.09**	**2.78**	**3.3**

ND Non detect
NS No Sample
* Analyzed for Radium 226, Thorium 230 and 232
1/2 of DL used for averages for ND

Detection Limit (DL) is 1.0 pCi/g
Source: (Geotechnology 1989)

levels (< 1 to 3 pCi/g). These elevated levels of radionuclides are attributed to seepage from the quarry to the slough, water and filtration in slough sediments.

Uranium contamination is present north of the slough in groundwater and also in elevated levels in surface water in the slough. Monitoring wells south of the slough lack elevated radionuclides.

Due to the absence of comparable local radionuclide background data and lack of data for nitroaromatics, metals (As, Ba) and anions (nitrate, sulfate), additional slough sampling is required as outlined in this plan.

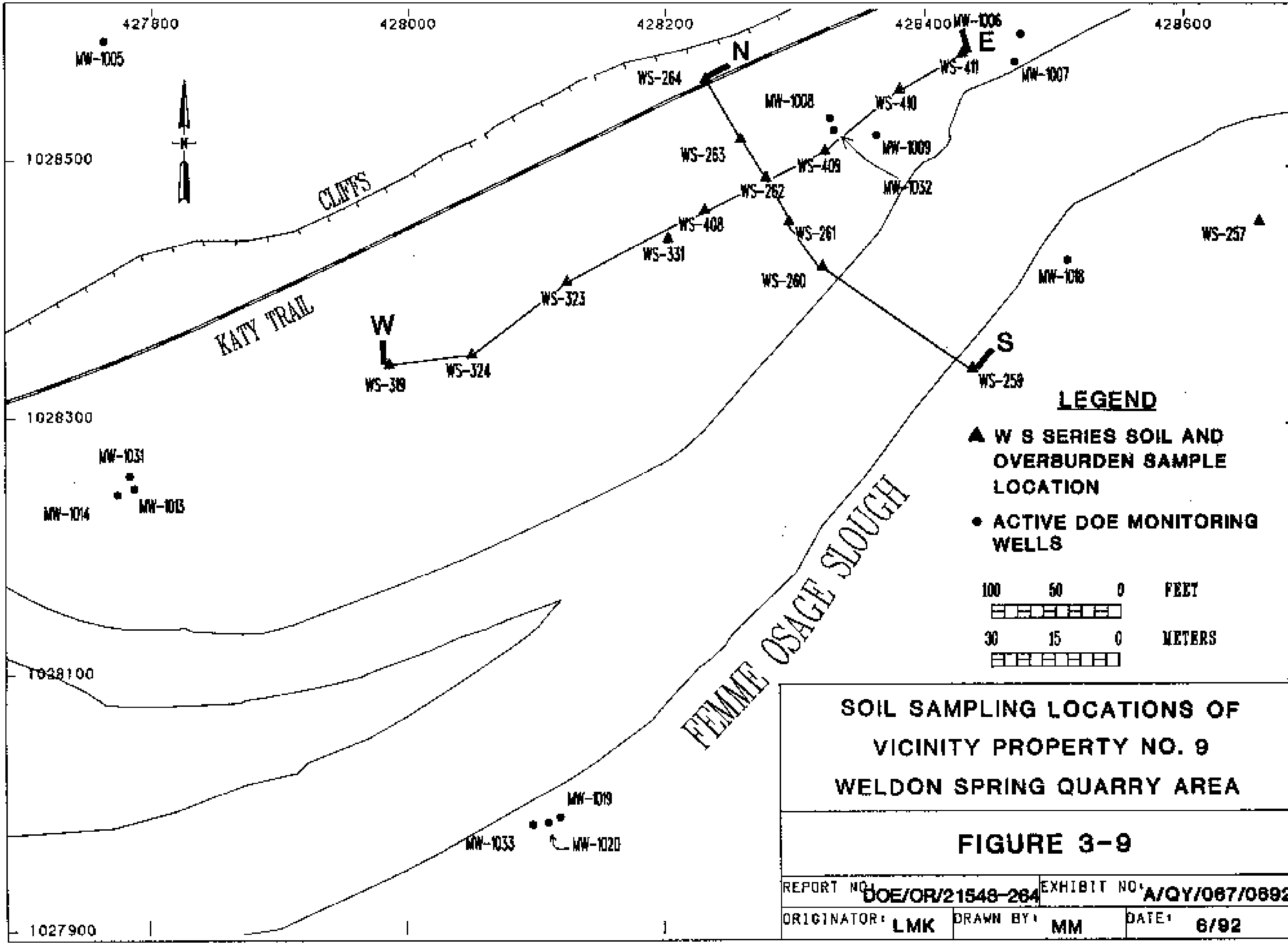
3.2.4 Soils

Vicinity property No. 9, a contaminated area south of the quarry between the Katy Trail and the Little Femme Osage Slough, contains anomalous levels of uranium from the surface to a depth of about 3.7 m (12 ft) (Marutzky et al, 1988). (See Figures 3-9 through 3-11). Table 3-5 is a summary of uranium concentrations in soil within or near vicinity property No. 9. Present data indicates that this contamination is essentially limited to the upper 3.7 m (12 ft) and has not migrated south of the slough.

Additional soil and subsurface soil sampling is not contemplated under this plan.

3.2.5 Air

Air monitoring at or near the WSQ has included radon, gamma radiation, radioactive air particulates, and radiological emissions. Figure 3-12 shows current air monitoring locations. Results show that radon is detected at higher concentrations in the quarry due to higher radium concentrations associated with quarry wastes (MKF and JEG 1991d). Radon concentration for locations outside the quarry are below background, or slightly elevated, but are significantly below regulatory requirements and DOE guidelines (MKF and JEG 1991c). Gamma radiation within the quarry is above background, while locations outside the quarry remain at background. Radioactive air particulate monitoring results indicate no release of radioactivity from the quarry that can be distinguished from background levels. Radiological contamination surveys performed at various locations surrounding the quarry have indicated that contaminated materials are not being carried into unrestricted areas via air migration.



SOIL SAMPLING LOCATIONS OF
VICINITY PROPERTY NO. 9
WELDON SPRING QUARRY AREA

FIGURE 3-9

REPORT NO: DOE/OR/21548-264		EXHIBIT NO: A/QY/067/0692
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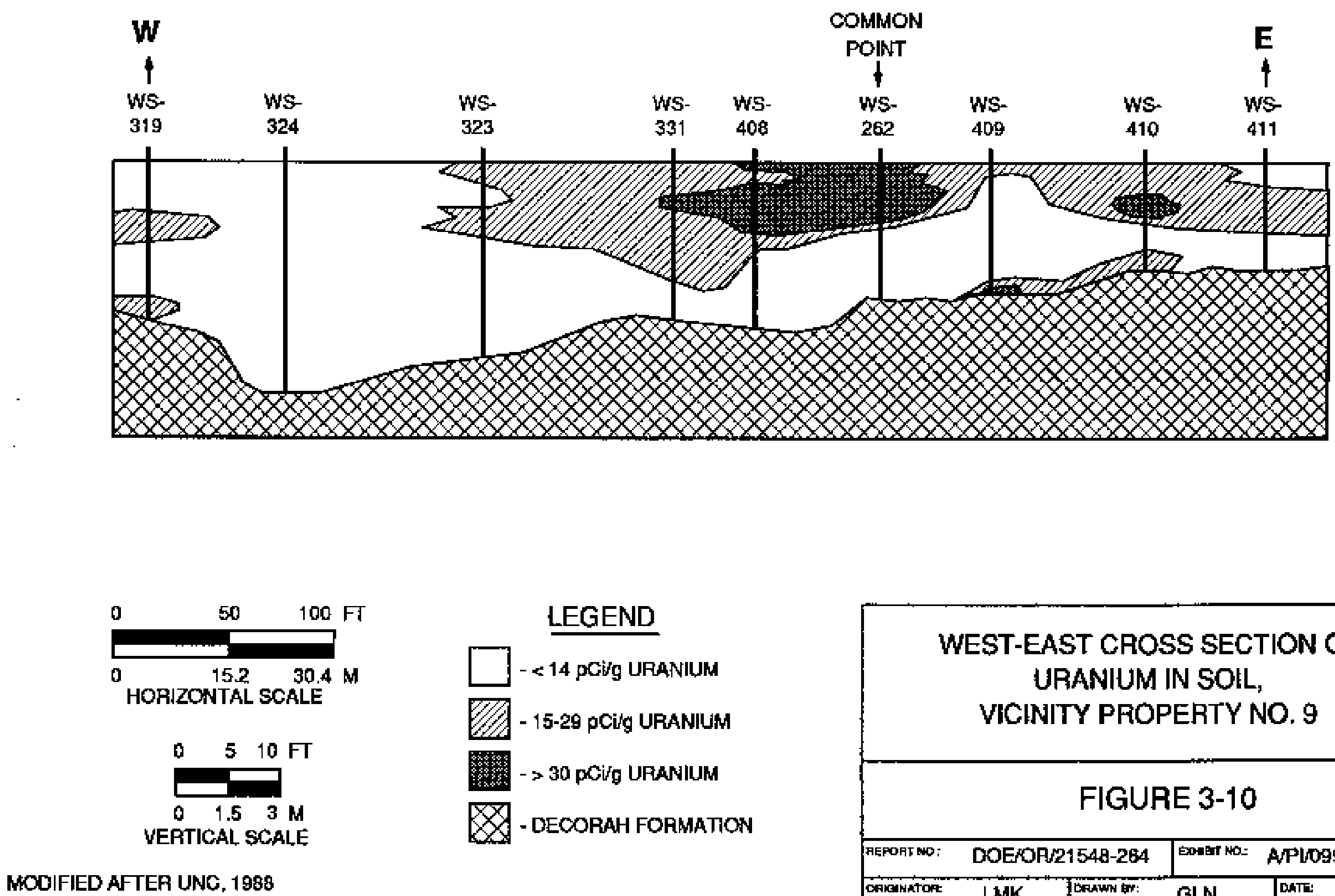
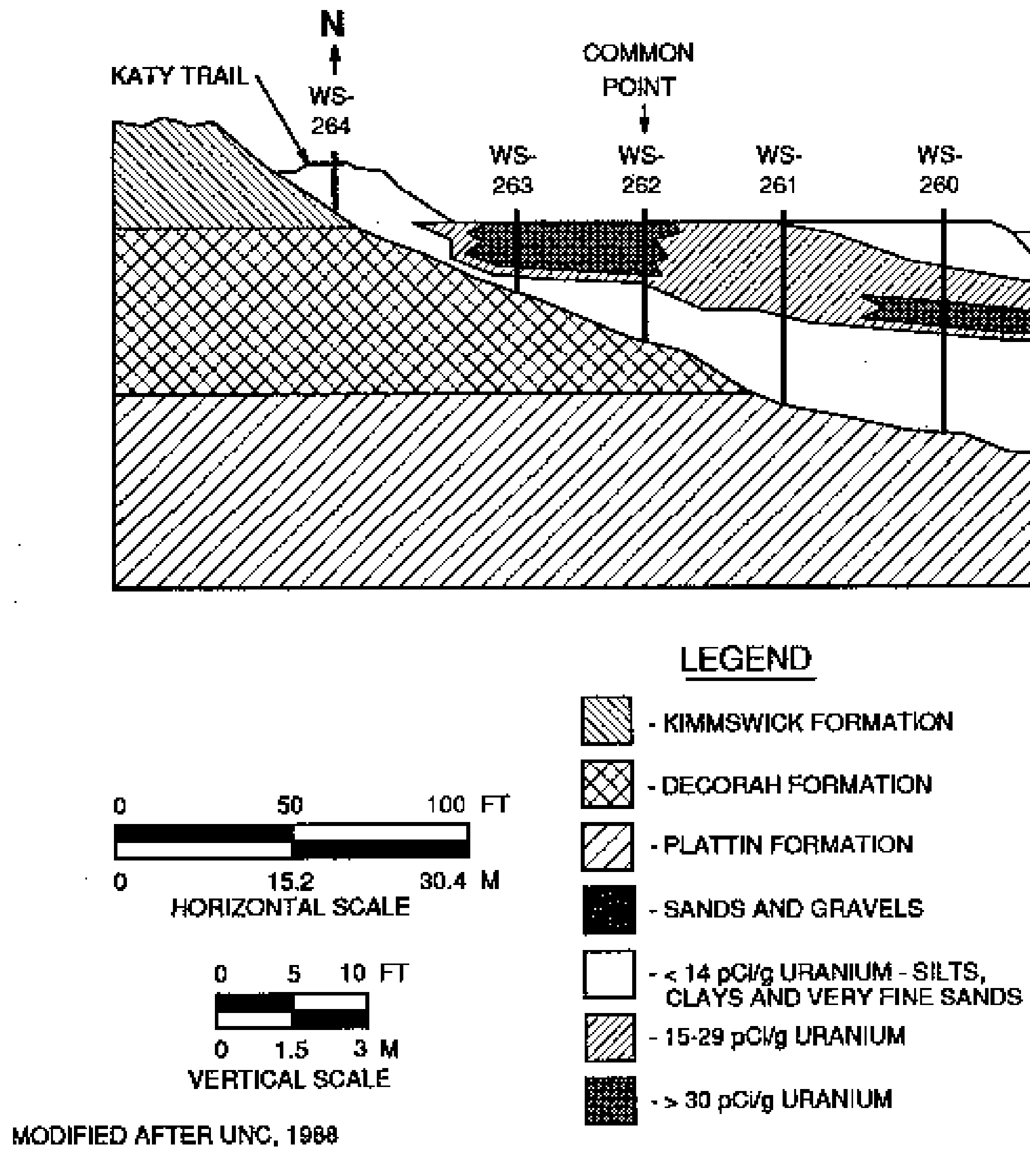


WEST-EAST CROSS SECTION OF URANIUM IN SOIL, VICINITY PROPERTY NO. 9

FIGURE 3-10

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/PI/099/0692	
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 6/92	



