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2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
847 LANDFILL
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

by Haley & Aldrich, Inc.
Cleveland, Ohio

for Westar Energy, Inc.
Topeka, Kansas

File No. 129778-019
January 2019

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This Annual Groundwater Monitoring and Corrective Action Report documents the groundwater monitoring system for the Lawrence Energy Center (LEC) 847 Landfill consistent with applicable sections of § 257.90 through 257.98, and describes activities conducted in the prior calendar year (2018) and documents compliance with the United States Environmental Protection Agency Coal Combustion Residual Rule. I certify that the 2018 Annual Groundwater Monitoring and Corrective Action Report for the LEC 847 Landfill is, to the best of my knowledge, accurate and complete.

Signed: ______________________
Professional Geologist

Print Name:	Mark Nicholls
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Company:	Haley & Aldrich, Inc.

MARK D. NICHOLLS LICENSED 881 1/31/19 KANSAS PROFESSIONAL GEOLOGIST

Mark Nicholls Digitally signed by Mark Nicholls Date: 2019.01.31 13:36:42 -07'00'

1. Introduction

This 2018 Annual Groundwater Monitoring and Corrective Action Report (Annual Report) addresses the 847 Landfill (also known as Ash Landfill 847) at the Lawrence Energy Center (LEC), operated by Westar Energy, Inc. (Westar). This Annual Report was developed in accordance with the United States Environmental Protection Agency Coal Combustion Residual (CCR) Rule effective 19 October 2015 (Rule), specifically Code of Federal Regulations Title 40 (40 CFR), subsection § 257.90(e). The Annual Report documents the groundwater monitoring system for the 847 Landfill consistent with applicable sections of § 257.90 through 257.98, and describes activities conducted in the prior calendar year (2018) and documents compliance with the Rule. The specific requirements for the Annual Report listed in Sections § 257.90(e) of the Rule are provided in Section 2 of this Annual Report and are in bold italic font, followed by a short narrative describing how each Rule requirement has been met.

2. 40 CFR § 257.90 Applicability

2.1 40 CFR § 257.90(a)

Except as provided for in §257.100 for inactive CCR surface impoundments, all CCR landfills, CCR surface impoundments, and lateral expansions of CCR units are subject to the groundwater monitoring and corrective action requirements under §257.90 through 257.98.

Westar has installed and certified a groundwater monitoring system at the LEC 847 Landfill. The 847 Landfill is subject to the groundwater monitoring and corrective action requirements described under 40 CFR § 257.90 through 257.98. This document addresses the requirement for the Owner/Operator to prepare an Annual Report per § 257.90(e) (Rule).

2.2 40 CFR § 257.90(e) – SUMMARY

Annual groundwater monitoring and corrective action report. For existing CCR landfills and existing CCR surface impoundments, no later than January 31, 2018, and annually thereafter, the owner or operator must prepare an annual groundwater monitoring and corrective action report. For new CCR landfills, new CCR surface impoundments, and all lateral expansions of CCR units, the owner or operator must prepare the initial annual groundwater monitoring and corrective action report no later than January 31 of the year following the calendar year a groundwater monitoring system has been established for such CCR unit as required by this subpart, and annually thereafter. For the preceding calendar year, the annual report must document the status of the groundwater monitoring and corrective action program for the CCR unit, summarize key actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year. For purposes of this section, the owner or operator has prepared the annual report when the report is placed in the facility's operating record as required by §257.105(h)(1).

This Annual Report describes monitoring completed and actions taken for the groundwater monitoring system at the LEC 847 Landfill as required by the Rule. Groundwater sampling and analysis was conducted in accordance with requirements described in § 257.93, and the status of the groundwater monitoring program described in § 257.94 is provided in this report. This Annual Report documents the applicable groundwater-related activities completed in the calendar year 2018.

2.2.1 Status of the Groundwater Monitoring Program

Statistical analyses completed in January 2018 using detection monitoring analytical data received in October 2017 showed a statistically significant increase (SSI) above background concentrations of boron and fluoride at well MW-34. An alternative source demonstration (ASD) was completed and certified on 13 April 2018, which is within 90 days of the completion of statistical analyses that indicated the SSI. The ASD demonstrated that the SSI was the result of natural variability of groundwater quality. Because the ASD was completed and certified within 90 days of the SSI being identified, 847 Landfill remained in the detection monitoring program.

2.2.2 Key Actions Completed

The 2017 Annual Groundwater Monitoring and Corrective Action Report was completed in January 2018. Statistical analysis was completed in January 2018 on analytical data from the initial detection monitoring sampling event. A successful Alternate Source Demonstration was completed for all SSIs. Sampling for the first semi-annual detection monitoring event was completed in March 2018. Statistical analysis was completed within 90 days of receipt of finalized laboratory data. No SSIs were determined for this sampling event. Sampling for the second semi-annual detection monitoring sampling event was completed in September 2018. Statistical analysis of the results from the second semi-annual detection monitoring sampling event are due to be completed in January 2019 and will be reported in the next annual report.

2.2.3 Problems Encountered

No noteworthy problems (i.e., problems could include damaged wells, issues with sample collection or lack of sampling, and problems with analytical analysis) were encountered at the 847 Landfill groundwater monitoring program in 2018.

2.2.4 Actions to Resolve Problems

No problems were encountered at the 847 