NORTH-SOUTH CROSS SECTION OF URANIUM IN SOIL, VICINITY PROPERTY NO. 9

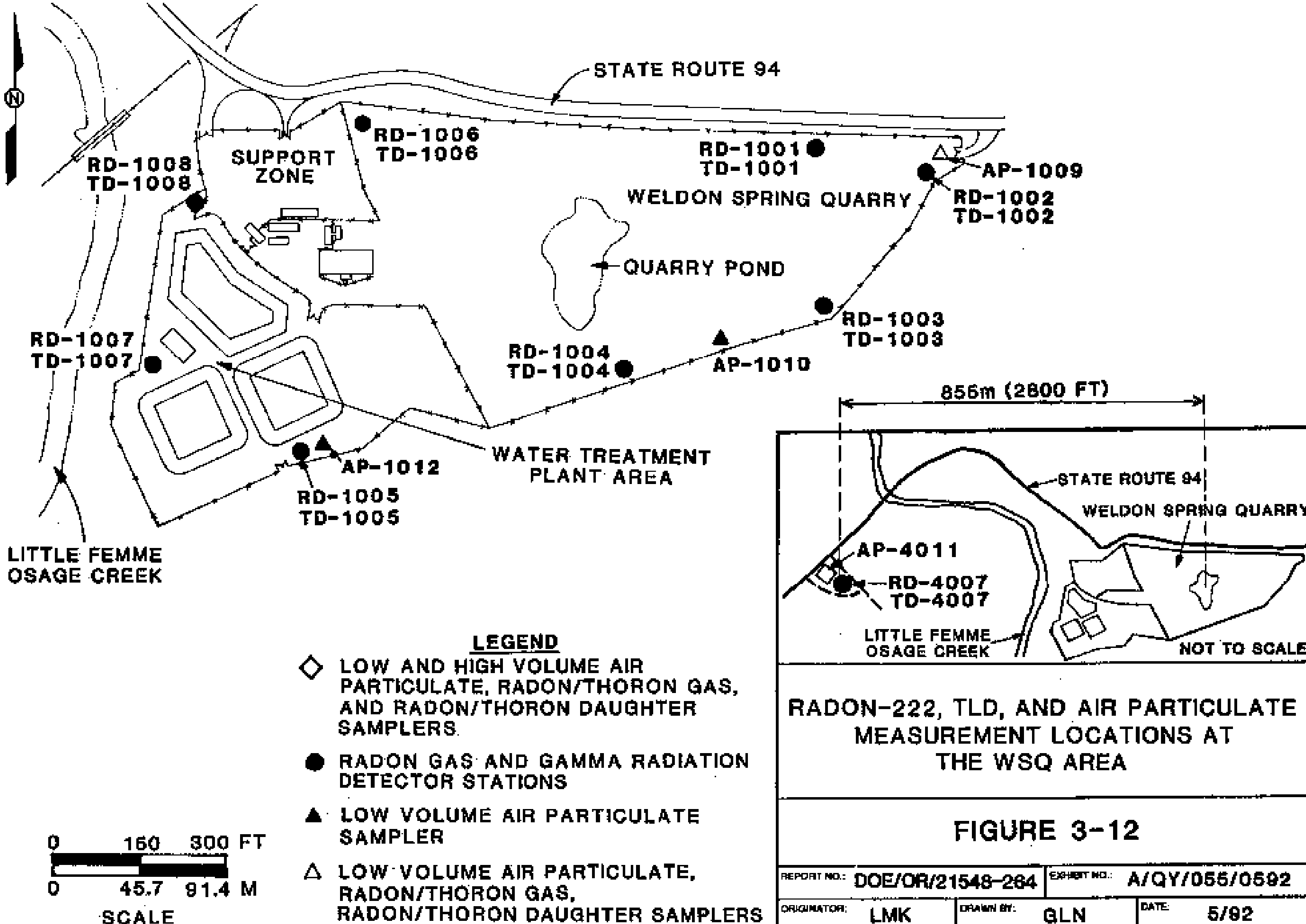
FIGURE 3-11

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/PI/100/0692	
ORIGINATOR: LMK	DRAWN BY: GLN		DATE: 6/92

TABLE 3-5 Summary of Uranium Concentrations in Soil Within or Near Vicinity Property No. 9

Borehole No.	Depths (ft) with +10 pCi/g[a]	Max. Concentration/(depth) [pCi/g[a]/(ft)]
WS-257	N/A	0.3
WS-259	N/A	0.7
WS-260	0-11.0	44.4 (8-9)
WS-261	0-8.0	28.5 (3-4)
WS-262	0-6.0	106.9 (0-1)
WS-263	0-8.0	65.9 (0-1)
WS-264	N/A	0.3
WS-319	0-16.0	24.8 (15-16)
WS-323	0-8.0	16.5 (6-7)
WS-324	N/A	6.3 (4-5)
WS-331	0-13.0	34.4 (3-4)
WS-408	0-9.0	45.0 (0-1)
WS-409	0-13.5	93.3 (13-13.5)
WS-410	0-6.0	38.7 (3-4)
WS-411	0-11.0	27.5 (4-5)

N/A Not applicable, <10 pCi/g.
Source: Marutzky et.al. 1988



LEGEND

◇ LOW AND HIGH VOLUME AIR PARTICULATE, RADON/THORON GAS, AND RADON/THORON DAUGHTER SAMPLERS

● RADON GAS AND GAMMA RADIATION DETECTOR STATIONS

▲ LOW VOLUME AIR PARTICULATE SAMPLER

△ LOW VOLUME AIR PARTICULATE, RADON/THORON GAS, RADON/THORON DAUGHTER SAMPLERS

RADON-222, TLD, AND AIR PARTICULATE MEASUREMENT LOCATIONS AT THE WSQ AREA

FIGURE 3-12

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/QY/055/0592
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92

Radiological and air particular emissions will change during, and following, bulk waste removal. Additional monitoring sites are not proposed in this plan.

4 DATA QUALITY OBJECTIVES

Environmental data are collected for making and defending many decisions. Using the data quality objective (DQO) process to plan new data collection efforts helps to ensure that the right type and quality of information will be collected and that the study design developed will efficiently support the decision. Using the DQO process can help improve the effectiveness, efficiency, and defensibility of decision making. The DQOs are determined by the end uses of the data to be collected. Data quality objectives have been established as part of this sampling plan. Data quality requirements including chemical compounds and radionuclides, field measurements, analytical methods, and detection limits have been selected from the list as shown in Table 4-1 to provide additional characterization and environmental monitoring of the quarry.

The DQO process is a total quality management tool developed to facilitate the planning of data collection activities. The following discussions will provide insight on how this process affects this investigation.

1. Existing Problem

The types, spatial extent, and magnitude of contamination in different media are not adequately defined in the area surrounding the Weldon Spring Quarry (WSQ). Previous investigations and ongoing routine surveillance activities have provided a general understanding of the contamination. Current unknowns include the exact groundwater pathways from the quarry source to the Missouri River alluvium, the extent of the groundwater contamination in the bedrock west of the quarry, and the eastern boundary of the contamination in the alluvium and underlying bedrock. The groundwater background in both the alluvium and in the bedrock has not been established for all parameters. This plan had been written to identify environmental monitoring data gaps in the groundwater, surface water, sediments, and soils.

2. Decisions to be Made

The environmental monitoring efforts require that decisions be made with respect to protecting the public health, biota, and the environment. This plan addresses specific data collection from the following media: groundwater; surface water; surface and subsurface soils; and sediments of the Femme Osage Slough and the Femme Osage creeks. Existing data, and data collected from this plan, will be used to determine the adequacy of the existing monitoring network.

TABLE 4-1 Parameters, Analytical Methods and Detection Limits to be Used for Characterization of the Weldon Spring Quarry

Category	Analytical			Soil			Water			Comments
	Parameter	Level	Method	MDC µg/g	Precision	Accuracy	MDL µg/l	Precision	Accuracy	
Radiation	Gross alpha	I	2.6.4*	NA	NA	NA	NA	NA	NA	ES&H SOP
Screening	Gross beta/gamma	I	2.6.3*	NA	NA	NA	NA	NA	NA	ES&H SOP
Field Measurements	pH	I	4.5.1*	NA	NA	NA	NA	20	NA	ES&H SOP
	Temperature	I	4.5.1*	NA	NA	NA	NA	20	NA	ES&H SOP
	Conductivity	I	4.5.2*	NA	NA	NA	NA	20	NA	ES&H SOP
	Specific ions	I	4.5.5*	NA	NA	NA	NA	20	NA	ES&H SOP
	Organic vapors	I	3.1.1*	NA	NA	NA	NA	20	NA	ES&H SOP
	Settleable solids	I	4.5.7*	NA	NA	NA	0.1	20	NA	ES&H SOP
On-site radiological measurements	Th-230, Th-232	II	2 pCi/g	50	50	NA	NA	NA	NA	NA
	U-238, U-235,	III	EPA 901.1	1 pCi/g	50	30	NA	NA	NA	NA
	U-234, Ra-226,	III	EPA 901.1	1 pCi/g	50	20	NA	NA	NA	
	Ra-228									
Off-site radiological measurements	Nat. uranium	III	EPA 908.0	1 pCi/g	50	30	1 pCi/l	20	20	
	Radium-226, -228	III	EPA 903.1	1 pCi/g	50	30	1 pCi/l	20	20	
	Thorium-230, -232	III	EERF 00/07	1 pCi/g	50	30	1 pCi/l	20	20	
	Gross alpha	III	EPA 900.0	3 pCi/g	50	30	3 pCi/l	40	40	
	Gross beta	III	EPA 900.0	3 pCi/g	50	30	8 pCi/l	40	40	
Nitroaromatic Compounds	TNT	III	USATHAMA	1.2	e	e	0.03 d	f	f	
	2,4-DNT	III	USATHAMA	0.75	e	e	0.03 d	f	f	
	2,6-DNT	III	USATHAMA	1.41	e	e	0.01 d	f	f	
	1,3,5-TNB	III	USATHAMA	0.57	e	e	0.03 d	f	f	
	1,3-DNB	III	USATHAMA	0.9	e	e	0.09 d	f	f	
	Nitrobenzene	III	USATHAMA	1.44	e	e	0.03 d	f	f	

TABLE 4-1 Parameters, Analytical Methods and Detection Limits to be Used for Characterization of the Weldon Spring Quarry (Continued)

Category	Analytical			Soil			Water			Comments
	Parameter	Level	Method	MDC µg/g	Precision	Accuracy	MDL µg/l	Precision	Accuracy	
Miscellaneous	TSS	III	EPA 160.2	NA	NA	NA	2	20	20	
	TDS	III	EPA 160.2	NA	NA	NA		20	20	
	TOC	III	EPA 415.1				0.1	20	20	
	Lithium	III	EPA 200.7	5	50	50	50	20	20	
	Mo	III	EPA 200.7	4	50	50	4	20	20	
	Zr	III	EPA 200.7	20	50	50	20	20	20	
	Cr+3	III	EPA 200.7		50	50	10	20	20	
	Cr+6	III	Calorimetric		50	50	5	20	20	
	TOX	III	EPA 450.0	5	50	50		20	20	
	NO3	III	300.0/343.2c	0.5	50	50	0.25/0.1C*	20	20	mg/l
	SO4	III	300.0/375.4c	5	50	50	1.0/1.0c*	20	20	mg/l
	Cl	III	300.0/325.1c	1.5	50	50	0.25/0.2c*	20	20	mg/l
	Fl	III	300.0/340.2c	1.25	50	50	0.25/0.6c*	20	20	mg/l
	NO2	III	300.0	0.5	50	50		20	20	mg/l
	% Moisture	III	ASTM	NA	50	NA	NA	NA	NA	
	pH (soil)	III	EPA 160.2	NA	50	NA	NA	NA	NA	
CLP-VOA	All	IV	CLP	CRDL	As required by CLP		CRDL	As required by CLP		
CLP-Semi-VOA-BNA	All	IV	CLP	CRDL	As required by CLP		CRDL	As required by CLP		
CLP-Pest/PCB		IV	CLP	CRDL	As required by CLP		CRDL	As required by CLP		

TABLE 4-1 Parameters, Analytical Methods and Detection Limits to be Used for Characterization of the Weldon Spring Quarry (Continued)

Category	Analytical			Soil			Water			Comments
	Parameter	Level	Method	MDC μg/g	Precision	Accuracy	MDL μg/l	Precision	Accuracy	
CLP-Metals	AL	IV	CLP-ICP	20	As required by CLP		200	As required by CLP		
	AS	IV	CLP-ICP	1	As required by CLP		10	As required by CLP		
	BE	IV	CLP-ICP	0.5	As required by CLP		5	As required by CLP		
	C	IV	CLP-ICP	0.5	As required by CLP		5	As required by CLP		
	CR	IV	CLP-ICP	1	As required by CLP		10	As required by CLP		
	CU	IV	CLP-ICP	2.5	As required by CLP		25	As required by CLP		
	PB	IV	CLP-AA	0.5	As required by CLP		5	As required by CLP		
	HG	IV	CLP-CV	0.1	As required by CLP		0.2	As required by CLP		
	NI	IV	CLP-ICP	4	As required by CLP		40	As required by CLP		
	NA	IV	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	ZN	IV	CLP-ICP	2	As required by CLP		20	As required by CLP		
	BA	IV	CLP-ICP	20	As required by CLP		200	As required by CLP		
	AG	IV	CLP-ICP	1	As required by CLP		10	As required by CLP		
	FE	IV	CLP-ICP	10	As required by CLP		10	As required by CLP		
	K	IV	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	MN	IV	CLP-ICP	1.5	As required by CLP		15	As required by CLP		
	MG	IV	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	SE	IV	CLP-AA	0.5	As required by CLP		5	As required by CLP		
	VA	IV	CLP-ICP	5	As required by CLP		50	As required by CLP		
	TL	IV	CLP-AA	1	As required by CLP		10	As required by CLP		
	SB	IV	CLP-ICP	6	As required by CLP		60	As required by CLP		
	CA	IV	CLP-ICP	500	As required by CLP		5000	As required by CLP		
	CO	IV	CLP-ICP	5	As required by CLP		50	As required by CLP		

TABLE 4-1 Parameters, Analytical Methods and Detection Limits to be Used for Characterization of the Weldon Spring Quarry (Continued)

Category	Analytical			Soil			Water			Comments
	Parameter	Level	Method	MDC µg/g	Precision	Accuracy	MDL µg/l	Precision	Accuracy	
Other parameters not listed		II,III,IV	TBD	TBD	50	50	TBD	20	20	See note

* See comment section
TBD To be determined
NA Not applicable
MDC Minimum detection concentration
MDL Minimum detection limit
CLP Contract laboratory program
EPA U.S. Environmental Protection Agency
USATHAMA U.S. Army Toxic and Hazardous Material Agency
Accuracy = Percent bias = percent recovery - 100

(a) Accuracy and precision data presented from EPA DQO guidance document - specific precision and accuracy to be negotiated with the laboratory.
(b) New detection limits and/or methods to be established with new laboratory.
(c) Methods and detection limits established with current laboratory (JTC).
(d) Army Environmental Hygiene Agency (AEHA) detection limits.
(e) To be negotiated with the laboratory.
(f) To be provided by AEHA.

NOTE: Generic DQRs apply to media and/or analytical methods not listed in this table.
Source: MKF and JEG 1992b (modified)

Criteria to be evaluated include: media monitored, monitoring locations, radiological and chemical parameters, and sampling frequency. The decision will also support the final characterization planning efforts for the area outside the quarry.

3. Decision Inputs

Additional background, contamination, and physical data for each of the media are needed to evaluate the existing monitoring program. Physical data includes the preferential pathway analysis for groundwater media. Information obtained as a result of this sampling plan will be used to evaluate specific monitored media, monitoring locations, sampling frequency, and analytical parameters.

4. Boundary of Study Area

The area of the investigation includes all areas known or suspected to be contaminated by past U.S. Atomic Energy Commission (AEC) and Department of Defense (DOD) activities at the WSQ. This area is shown in Figure 1-1 and consist of the following boundaries:

North: Approximately 229 m (750 ft) north of highway 94 and Katy Trail
West: Little Femme Osage Creek
South: Femme Osage Creek
East: Missouri River

Some background sampling will be west and north of this area. The vertical extend is from the surface through the Plattin Limestone. The Missouri River alluvium, a triangular shaped area between the Katy Trail, Missouri River, and the Femme Osage and Little Femme Osage creeks, is of prime interest.

5. Decision Criteria

Decisions on environmental monitoring activities require sufficient data to assess health risks to the public and the environment. Decision criteria for this plan will determine if additional monitoring will be required, if the current and planned monitoring locations are adequate, and if the sampling density is adequate for a defensible statistical analysis. Contaminant pathways will be scrutinized to determine if additional groundwater monitoring is required. Examples include evaluating: flow regime, dust potential from contaminated areas, and biological uptake. For chemical groundwater parameters, the U.S. Environmental Protection Agency's (EPA) primary and secondary drinking water standards and site-specific background values will be used for decision criteria. Additional monitoring will be performed if chemical values are exceeded as a result of the WSQ.

6. Uncertainty Constraints

Time and budgetary constraints are not considered in this sampling plan. DOE Order 5400.1 mandates a risk level as low as reasonably achievable (ALARA).

7. Optimization of Data Collection

This sampling plan optimizes data collection activities to the extent possible. Insufficient data exists to permit a statistical design of the sampling plan.

Optimization of data collection will be considered in a subsequent sampling plan (quarry residuals sampling plan), using existing data and results from this sampling plan. Statistical approaches will be used in the quarry residual sampling plan to optimize design criteria including sampling frequency and sample density. Consideration will be given to analytical parameter and the number of sampling locations for each matrix.

5 SAMPLING AND INVESTIGATION PROGRAM

This section describes the investigation tasks, sample locations, and analytical parameters required for each sample collected. Sample frequency for groundwater and surface water samples is defined for the initial 12 mo period. After completion, monitoring samples will be incorporated into the regular monitoring program as defined annually in the *Environmental Monitoring Plan* (EMP). The EMP for calendar year 1992 (MKF and JEG 1992c) should be consulted for existing air and water monitoring programs.

Surface geophysical surveying will precede the final monitoring well site selections. The geophysical survey results will be used to define the bedrock/alluvium interface between existing wells and other new areas. Discrete in situ groundwater sampling results will determine the three dimensional contamination distribution and will also aid in selecting final monitoring well sites and screen intervals. In situ hydrological data will be collected from bedrock wells prior to well casing installations to take advantage of open holes. Pressure packer tests are planned.

All sampling efforts proposed in this sampling plan will be outlined in work packages and performed by subcontractor or Project Management Contractor (PMC) personnel; however, all work will be supervised by the PMC. Specifications for each sampling effort will be presented in the appropriate work packages.

Based upon previous investigations, the contaminants of concern in surface water and groundwater are uranium, nitroaromatics, sulfate, and arsenic. All water samples collected will be analyzed for the contaminants of concern; additionally, groundwater and surface water will be analyzed for pH, Eh, dissolved oxygen (DO) temperature, and conductivity in the field.

5.1 Geophysical Investigations

Both surface and subsurface geophysical activities are planned. The surface geophysical work will help to refine the geological/hydrogeological model and will precede drilling activities. Results will be used to select the final borehole locations for the monitoring wells. Additionally, some locations for the in situ sampling points (Section 5.2.1.2) will be selected based on surface geophysical results. In contrast, subsurface geophysical work or wireline logging will follow the drilling phase. Existing monitoring wells will also be logged with a gamma probe during the subsurface geophysical activities.

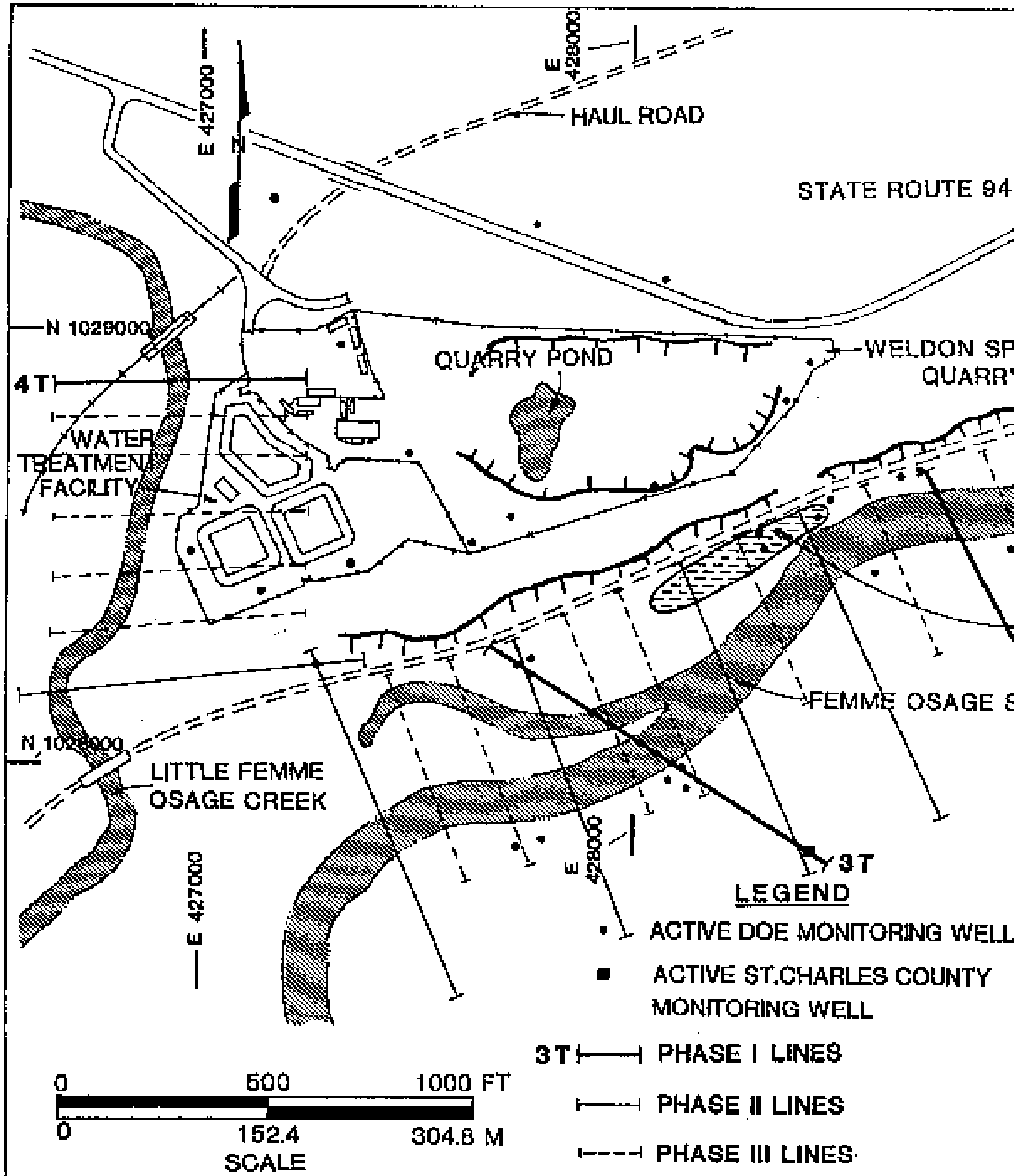
5.1.1 Surface Geophysical Surveys

Surface geophysical methods, consisting of electromagnetic (EM) and shallow seismic refraction surveys, will be utilized to provide additional information between boreholes on bedrock topography and significant sediment facies changes in the alluvium. The surface geophysical surveys will be performed by a PMC subcontractor under the guidance of an approved, task-specific work package that will define equipment requirements and utilization, data reduction, and interpretation and reporting requirements.

5.1.1.1 Electromagnetic Survey. Electromagnetic investigation, commonly known as EM surveying, is a continuous surface profiling method to detect gross conductivity differences in overburden or rocks. A weak, man-made magnetic field generated from a battery is induced into the ground with a transmitter coil and the site-specific magnetic response is noted with a second receiver coil. Type of coils, inter-coil spacing, and coil orientation determine exploration penetration depth. EM surveys will be performed to determine the depth to water table, and to map differences in water conductivity that may be associated with contamination in the alluvium. The EM-34 instrumentation will be used for depth penetration capacity. This system has an inter-coil spacing of 10 m (33 ft), 20 m (66 ft) , and 40 m (131 ft) and is capable of a depth penetration of up to 60 m (197 ft). Vertical or horizontal coil orientation, and type of array (discrete sampling vs. continuous measurements), will be outlined in a work package of the geophysical investigations.

5.1.1.2 Shallow Seismic Refraction Survey. Shallow seismic refraction surveys will be used to establish overburden and bedrock velocities. Velocity contrasts between different units will permit delineation between unsaturated and saturated alluvium and the alluvium/bedrock interface. Secondary features expected to be observed include sedimentary channels and channel remnants of the Femme Osage Creek, Little Femme Osage Creek, the Missouri River, major clay lenses, and possibly major fractures in the underlying bedrock.

The surveys are divided into three phases as shown in Figure 5-1. Phase I will consist of four test lines 244 m to 274 m (800 ft to 900 ft) long with 6.6 m (20 ft) between stations and will determine the applicability of the EM and/or shallow seismic methods. These four test lines (1T to 4T) intercept existing borehole locations where the water levels and alluvium/bedrock interfaces are known. Phase II consists of an additional six north-south and three east-west lines each 244 m (800 ft) long. Provision has been made to complete 20 additional short (91 m to



PLANNED GEOPHYSICAL LINES NEAR THE WELDON SPRING QUARRY

FIGURE 5-1

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ORIGINATOR: LMK	DRAWN BY: SRS		DATE: 5/92

182 m [300 ft to 600 ft]) fill-in lines for the final third phase. The information to be gained from Phase III includes specific details of the geology, such as old river channels in the bedrock, major lineaments, or unexpected sedimentary features.

Results of the surveys will influence selection of final in situ groundwater sampling, depth locations and monitoring well locations.

5.1.2 Borehole Geophysical Logging

Borehole geophysical or wireline logging is a method of identifying and correlating geological criteria and units between boreholes. Geophysical logging is based on the premise that different electrical responses or signals are generated from different geologic material and associated formation fluid encountered by a probe moving within a borehole. Electric impulses, representing specific downhole measurements, are plotted on a continuous strip chart related to the probe depth. Geophysical logging will identify marker beds, formation contacts, and lithologic changes. The relationship between the various methods and their applications is outlined in Table 5-1.

All uncased holes drilled for this investigation will be logged with probes capable of recording self potential (SP) also referred to as spontaneous potential, resistivity (R), natural gamma, and possibly caliper and temperature. Holes requiring casing prior to auger removal will be logged with a gamma detection probe to obtain inherent natural gamma data characteristic for each formation. Gamma radiation is the only geophysical tool available for cased holes.

The logging methods to be used are shown in Table 5-2.

5.2 Groundwater Investigations

A phased approach will be used in this groundwater sampling plan. Surface geophysical surveys, as described in Section 5.1.1, and in situ groundwater sampling will precede the final borehole location selection. The goal of all activities is to obtain background water quality data outside the contaminated area and define contamination in three dimensions. The latter is particularly important for alluvium groundwater, which may contain up to 96% of the soluble uranium outside the quarry proper (see Appendix A).

TABLE 5-1 Relationship of Different Wireline Logging Methods and Potential Application

Type of log	Properties measured	Potential applications	Required borehole conditions	Other limitations
Spontaneous potential.	Electric potential caused by salinity differences in borehole and interstitial fluids.	Lithology, shale content, and water quality.	Uncased borehole filled with conductive fluid.	Salinity difference needs between borehole fluid and interstitial fluids; correct only for NaCl fluids.
Single-point resistance.	Resistance of rock, saturating fluid, and borehole fluid.	High-resolution lithology; fracture location by differential probe.	Uncased borehole filled with conductive fluid.	Not quantitative; hole diameter effects substantial.
Gamma.	Gamma radiation from natural or artificial radioisotopes.	Lithology—may be related to clay and silt content and permeability; spectral identifies radioisotopes.	Any borehole conditions, except large diameter, or several strings of casing and cement.	None.
Caliper.	Borehole or casing diameter.	Borehole-diameter corrections to other logs, lithology, fractures, and borehole volume for cementing.	Any conditions.	Deviated holes limit some probes; significant resolution difference between tools.
Temperature.	Temperature of borehole fluid near sensor.	Geothermal gradient, flow within borehole, location of injected water, correction of other logs, and curing cement.	Fluid-filled.	Accuracy and resolution of probes varies.
Conductivity.	Most measure resistivity of fluid in borehole.	Quality of borehole fluid, flow within borehole, and location of contaminant plumes.	Fluid-filled.	Accuracy varies, requires temperature correction.

Source: (Keys 1989 [modified]).

TABLE 5-2 Type of Wireline Logging Methods for Wells

Host Rock	SP	R	Gamma	Caliper	Temp.
Alluvium, Open	X	X	X		X
Alluvium, Cased*			X		X
Bedrock, Open	X	X	X	X	X
Bedrock, Cased*			X		X

* Includes existing monitoring wells.

5.2.1 In situ Groundwater Sampling

Groundwater quality has not been fully characterized, particularly in the alluvium. To fully determine the extent, magnitude, and distribution of the contamination south of the quarry, in situ groundwater samples will be collected at 35 locations with approximately 200 discrete samples.

In situ, or discrete, groundwater sampling is an effective method for obtaining one-time samples from a specific point without installing permanent monitoring wells. It is used to determine contaminant boundaries and delineate three-dimensional variations of groundwater quality. In situ groundwater samples (IGS) will be obtained from discrete sample points in the Missouri River alluvium aquifer.

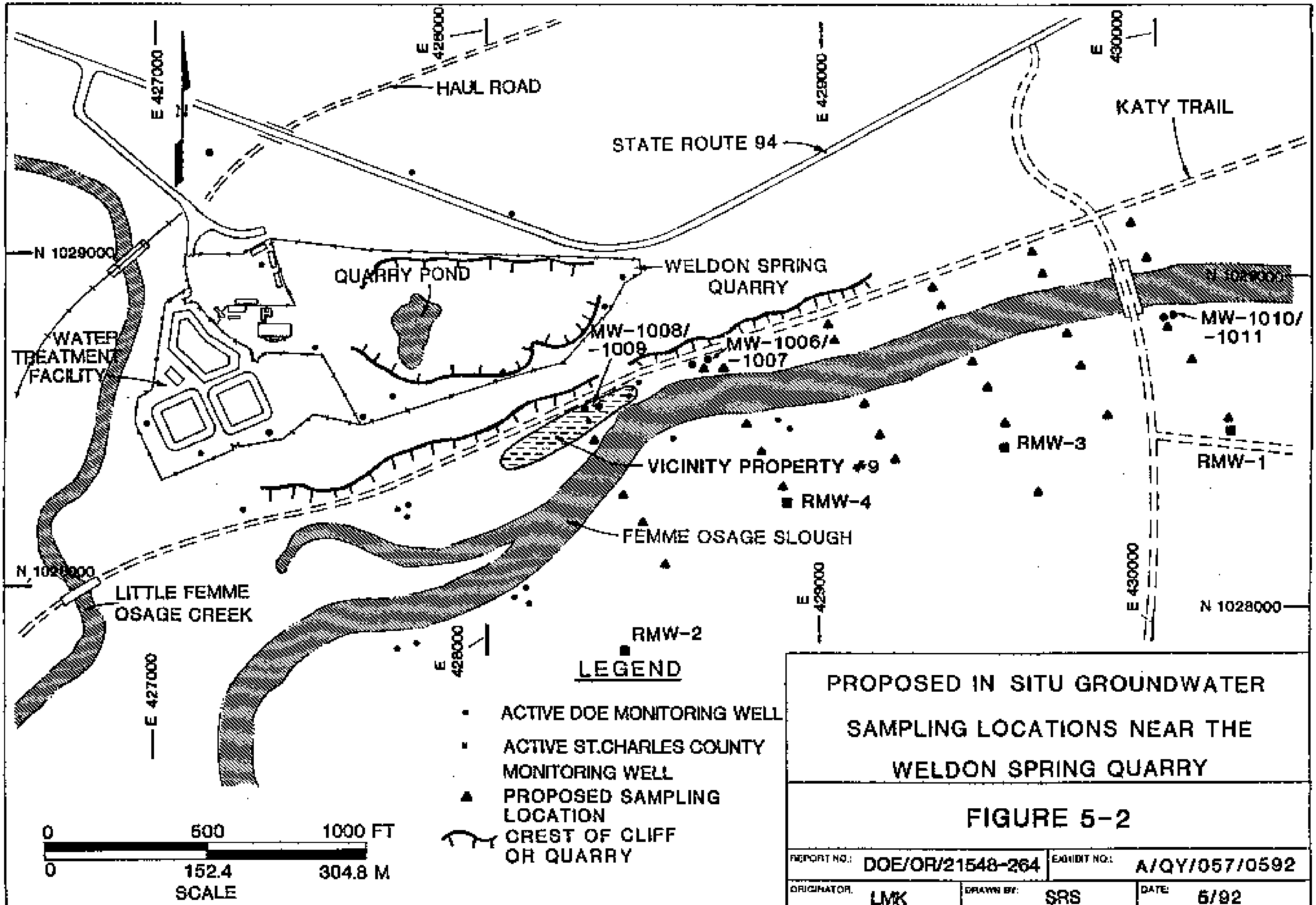
5.2.1.1 Method. A groundwater sampler such as BAT's Enviro Probe, In situ Technology's Hydrocone, or QED Environmental System's Hydropunch® or Hydropunch II® will be used with a hollow stem auger drill. The groundwater sampling tool will be pressed to the desired depth with a push or a drill rod. The drill rod will then be raised approximately 0.3 m (1 ft) to open up the sampling tool. The tool will be left open at the specific sample depth for 20 min to 60 min. Formation water will enter through a filter to the sample chamber either under hydrostatic pressure or with induced negative pressure provided by an inert gas. The tool will be retracted to the surface for one-time, representative water sample. By sampling at different depths, several samples can be obtained from one site. Holes created will be plugged according to ES&H procedure 4.4.4s/0.

5.2.1.2 Location and Rationale. IGS locations are designed to obtain data in three dimensions along lines perpendicular to the depositional trend of the alluvium (Figure 5-2). The location of the profile lines corresponds to the shallow seismic and EM geophysical lines. The exact location of sample, and sample depths, depends upon geophysical results to optimize IGS data and reduce the total sample number. Representative samples will be collected from each different geological environment. Six profile lines are planned, each containing five IGS locations. Discrete samples will be collected at 1.5 m to 3 m (5 ft to 10 ft) depth intervals depending on the homogeneity of the alluvium.

Markedly different uranium and other contamination values are present in some paired alluvium wells north of the Little Femme Osage Slough . For example, for well pair MW-1008 and MW-1009, separated horizontally 11.7 m (38.4 ft), the 1991 average values are 4,076 pCi/l and 5 pCi/l uranium, respectively. Five IGS locations have been selected to investigate contamination variability. These locations are north of the slough except for well pair MW-1011/MW-1010.

5.2.1.3 Chemical and Physical Characterization. The volume of the IGS available from each discrete sampling point is limited, and depends upon the type of sampling tool used, the time the tool is left in the ground, and the amount of water collected as shown in Table 5-3. Priority sample I is the most important, and will be obtained first from each sample point and analyzed in the laboratory. Priority sample II criteria will be determined in the field. If sufficient sample volume is available, Priority sample III criteria will also be sent to the laboratory for analysis. Sample filtration; collection and preservation; labeling; field determinations; and shipping instructions, including chain of custody, are covered in the following Weldon Spring Site Remedial Action Project (WSSRAP) procedures:

Procedure No.	Method
ES&H 4.1.1	*Environmental Numbering System*
ES&H 4.1.2	*Chain of Custody*
ES&H 4.1.3	*Sampling Equipment Decontamination*
ES&H 4.5.1	*pH and Temperature Measurement in Water*



PROPOSED IN SITU GROUNDWATER SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 5-2

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Procedure No.	Method
ES&H 4.5.2	*Specific Conductance Measurement in Water*
ES&H 4.5.8	*Water Sample Filtering*

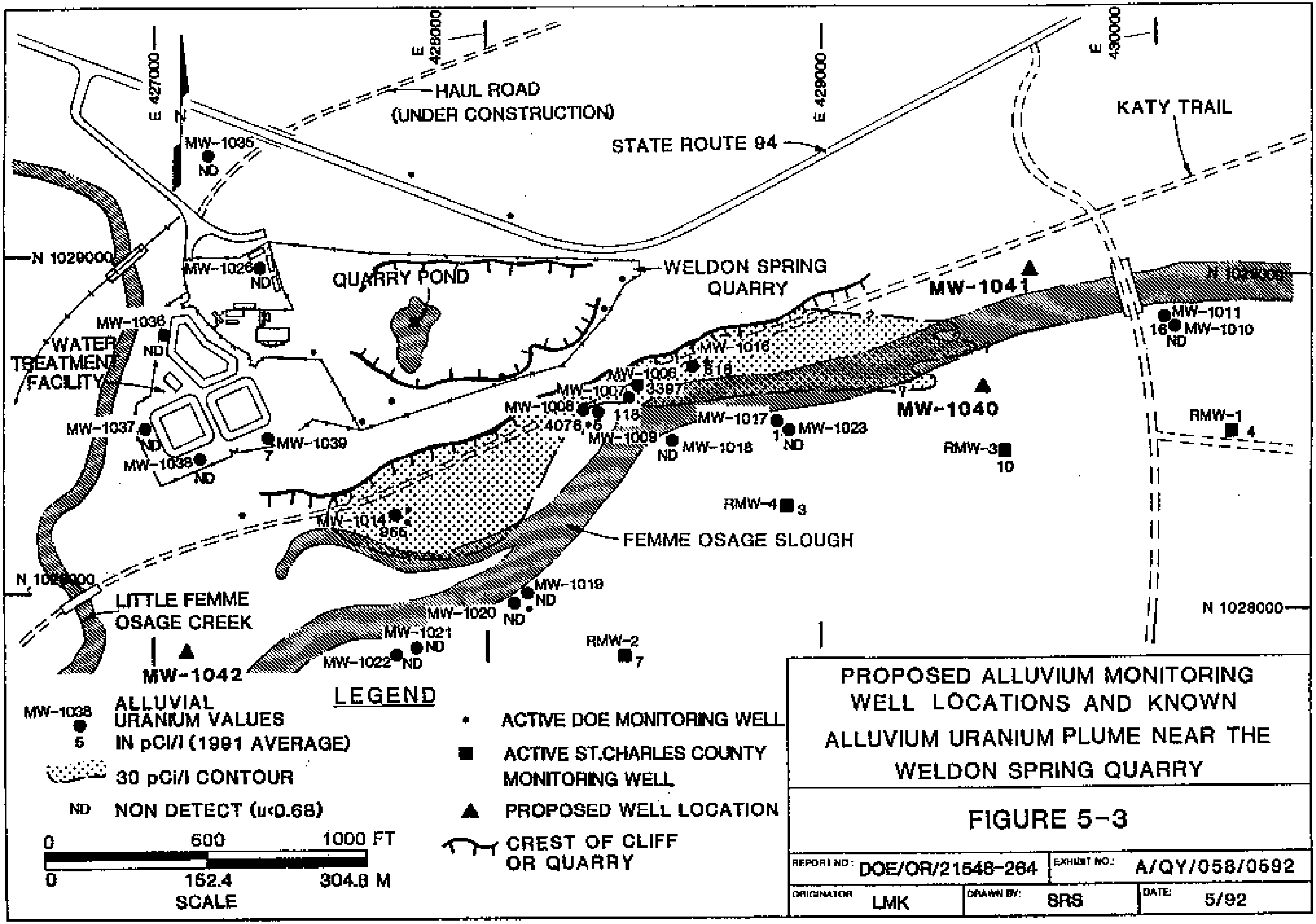
TABLE 5-3 Chemical and Physical Analysis for In-situ Groundwater Samples

Priority Sample I	Priority Sample II	Priority Sample III
Minimum Sample Requirement		
120 ml	100 ml	250 ml
Analytical Requirement		
Uranium	Temperature (T) pH Eh Specific Conductance (SC) Dissolved Oxygen (DO)	As, Ba Alkalinity Sulfate (SO_4)

5.2.2 Alluvium Monitoring Wells

All alluvium wells will be in the Missouri River alluvium, an extensive fluvial deposit south of the quarry containing the St. Charles County well field.

5.2.2.1 Location and Rationale. The current position of the contamination plume for the alluvium south of the quarry suggests using a minimum of three additional monitoring wells (Figure 5-3). The final number of wells will depend upon the results of the geophysical surveys and the results of the in situ sampling program.



PROPOSED ALLUVIUM MONITORING WELL LOCATIONS AND KNOWN ALLUVIUM URANIUM PLUME NEAR THE WELDON SPRING QUARRY

FIGURE 5-3

The locations of the three holes are dictated by knowledge of the current plume position, existing monitoring wells, and the depositional history of the alluvium.

Proposed well MW-1040 will be located south of the slough, north of RMW-3, in the projected path of the plume where well data is currently lacking. This well will serve as additional well field protection. Well MW-1041 is located north of the slough about 152 m (500 ft) east of the plume. The exact position of this proposed well will depend on the chemical data obtained from the in situ sampling results. The location of well MW-1042 will be outside of the western plume limit. Water quality data of the alluvium in this area is presently lacking. Table 5-4 summarizes these locations and rationale.

Estimated drill depth, screened formation, and screened interval are listed in Table 5-5.

5.2.2.2 Geological and Chemical Characterization. During drilling operations, and prior to well installation, unconsolidated samples will be collected for analysis at the intervals indicated in Table 5-6. The constituents of the solid material to be analyzed are outlined in Table 5-7. Sampling procedures are described in Section 5.2.1.3.

Physical parameters to be determined include soil water retention characteristics (Ku), hydraulic conductivity (Ks), grain size distribution (GSD), cation exchange capacity (CEC), mineralogy, total organic carbon (TOC), density, pH, moisture, and porosity. Physical parameters will be determined according to WSSRAP engineering standards and are covered in specific subcontractor tasks.

Groundwater sampling frequency and analytical requirements will include the anions and cations shown in Tables 5-7 and 5-8. The ions and organics selected are those known or suspected to have migrated from the quarry area. A monthly sampling frequency has been selected to quickly establish background values for upgradient and downgradient wells. Sampling frequency will be determined once background levels have been established (MKF and JEG 1991e).

TABLE 5-4 Proposed Monitoring Wells Location and Rationale

Well ID	Location	Rationale
Alluvium Wells		
MW-1040	300 ft north of RMW-3, south side of the slough.	Obtain information on westerly extent of plume and vertical gradient.
MW-1041	750 ft northwest of MW-1011/MW-1010 cluster north of slough, south of the Katy Trail.	Obtain information on east component of plume and vertical gradient; fill data gap.
MW-1042	900 ft west of MW-1022 between the Little Femme Osage Creek and slough.	Obtain information on west component of plume and vertical gradient.
Bedrock Wells		
MW-1043	Clustered with RMW-4.	Obtain information on vertical gradient and extent of contamination in Plattin.
MW-1044	Clustered with MW-1035.	Obtain information on background chemical data and vertical gradient in Plattin.
MW-1045	400 ft west of MW-1037, west side of Little Femme Osage Creek.	Obtain information on vertical gradient and extent of contamination in Plattin.

TABLE 5-5 Estimated Depth of Proposed Monitoring Wells

Well I.D.	Estimated Depth (ft)	Estimated Screened Interval Formation	Estimated Screened Interval Depth (ft)
Alluvium Wells			
MW-1040	60	Missouri River alluvium	50-60
MW-1041	50	Missouri River alluvium	40-50
MW-1042	90	Little Femme Osage and Missouri River alluvium	80-90
Bedrock Wells*			
MW-1043	140	Plattin	130-140
MW-1044	60	Plattin	50-60
MW-1045	130	Decorah or Plattin	120-130

* Bedrock wells will have 15 cm (6 in.) diameter surface casing cemented 3 m (10 ft) into bedrock.

TABLE 5-6 Soil Sample Collection Intervals and Analytical Parameters for Proposed Monitoring Wells

Interval	Ku	Ks	GSD	CEC	M	TOC	BD	pH	POR
Alluvium									
2 ft-4 ft	X		X	X	X, C	X	X	X	X
10 ft-12 ft	X	X	X	X	O, C	X	X	X	X
30 ft-32 ft		X	X	X	O, C	X	X	X	X
50 ft-52 ft		X	X	X	O, C	X	X	X	X
70 ft-72 ft		X	X	X	O, C	X	X	X	X
2 ft above rock		X	X	X	O, C	X	X	X	X
Bedrock									
2 ft-4 ft below alluvium		X			X, C	X	X	X	X
10 ft-12 ft		X			X, C	X	X	X	X
1 ft above TD		X			X, C	X	X	X	X

Ku - Soil water retention characteristics
Ks - Hydraulic conductivity
GSD - Grain size distribution, including hydrometer analysis for particles passing 200 mesh sieve
CEC - Cation exchange capacity
M - Mineralogy
TOC - Total organic content
BD - Bulk density
pH - pH
POR - Porosity (Precent moisture if unsaturated)
C - Chemical analysis; Table 5-7
O - Intervals to be determined based on visual observations of conditions encountered.

See Figures 5-3 and 5-4 for locations.

TABLE 5-7 Analytes for Alluvium and Bedrock Matrix

Cations	Anions	Organics
Arsenic Barium Uranium (Natural)	Sulfate (SO_4)	Nitroaromatics (Total)

TABLE 5-8 Groundwater Sampling Schedule for Proposed Wells, Weldon Spring Quarry Area

	Proposed Monitoring Wells					
Sampling Date	MW-1040	MW-1041	MW-1042	MW-1043	MW-1044	MW-1045
September 1992	X	X	X	X	X	X
October 1992	X	X	X	X	X	X
November 1992	X, R	X, R	X, R	X, R	X, R	X, R
December 1992	X	X	X	X	X	X
January 1993	X	X	X	X	X	X
February 1993	X	X	X	X	X	X
March 1993	X	X	X	X	X	X
April 1993	X	X	X	X	X	X
May 1993	X, R	X, R	X, R	X, R	X, R	X, R
June 1993	X	X	X	X	X	X
July 1993	X	X	X	X	X	X
August 1993	X	X	X	X	X	X

X = Uranium, arsenic, barium, sulfate, nitroaromatic compounds
R = Radiological - U, Th-230, Th-232, Ra-226, Ra-228 gross alpha and beta

Note: Assumes wells are installed and developed by September 1992.

5.2.3 Bedrock Monitoring Wells

A total of three bedrock wells will be completed and incorporated in the Environmental Protection Monitoring Program. The locations, justifications, and initial sampling programs are described in the following sections (See Table 5-4).

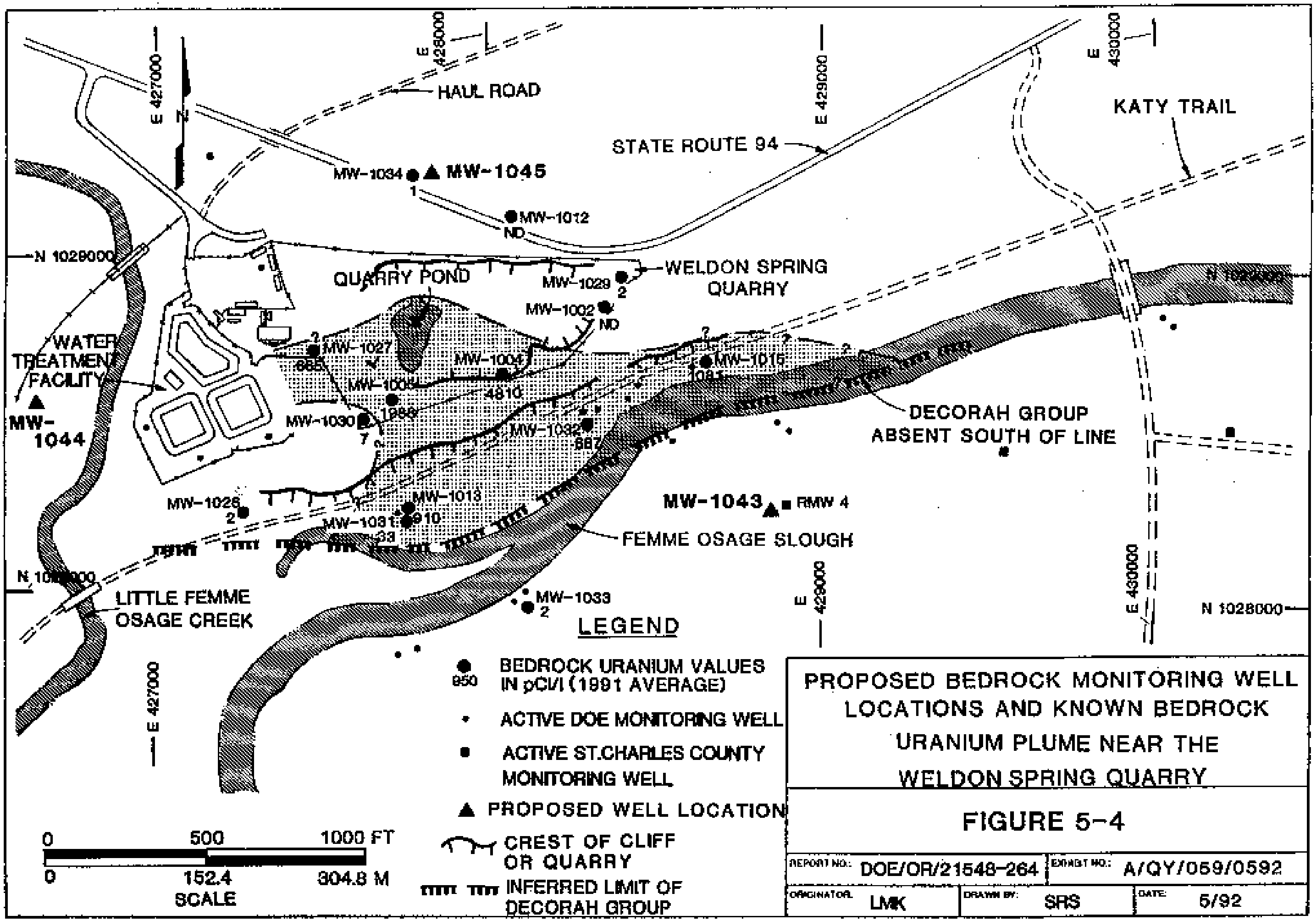
5.2.3.1 Locations and Rationale. Currently 13 bedrock monitoring wells are routinely sampled. These wells are completed in the Decorah Group (nine) and in the underlying Plattin Limestone (two). MW-1034 is screened in the overlying Kimmswick Limestone and Decorah Formation while MW-1028 is screened in the upper Plattin and lower Decorah contact. The stratigraphic relationship between these formations and the alluvium is shown in a generalized north-south cross-section (Figure 2-4).

The uranium plume in the Decorah Group extends from the quarry to the south and terminates in an erosional pinch out. Proposed bedrock well MW-1043 will be located south of the Decorah pinch out in the Plattin Limestone. The location is along the strike of a pervasive fracture pattern near existing county monitoring well RMW-4.

Proposed monitoring well MW-1044 (Figure 5-4) will test the absence or presence of contaminants west of the quarry where a data gap currently exists. Geophysical results will be used to determine the final location of this well. The screen will be set either in the Decorah Group or in the Plattin Limestone, depending on the stratigraphic position, which is unknown at this time.

No upgradient sample point exists in the Plattin Limestone at this time. To fill this gap, a monitoring well is planned at location MW-1045 next to MW-1034 in the Decorah. It is anticipated this well will confirm that the hydraulic gradient within the Plattin Limestone is parallel to the gradient of the Decorah Group and follows a general southerly direction, i.e., parallel to the topography. Proposed well locations are shown in Figure 5-5.

5.2.3.2 Routine Sample Collection. Core drilling will produce continuous cores in competent rock. Lack of core with the advancement of the core bit is an indication of voids, extensive weathering, or faults. Specifics on marking cores, core logs, handling, storing, and core logging procedures are described in procedure ES&H 4.4.7s and will be covered in the



PROPOSED BEDROCK MONITORING WELL LOCATIONS AND KNOWN BEDROCK URANIUM PLUME NEAR THE WELDON SPRING QUARRY

FIGURE 5-4

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/QY/059/0592
ORIGINATOR: LMK	DRAWN BY: SRS	DATE: 5/92

WELDON SPRING SITE REMEDIAL ACTION PROJECT
FIELD PRESSURE TEST DATA AND COMPUTATION FORM

PROJECT:	JOB NUMBER:	TEST SECTION:	BORE HOLE:
TEST EQUIPMENT IDENTIFICATION:	BORE HOLE ORIENTATION:	SIZE:	TEST BY: DATE:
PACKERS ON CASING SINGLE/DOUBLE HYDRAULIC/INFLATABLE	GROUNDWATER DEPTH: FT.	GAUGE HEIGHT ABOVE GROUND: FT.	GRAVITY HEAD: FT.

TEST INFLOW PRESSURE (HP) ________ PSI X 2.31 = ________ FEET

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
METER READING GALLONS OR CU. FT.												GPM CFM
TAKE PER MIN.												CFM X 7.48 - GPM

TOTAL HEAD (HT) = GRAVITY HEAD (HG) + PRESSURE HEAD (HP) - HEAD LOSSES (HI)

___ FT. = ___ FT. + ___ FT. - ___ FT.

$$K = \frac{Q\ (GPM)}{HT\ (FT) \times L\ (FT)} \times 0.11\ IN. \frac{L\ (FT)}{R\ (FT)} = \frac{\quad}{\quad X \quad} \times \quad = \quad$$ K, CM/SEC

TEST INFLOW PRESSURE (HP) ________ PSI X 2.31 = ________ FEET

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
METER READING GALLONS OR CU. FT.												GPM CFM
TAKE PER MIN.												

HT ___ FT. = HG ___ FT. + HP ___ FT. - HL ___ FT.

$$K = \frac{Q}{HT \times L} \times 0.11\ IN. \frac{L}{R} = \frac{\quad}{\quad X \quad} \times \quad = \quad$$ K, CM/SEC

TEST INFLOW PRESSURE (HP) ________ PSI X 2.31 = ________ FEET

TIME, MIN.	0	1	2	3	4	5	6	7	8	9	10	Q AVERAGE FLOW
METER READING GALLONS OR CU. FT.												GPM CFM
TAKE PER MIN.												

HT ___ FT. = HG ___ FT. + HP ___ FT. - HL ___ FT.

$$K = \frac{Q}{HT \times L} \times 0.11\ IN. \frac{L}{R} = \frac{\quad}{\quad X \quad} \times \quad = \quad$$ K, CM/SEC

WELDON SPRING SITE
REMEDIAL ACTION PROJECT
FIELD PRESSURE TEST DATA AND COMPUTATION FORM

FIGURE 5-5

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/PI/088/0592	
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92	

drilling subcontract. Cored intervals to be tested are outlined in Table 5-6. Estimated depths and screen locations are shown in Table 5-7.

5.2.3.3 Packer Tests. Packer, or down hole pressure, tests will be performed to obtain hydraulic conductivity information in bedrock. These tests are performed by isolating a drill hole interval with inflatable packers and injecting pressurized water into the formation. The relationship between pressure and injection rate permits a calculation of hydraulic conductivity.

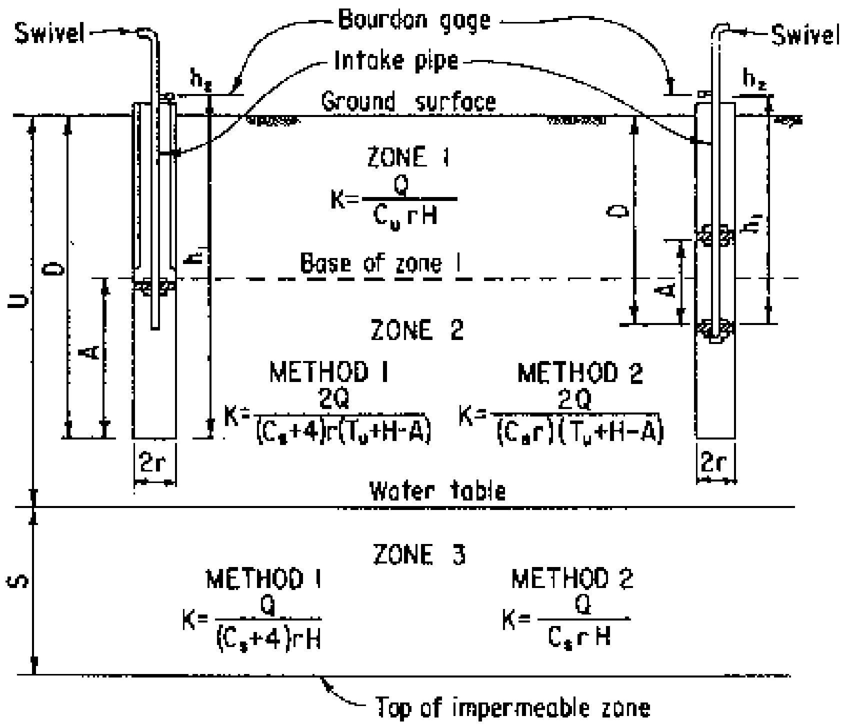
All bedrock boreholes drilled will have packer testing performed during drilling operation prior to screen and casing installation. Bedrock units will be tested in 3 m (10 ft) intervals with additional tests performed in fracture zones identified from cores. These data will provide information on the variability of hydraulic conductivity for bedrock units.

Tests will be conducted using a single inflatable packer. Water flow and pressure will be monitored using a flow meter and pressure gauge, respectively. Generally, three tests of 5 min duration will be performed at each test interval. Once a test section has been cored, the hole will be flushed with potable water and the drill string will be removed. The packer assembly and associated piping will be lowered and set at the interval to be tested and the packer will be inflated with inert gas. Once the packer is securely seated, the hole will be pressurized with potable water to the desired pressure and allowed to stabilize and the flow rate will be monitored. The initial test will be conducted at an approximate pressure of 69 kPa to 414 kPa (10 psi to 60 psi), followed by another test at approximately 137 kPa to 620 kPa (20 psi to 90 psi), and a final test run at 69 kPa to 414 kPa (10 psi to 60 psi). For each test, the inflow pressure, average flow rate, length of test interval, and total head will be recorded on test logs.

Packer testing data will be performed and analyzed using methods described in the *Ground Water Manual* (U.S. Department of the Interior 1977). Types of data to be collected in the field are shown in Figure 5-5. Figure 5-6 presents applicable schematic details and equations and defines variables to be used in packer test data analysis.

5.2.4 Drilling Methods and Sample Collection

Drilling methods were evaluated with respect to the type of geologic materials anticipated and the relative advantages and disadvantages of each method as described in the U.S. Environmental Protection Agency (EPA) guidance handbook (Allen et al., 1989). Drilling



K = coefficient of permeability, feet per second under a unit gradient
Q = steady flow into well, ft^3/s
$H = h_1 + h_2 - L$ = effective head, ft
h_1 (above water table) = distance between Bourdon gage and bottom of hole for method 1 or distance between gage and upper surface of lower packer for method 2, ft
h_1 (below water table) = distance between gage and water table, ft
h_2 = applied pressure at gage, 1 lb/in^2 = 2.307 ft of water
L = head loss in pipe due to friction, ft; ignore head loss for Q<4 gal/min in $1\frac{1}{4}$ - inch pipe; use length of pipe between gage and top of test section for computations
$X = \frac{H}{T_u}(100)$ = percent of unsaturated stratum
A = length of test section, ft
r = radius of test hole, ft
C_u = conductivity coefficient for unsaturated materials with partially penetrating cylindrical test wells
C_s = conductivity coefficient for semi-spherical flow in saturated materials through partially penetrating cylindrical test wells
U = thickness of unsaturated material, ft
S = thickness of saturated material, ft
$T_u = U - D + H$ = distance from water surface in well to water table, ft
D = distance from ground surface to bottom of test section, ft
a = surface area of test section, ft^2; area of wall plus area of bottom for method 1; area of wall for method 2

Limitations:
$Q/a \leq 0.10$, $S \geq 5A$, $A \geq 10r$, thickness of each packer must be $\geq 10r$ in method 2

SOURCE: U.S DEPARTMENT OF INTERIOR (1977)

PERMEABILITY TEST SET UP FOR SATURATED AND UNSATURATED BEDROCK

FIGURE 5-6

REPORT NO.:	DOE/OR/21348-264	EXHIBIT NO.:	A/PI/050/0392		
ORIGINATOR:	LMK	DRAWN BY:	SRS	DATE:	3/92

methods must be capable of drilling both consolidated and unconsolidated materials above and below the water table. Drilling methods will include equipment that minimizes both surface and subsurface disturbance, eliminates or minimizes cross contamination, and provides representative samples of the geology for both visual identification and for laboratory analyses.

Based on these criteria, the following drilling methods have been selected:

1. Hollow-stem augering (for alluvium drilling).
2. Water rotary (for bedrock coring).
3. Air rotary (for bedrock reaming).

The following general precautions will be taken to minimize and evaluate the effects of drilling on the subsurface environment:

- All drilling equipment and tools will be decontaminated prior to drilling activities and between borings.

- All drilling operations will be performed with either air or potable waters as coolant and lubricant. Other additives will not be used.

- Only teflon tape or vegetable-based lubricants shall be used on the threads of downhole drilling equipment. Oils, greases, or pipe dope shall not be used on pipe threads, drilling rods, downhole hammer bits, or other downhole tools. Similarly, no hydrocarbon-based oils or greases shall be used on rotary tables, slides or other open, lubricated surfaces on the drilling rig.

Precautions will be taken at all times during drilling operations to prevent the contamination or cross-contamination of all wells and borings. Potential contaminants include, but are not limited to, oil, greases, hydraulic fluids, fuels, and contaminated soils.

All cuttings not sampled for laboratory analysis or other use, and all fluids generated as a result of drilling operations, will be managed in accordance with procedure RC-30, which specifies either retention at the well location or on-site storage.

A qualified geologist, or technical trained person, will prepare a lithologic log for each borehole in accordance with procedure ES&H 4.4.7s. An example of the soil log form is shown in Figure 5-7. Particular emphasis will be placed on recording lithology, stratigraphic features, and discontinuities that could affect contaminant transport and facilitate selection of screened intervals for the monitoring wells. The wellside geologist will also maintain observations of drilling rate, percent fluid circulation, sample recovery, and rock quality designation (RQD) for cored intervals.

A logbook will be maintained by the site geologist during all drilling activities to allow for a recreation of activities. The logbook will contain information not recorded on approved forms and may include: sample recovery, grout density, drilling operations, and recording of water losses/gains related to groundwater data or any unusual event. All well installation procedures will be recorded on the approved form (Figure 5-8). The log books will consist of bound waterproof paper and will be completed using waterproof ink or marker. Logbook entries will contain, at a minimum, a listing of all personnel at the sampling location and their affiliation; a description of each sampling location; personnel visiting and/or inspecting or auditing the sampling crews; accidents; unusual occurrences or observations; weather conditions; and other relevant information necessary to allow a recreation of events. These log books will be signed daily by the recording person. All errors will be deleted by a single mark through the error, and the person correcting the error will initial and date the strike mark. Logbook maintenance is detailed in procedure ES&H 1.1.4.

Drilling methods and additional method-specific requirements and precautions are described in the following sections.

5.2.4.1 Alluvium. The alluvium will be drilled using hollow-stem augering techniques. Minimum outside diameter will be 17.7 cm (7 in). Samples will be collected continuously during augering operations using split spoon samplers or other continuous sampling methods. Samples will be collected before or during auger advance. A plug may or may not be used, depending upon the sampling method selected.

5.2.4.2 Bedrock. Once competent rock has been encountered with the auger, core drilling will be used. Portable recirculation tanks will be used to minimize the use of potable water and prevent contamination. Water usage, in terms of percent circulation and volumetric losses, will be recorded during coring operations.

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

PAGE ____ OF ____

SITE ID: ________ LOCATION ID: ________
SITE COORDINATES (FT.): ________
N ________ E ________
GROUND ELEVATION (FT. MSL): ________
DRILLING METHOD: ________
DRILLING CONTR.: ________
DATE STARTED: ________
DATE COMPLETED: ________
FIELD GEOLOGIST/ENGINEER: ________

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION ________

SITE CONDITION ________

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION

COMMENTS: ________

BORHOLE LOG FORM

FIGURE 5-7

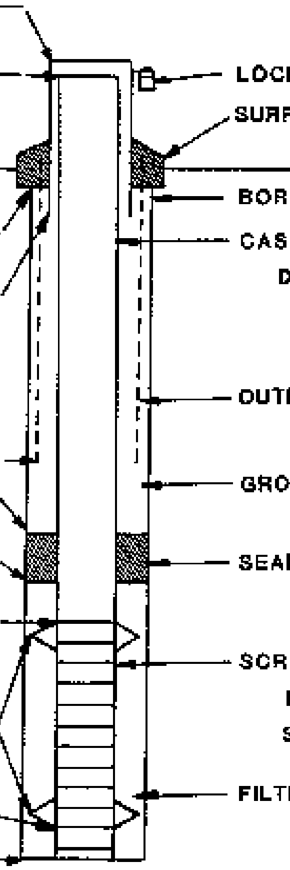
REPORT NO.: DOE/OR/21548-264		DRAWING NO.: A/PI/089/0592
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WELL COMPLETION RECORD

WELL NUMBER ____________ DATE INSTALLED ____________

PMC REPRESENTATIVE ____________ DRILLER ____________



COMMENTS ____________

PMC REPRESENTATIVE SIGNATURE ____________ DATE ____________

WELL COMPLETION RECORD FORM

FIGURE 5-8

REPORT NO. DOE/OR/21548-264		DRAWING NO.: A/PI/090/0592
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92

Rock coring will be accomplished using wireline methods in accordance with the American Society for Testing and Materials (ASTM) standard method D-2113. The core obtained will be standard NX diameter (approximately 5 cm [2 in]). A diamond-impregnated core bit and inner barrel will be used. Core will be collected by continuous coring from top of bedrock to the specified depth. Core will be collected to obtain lithological, mineralogical, permeability, and porosity data. Evidence of bedrock contamination will be noted. Each corerun will depend on drilling conditions but not exceed 3 m (10 ft) in length. The core will be placed in premanufactured wood core boxes designed to hold at least 3 m (10 ft) of core.

The rock core will be placed in the core boxes and clearly labelled to indicate tops of core intervals, core recovery, depth and location of samples, and RQD. Unconsolidated, very friable, or clayey sections of core will be placed in clear core tubing or bags; sealed, and stored along with the competent core in the core boxes. Cores will be logged and retained on site. Core losses will be noted by marked wooden blocks showing approximate depth of losses.

When the desired depth has been reached with coring and pressure tests are completed, air rotary drilling will be used prior to well installation. This method is required to ream boreholes to a minimum diameter of 15 cm (6 in.). The following precautions and requirements will apply to air rotary drilling operations:

- Specify the type of air compressor and compressor lubricating oil to be used. Retain a sample of each oil. Record oil consumption on the boring log. This information may be required for evaluation in the event of contamination problems.

- Utilize an air line oil filter maintained in accordance with manufacturer's recommendations. This maintenance activity will be recorded on the boring log. Filter changes will be done on a basis that is sufficient to eliminate oil from filtered air.

- Fully describe, on the boring logs or logbooks, air usage to include equipment descriptions, manufacturer, model, air pressures used, frequency of oil filter change, and evaluations of the system performance.

5.2.4.3 Sample Collection. Auger samples for physical, chemical, and/or radiological analysis will be collected according to procedure ES&H 4.4.5 at depth intervals previously specified. In addition, samples of representative geologic materials will be collected to maintain physical evidence of the materials encountered in each borehole.

Auger samples for laboratory analyses will be collected using stainless steel spatulas and pans (for compositing). Samples will be placed into containers supplied by the analytical laboratory. Sample labels will be completed using waterproof ink and covered with clear tape to prevent damage during shipping. Sample numbering and chain of custody will be maintained according to approved procedures ES&H 4.1.1 and 4.1.2, respectively. Sampling personnel will wear new, clean latex gloves when collecting samples for laboratory analysis.

All core samples removed from the core box will be replaced with wooden block showing intervals and sample number.

Samples of representative geologic materials will be collected at the discretion of the geologist. At a minimum, a sample will be collected for each type of unconsolidated material encountered during drilling operations at each borehole. These samples will be placed in glass jars and labeled with the date collected, interval sampled, borehole number, and sampling personnel names.

5.2.5 Well Construction and Development

Monitoring well installation will begin as soon as practicable or a maximum of 48 hr after drilling and coring activities are complete. The security and integrity of the borehole and subsequent well will be maintained by providing a tamper-detection seal with locks to prevent unauthorized access. After initiating well installation, operations will continue until the bentonite seal has been emplaced above the filter pack. Figure 5-8 illustrates typical monitoring well construction details and well completion record. Monitoring wells completed in the alluvium will be constructed according to the following procedures:

- Prior to well installation , the borehole will be cleaned of cuttings.

- Well casing will consist of new, threaded flush-joint, Type 316L stainless steel casing with a nominal 5 cm (2 in.) inside diameter. All well casing will conform to the requirements of Type 316L stainless steel casing.

- Continuous, wire-wound, flush-jointed well screen, will be used. The well screen will be constructed of 5 cm (2 in.) Type 316 stainless steel. Slot size shall be 0.25 mm (0.010 in.).

- Well screen and well casing sections will be jointed by threaded, flush-jointed couplings to form straight, water-tight unions. No solvents or glue will be used in the construction of the wells.

- The well screen will have a threaded stainless steel bottom cap securely attached providing a tight seal. The well casing shall have a threaded stainless steel top cap. A vent hole, not to exceed 3 mm (1/8 in.) in diameter, shall be drilled in the side of the top.

- The following information shall be recorded (to the nearest tenth of a foot) both in the log book and on the well completion record: total depth drilled, total length of casing, location of well screen, filter pack top and bottom, and bentonite seal interval. Data for these measurements will be from ground surface and recorded as below ground surface.

- Each screen/casing assembly will be centered in the borehole using at least two stainless steel centralizers at the bottom and top of the screen.

- The wells will be installed through either hollow-stem augers or temporary casing through overburden or alluvium.

- The well assembly will be lowered upon 3 in. of filter pack material. Filter pack material will consist of clean, medium to coarse-grained (70% retained by a 40 mesh sieve), well rounded, uniform silica sand. Filter pack will be added to the annulus to a height of 1 m (3 ft) above the screen. A weighted tape will be used to continuously tag the top of the filter pack to ensure accurate placement. The source of filter pack and gradational curves shall be provided.

- An annular seal will be constructed by placing 15 cm (6 in.) lifts of 6.3 mm to 9.5 mm (1/4-3/8 in.) granular bentonite or prefabricated bentonite pellets specifically designed for sealing purposes to a height of 1 m (3 ft) above the filterpack. Tablets will be hydrated by the addition of at least five liters (1.3 gal) of potable water per 15 cm (6 in.) lift if placed above the water table.

- The remaining annular space will be grouted to the surface using a side discharge tremie-placed high clay solids bentonite based grout. The grout will consist of 87 liter (23 gal) water per 22.7 kg (50 lb) sack of grout plus 1 kg (2 lb) of initiator; and will be mixed by jetting through the hopper and circulated through the rig's mud pump. This ratio will be properly documented. Grout mix must achieve a weight of 1.1 kg/liter (9.4 lb/gal) prior to placement. Grout weight will be verified through the use of a mud balance.

- All depths and thicknesses including total depth of hole, filter pack thickness, and depth to top of bentonite seal will be checked and recorded using a weighted tape.

- Locking protective casings will be installed at each well. A concrete pad sloped to drain away from the well with minimum dimensions of 0.75 m (30 in.) by 0.75 m (30 in.) by 0.15 m (6 in.) will be installed. A brass monument will set in the protective pad. At least three protective posts will also be installed to guard against incidental damage from vehicles.

- Following well installation, top of casing elevations (TOC) and the coordinates of each well will be surveyed by a licensed surveyor. TOC elevations will be to the nearest 0.003 m (0.01 ft). Horizontal control will be within 0.15 m (0.5 ft).

Monitoring wells completed in bedrock where the unconsolidated materials are saturated will be completed as described above with the following additional measures implemented to ensure the integrity of the completion:

- A surface casing will be installed at least 3 m (10 ft) into solid bedrock and grouted in place prior to coring and reaming to final depth.

- Coring and reaming will not commence until at least 48 hr after the outer casing has been grouted in place to allow for grout solidification.

- Well completion will be as described previously.

- The annular space in between the surface outer casing and the well casing will be filled with grout as previously described.

Wells installed during this investigation will be developed to produce clear water which is representative of natural groundwater. A variety of methods may be employed depending on the conditions encountered. Development activities will be documented on the Well Development Form shown in Figure 5-9. The following guidelines will be used during well development activities:

- Development will not commence until at least 48 hr after the well casing has been grouted in place.

- Development methods will provide a surging action through the well screen and filter pack to remove fines.

- Development will continue until surging fails to produce turbid water and three consecutive pH, temperature, and conductivity measurements have stabilized within 20%. If clear water is not attained following at least 4 hr of surging and water removal, development activities will be considered complete if the three consecutive sets of measurements have stabilized within 20%.

Water and waste generated during well development will be managed in accordance with procedure RC-30.

5.2.6 Equipment Decontamination

Equipment used in drilling operations and sample collection, and materials used in well construction, will be decontaminated according to the following guidelines:

- Drill rigs will be decontaminated with hot water using a high pressure washer prior to, and upon completion of, all drilling activities. Working areas of the drill rig will be decontaminated between boring locations. Pumps and hoses will be flushed with potable water between locations.

- Drilling equipment and tools will be decontaminated with hot water using a high pressure washer and allowed to air dry prior to, and between, boreholes and upon

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELL DEVELOPMENT FORM

DATE ________________ PAGE _____ OF ______

WELL NUMBER __________ WELL SIZE WITH FILTER PACK r = d/2 = __________ INCH

FIELD PERSONNEL ____

TOTAL WELL DEPTH ________ ft - DEPTH TO SWL ______ ft = _______ft WATER (L)

WELL VOLUME (CASING AND FILTER PACK) = (____^{2})(.163)(____ ft)= _____ (gl)

{VOLUME (WELL) = $r^2 \pi L$; FOR ANY WELL: V (gl) = [r^2 (in)] (.163) (L)}

L = LENGTH IN ft; r = RADIUS IN INCHES; .163 = CONVERSION FACTOR

DEVELOPMENT METHODS(S) ____

____

BEGINNING TIME ____

INITIAL WATER CONDITIONS ____

	INITIAL	1	2	3	
TEMPERATURE	°C	°C	°C	°C	INSTRUMENTS USED
pH					
CONDUCTIVITY					
DISSOLVED OXYGEN					
WATER REMOVED	gl	gl	gl		gl

ESTIMATE RECHARGE RATE (gl) ______________/______________

END TIME ______________ FINAL SWL DEPTH ______________

TOTAL WATER REMOVED _________ gl FINAL TURBIDITY MEASUREMENT _________NTU

TOTAL WELL VOLUMES REMOVED (gl/WELL VOLUME) ______________

FINAL WATER LEVEL ______________ FINAL SWL DEPTH ______________

COMMENTS ____

____

____

PMC REPRESENTATIVE SIGNATURE______________DATE______________

WELL DEVELOPMENT FORM

FIGURE 5-9

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/PI/091/0592	
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92	

arrival at the site. On wells with an outer casing, drilling equipment will be decontaminated after outer casing has been installed and prior to coring or reaming activities. Equipment and tools will be stored in a manner that maintains the cleanliness of the equipment.

- Continuous samplers, split spoons, and other sampling equipment will be washed with potable water between samples in a given borehole if contaminant samples will not be collected. Continuous samplers and other sampling equipment will be cleaned using a hot, high pressure washer and allowed to air dry prior to collecting samples for contaminant analyses.

- All well screen, casing, caps, and outer casing will be cleaned using a hot, high pressure washer and allowed to air dry prior to installation. Cleaned materials will be stored in a manner that maintains the cleanliness of the materials.

- All well development tools and equipment will be cleaned using a hot, high pressure washer and allowed to air dry prior to initial usage and between wells. Cleaned materials will be stored in a manner that maintains the cleanliness of the materials.

- All downhole geophysical tools and equipment will be cleaned using a hot, high pressure washer and allowed to air dry prior to initial usage and between wells. Cleaned materials will be stored in a manner that maintains the cleanliness of the materials.

Water and other wastes generated during decontamination activities will be collected and disposed of in accordance with procedure RC-30.

5.2.7 Abandonment of Wells

Any well or borehole that is no longer required for sampling, testing, or monitoring will be plugged and abandoned. The abandonment procedure consists of removing any existing pipe, including screen, from the borehole and filling the borehole from the bottom to the top utilizing the drill stem or tremie pipe with an abandonment mud. The minimum specifications are described in Section 5.2. Procedure ES&H 4.4.4s will be followed to plug and abandon subsurface structures.

5.3 Slough and Stream Sediment Investigations

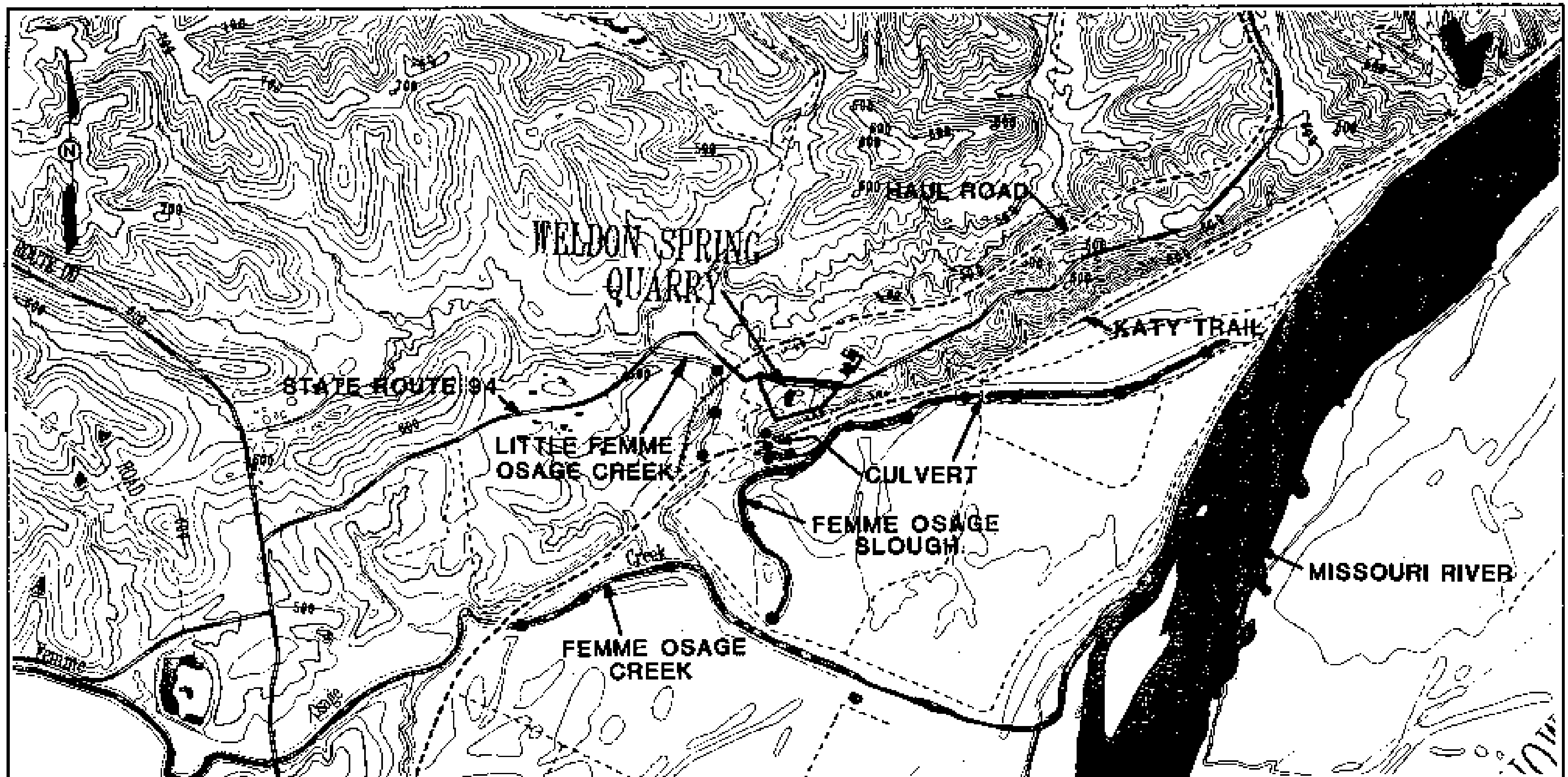
Contamination data for stream sediments is limited to the Femme Osage Slough for total uranium and some radium and thorium. An additional 20 samples will be collected to obtain chemical parameters, comparable background information, and to verify existing data (Figure 5-10).

Four locations will be sampled within the northern arm of the slough including upstream and downstream of a culvert below the Katy Trail. Ten locations will be sampled within the main Femme Osage Slough, three of which are east of the access road culvert. Three sites will be sampled in the Femme Osage Creek upstream of the Little Femme Osage Creek junction for clay rich background information, and three locations will be sampled in the Little Femme Osage Creek; the most northerly for background data in that environment. In order to reduce the matrix variable, each sample will consist of an equal portion of a homogenized mixture of sediments from at least three different locations across the slough or stream as illustrated in Figure 5-11.

Sample designations will be determined in the field according to procedure ES&H 4.1.1. All samples will be analyzed for total uranium, thorium, radium, nitroaromatics, nitrate, sulfate, arsenic, and barium. One half of all samples will be air dried and the -80 fraction silt will be analyzed for organic carbon, uranium, arsenic, barium, sulfate, nitrate and nitroaromatics. These additional analytical data are needed to determine the inter-relationship of uranium, metals, and anions to organic carbon content and silt-size fraction. Knowledge of these inter-relationship will greatly aid in characterizing the contamination plume.

5.4 Surface Water Sampling Investigations

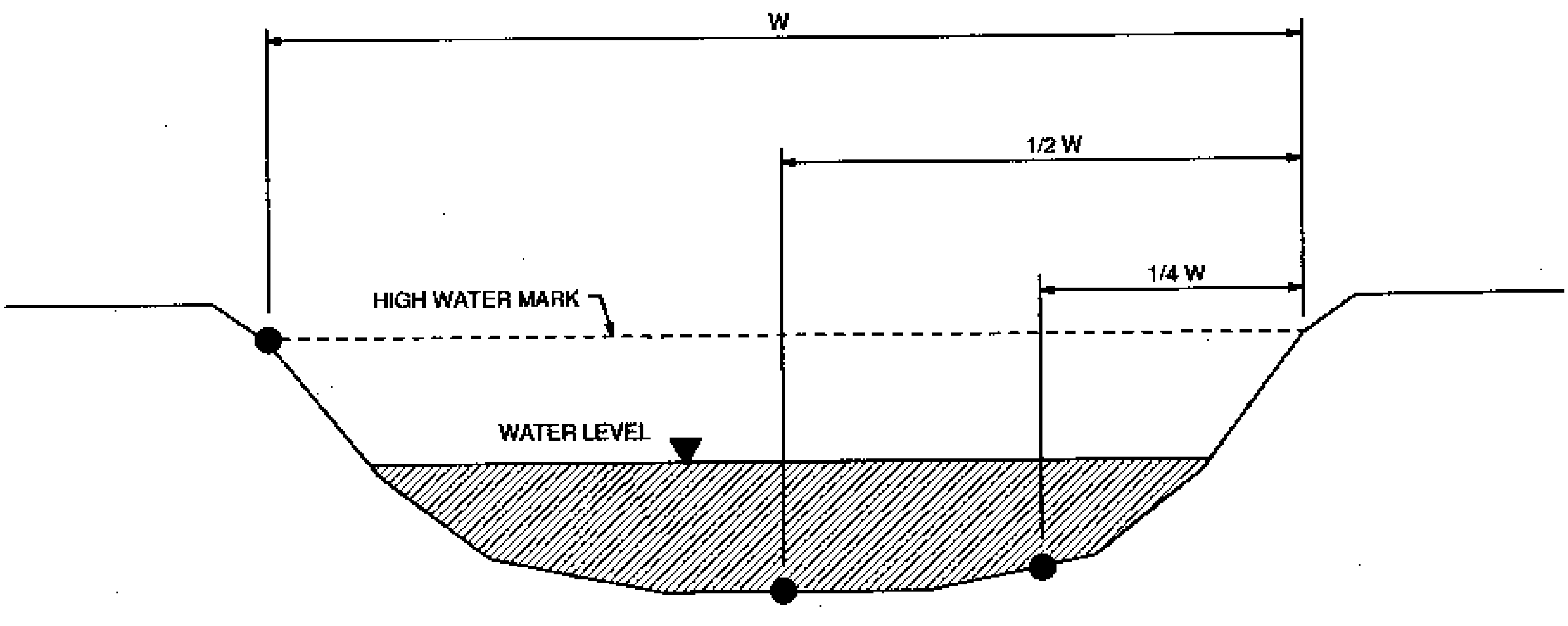
As stated previously in Section 3 and in the *Environmental Monitoring Plan* (EMP) (MKF and JEG 1992c) and the *Annual Site Environmental Report* (ASER) (MKF and JEG 1992a, surface water has been sampled and analyzed for uranium, thorium, radium, nitroaromatics, anions, and metals at 14 locations on a routine basis. Additional monitoring information from previous years also exists. This information provides adequate environmental monitoring of the surface water; therefore, additional sampling is not proposed at this time (See Figure 3-5 and 3-6 for sampling locations). Additional sampling, if necessary, may be performed in the future based upon other media results as a result of this sampling plan.



PROPOSED SLOUGH AND STREAM SEDIMENT SAMPLING LOCATIONS NEAR THE WELDON SPRING QUARRY

FIGURE 5-10

REPORT NO.: DOE/OR/21548-264		EXHIBIT NO.: A/QY/061/0592	
ORIGINATOR: LMK	DRAWN BY: GLN	DATE: 5/92	



STREAM OR SLOUGH CROSS SECTION

● - SAMPLE POINT

NOTE : EQUAL AMOUNT OF SAMPLE FROM EACH POINT IS HOMOGENIZED IN DECONTAMINATED STAINLESS STEEL CONTAINER.

NOT TO SCALE

PROPOSED SAMPLING POINTS FOR SLOUGH OR CREEK SEDIMENT SAMPLES

FIGURE 5- 11

REPORT NO.: DOE/0R/21548-264		EXHIBIT NO.: A/PI/087/0592	
ORIGINATOR: LMK	DRAWN BY: GLN		DATE: 5/92

6 QUALITY ASSURANCE/QUALITY CONTROL

All environmental activities including data collection, monitoring, surveillance, data analysis, interpretations and report writing at the Weldon Spring Site Remedial Action Project (WSSRAP) must adhere to a quality assurance standard as outlined in the *Quality Assurance Program Plan* (QAPP) (MKF and JEG 1991f). The QAPP has been developed to fulfill the requirements of DOE Order 5700.6B which references quality assurance standards established by the U.S. Environmental Protection Agency (EPA) (EPA/QAMS-005/80), American Society of Mechanical Engineers (ASME) (MK 1991), and the American National Standard Institute (ANSI/ASQC-54). All of these standards specifically address radiological standards. Guidance provided by the Office of Environmental Restoration and Waste Management document, *Quality Assurance Requirements and Description* (QARD) is also incorporated in the QAPP. The QAPP is reviewed and approved by the Project Management Contractor (PMC) manager responsible for all WSSRAP operations, the Quality Assurance Manager, and the U.S. Department of Energy (DOE) WSSRAP Project Manager.

In addition to the QAPP, the *Environmental Quality Assurance Program Plan* (EQAPP) (MKF and JEG 1991a) has been prepared for WSSRAP to cover Quality Assurance/Quality Control (QA/QC) aspects as they are specifically related to environmental activities and monitoring. The EQAPP addresses only the EPA requirements under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA). The guiding document for the EQAPP is the U.S. Environmental Protection Agency/Quality Assurance Management Staff (EPA/QAMS) 005-80 *Quality Assurance Requirements*.

The quality of the environmental characterization is maintained and documented through a number of measures which include: the use of standard operating procedures; the collection, analysis, and evaluation of quality control samples; performance audit samples; the use of standardized analytical methods; data management activities (data verification); data quality evaluation (data validation); maintaining quality assurance records; performing self assessments; supporting project quality assurance personnel in auditing and evaluating analytical laboratories; and audits by quality assurance personnel. These items will be discussed in following subsections. Documentation also includes performing field oversight for subcontractors to ensure that specifications are properly performed.

6.1 Procedures

Standard operating procedures (SOPs) have been developed for activities associated with environmental monitoring and characterization at the Weldon Spring site. Refer to Table 6-1 for procedures applicable to this proposed sampling effort. These procedures have been developed from U.S. Environmental Protection Agency (EPA) and DOE guidelines and from standard industry practices and are specific to the Weldon Spring site (WSS). Procedures at the WSS are prepared, reviewed, and approved by the cognizant department manager, the Quality Assurance Manager, and project management. Controlled copies of procedures are maintained in accordance with the document control requirements of ANSI/ASME NQA-1. Procedures are reviewed annually and revised as appropriate.

All sample identification, collection, and documentation will be performed in accordance with Environmental Safety and Health (ES&H) procedures. All documentation will be written on field sheets and/or kept in a logbook according to specific procedures. Completed field sheets and logbooks will be transmitted to the Quality Assurance Department and retained as QA records upon completion of the field work.

6.2 Quality Control Samples

Quality control samples will be collected to ensure consistent and accurate performance of sample collection and laboratory analysis. See Table 6-2 for a summary of the various quality control samples that will be collected under this plan.

Quality control for geophysics will consist of correlating results to physical data at boreholes and monitoring wells.

TABLE 6-1 Procedures Applicable to Environmental Characterization Activities

Procedure Number*	Procedure Title
CM&O-15	Task-specific Safety Assessments
ES&H 1.1.4s	Logbook Procedure
ES&H 4.1.1	Environmental Numbering System
ES&H 4.1.2	Chain of Custody
ES&H 4.1.3	Sampling Equipment Decontamination
ES&H 4.1.4	Packaging and Shipping Requirements for Non-regulated Samples
ES&H 4.3.1	Surface Water Sampling
ES&H 4.4.1	Groundwater Sampling
ES&H 4.4.2	Groundwater Level Monitoring and Well Integrity Inspections
ES&H 4.4.5	Soil/Sediment Sampling
ES&H 4.5.1	pH and Temperature Measurements in Water
ES&H 4.5.2	Specific Conductance Measurements in Water
ES&H 4.5.7	Measurement of Settleable Solids
ES&H 4.5.8	Water Sampling Filtering
ES&H 4.6.1	Area TLD Deployment for Environmental Sampling
ES&H 4.6.2	Radon Concentrations Measurement in Ambient Air
ES&H 4.9.1	Environmental Monitoring Data Verification
RC-22	Sample Disposal
RC-30	Monitoring Well Waste Management
RC-31	Environmental Monitoring Data Validation

* Refer to list of acronyms.

TABLE 6-2 Field Quality Control Sample Summary

QC Sample Type	Frequency	Purpose
Duplicate (DU)	1 per 20	Assess interlaboratory variability.
Equipment Blank (EB)	1 per 20	Assess effectiveness of decontamination.
Distilled Water Blank (WB)	1 per quarter	Assess quality of distilled water.
Trip Blank (TB)	1 per day when analyzing for VOAs	Assess potential cross-contamination during shipping.
Field Blank (FB)	1 per 20	Assess impact of ambient conditions on samples.
Matrix Spike (MS)	1 per 20*	Assess laboratory performance.
Matrix Duplicate (MD)	1 per 20*	Assess laboratory performance.

* Or one per sample batch, whichever is more frequent.

7 DATA ADMINISTRATION

Data administration will follow Weldon Spring Remedial Action Project (WSSRAP) procedures and the *Environmental Data Administration Plan* (EDAP) (MKF and JEG 1992b).

7.1 Data Reporting, Interpretation and Documentation

The WSSRAP quality assurance (QA) program for environmental data has numerous initiatives within each aspect of data documentation, interpretation, and reporting. The EDAP, (MKF and JEG 1992b) a specific program-level plan, provides the foundation for collecting, verifying, validating, and interpreting data. The EDAP provides site-specific guidance for managing data and associated documentation, and establishes general data quality goals. This plan also includes guidance on sampling plan preparation, data verification, validation requirements, database administration, and data archival.

Site specific procedures have been developed for all aspects of sample collection and handling. These procedures were developed from U.S. Environmental Protection Agency (EPA) and other relevant guidance documents. They are reviewed annually and revised as necessary. Sampling personnel are trained in appropriate procedures prior to sample collection. All procedure training is documented and tracked so that personnel are retrained as procedures are revised. Variances or field modifications to procedures are noted in field notebooks and on sampling forms.

Laboratories analyzing WSSRAP samples are required to use standard methods and to have a quality assurance program. These quality assurance programs are reviewed and approved by the project's Quality Assurance Department prior to commencement of analyses. Laboratories are also required to comply with standardized reporting requirements, thus simplifying data verification, validation, and interpretation. Laboratories are routinely audited to ensure compliance with their QA programs and appropriate analytical procedures.

All data received from analytical laboratories are subjected to data verification. The data verification process is detailed in procedure ES&H 4.9.1 and consists of a preliminary review of the quality-impacting aspects of sampling, analysis, and reporting. Data verification includes reviewing field sampling documentation, sample preservation, chain of custody, analytical holding times, and a comparison of electronic versus hard copy reporting. Data verification ensures that all data are received for every sample submitted for analyses and includes a preliminary review by the data users. The verification process also ensures that any discrepancies noted have been addressed and that the resultant changes are documented.

Data validation is performed independent of the analytical laboratory. Data validation consists of two primary functions. First, the analytical process is reviewed and the quality of the data is documented. This consists of reviewing all records related to sample integrity, sample preparation, and the analytical measurement systems. Second, the data are compared to the method-specific criteria and site-specific data quality requirements. This ensures that data quality is evaluated based on the end use of the data. At the WSSRAP, approximately 10% of all analytical data are validated according to site-specific procedures. Approximately 5% are evaluated on a random basis to provide coverage across all data sets. The other 5% are selected from critical data. The 10% validation actually reviews a large portion of the analytical lots, effectively validating a much larger percentage of the data base. This is accomplished by reviewing information affecting data quality, such as instrument calibration, which is the same for all samples in an analytical lot.

The useability of the data is established by data validation. The final step involves comparing results to the method criteria and data quality requirements. Qualifiers are attached to data records that have been validated. This allows data users to assess the quality of the data being used without requiring a detailed knowledge of the analytical processes. The data validation process is detailed in procedure RC-31.

These programs and procedures ensure that analytical data quality is known and documented and that data presented in the report have been verified and a given percent have been validated.

All raw and interpreted data collected for this sampling plan will be included in a completion report. The completion report, or reports, for each task can be used as an independent document and will be published according to DOE procedure.

8 HEALTH AND SAFETY

The health and safety of personnel performing tasks described in this sampling plan is addressed in task-specific approved plans and procedures. The health and safety of Project Management Contractor (PMC) personnel performing sampling activities is addressed in Construction Management and Operations procedure CM&O 15 *Task Specific Safety Assessment* (TaSSA). A TaSSA will be prepared, reviewed, and approved daily when field activities are performed by PMC personnel. The TaSSA ensures that: potential hazards associated with the activities to be performed are reviewed, personnel are aware of the potential hazards, proper protective measures are taken, and specific monitoring, if required, is performed.

Potential hazards associated with activities performed by subcontractors are addressed in Health and Safety Plans (HASP). A HASP will be prepared for each subcontract to identify potential hazards, define minimum safety measures that must be implemented, and identify responsibilities for safety. Each HASP addresses general construction safety and the hazards related to performing the work in the specified area. In addition, subcontractors are required to submit, for contractor approval, a Safe Work Plan which incorporates requirements specified in the HASP. The subcontractor's field supervisor reviews the appropriate provisions of the Safe Work Plan with all field personnel daily. If required, subcontractors will also receive oversight and personnel protection monitoring from PMC personnel.

In addition to the provisions previously discussed, PMC Safety Department personnel routinely inspect work areas. Equipment is also inspected prior to usage and routinely during usage.

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DOE ORDERS

5400.1 *General Environmental Protection Program*
5700.6C *Quality Assurance*

10 ACRONYMS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ASER	Annual Site Environmental Report (ASER)
ASME	American Society of Mechanical Engineers
BGA	Berkeley Geosciences Associates
BNI	Bechtel National, Inc.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CM&O	Construction Management and Operations
DA	U.S. Department of the Army
DNT	dinitrotoluene
DOE	U.S. Department of Energy
EDAP	Environmental Data Administration Plan
EPA	U.S. Environmental Protection Agency
EQAPP	Environmental Quality Assurance Program Plan
ES&H	Environmental Safety and Health
HASP	Health and Safety Plan
ID	identification number
IGS	In situ Groundwater Sample
JEG	Jacobs Engineering Group
LBL	Lawrence Berkeley Laboratory
MCL	Maximum Containment Level
MKF	MK-Ferguson Company
NEPA	National Environmental Policy Act
NLO	National Lead Company of Ohio
NQA	Nuclear Quality Assurance (of ASME)
OAE	Office of Area Engineer (Department of the Army)
ORO	Oak Ridge Operation (of DOE)
PMC	Project Management Contractor
QA/QC	quality assurance/quality control
QAMS	Quality Assurance Management Staff
QAPP	Quality Assurance Program Plan
QR	quarry residuals

RC	Regulatory Compliance
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act of 1986
SQP	Site Quality Procedure
TaSSA	Task Specific Safety Assessment
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
USGS	U.S. Geological Survey
VOA	Volatile Organic Analysis
WSOW	Weldon Spring Ordnance Works
WSQ	Weldon Spring Quarry
WSS	Weldon Spring site
WSSRAP	Weldon Spring Site Remedial Action Project

APPENDIX A
IOC From Lotar Klingmuller to File
Dated December 18, 1991

MK-Ferguson Company

Weldon Spring Site Remedial Action Project

TRANSMITTAL OF CONTRACT DELIVERABLE

Date: 12/21/95 **Transmittal No.:** CD-0091-00

Title of Document: Weldon Spring Quarry Supplementary Environmental Monitoring Investigations Sampling Plan

Doc. Num.: 264 **Rev. No.:** 0 **Date of Document:** August 1992)

Purpose of Transmittal: Request for Department of Energy acceptance of contract deliverable.

The Project Management Contractor has reviewed and approved the attached document and hereby delivers it to the U.S. Department of Energy, Weldon Spring Site Office.

The document will be considered accepted unless we receive written notification to the contrary within 30 days of the date of this transmittal.

James R. Powers

James R. Powers
Project Director

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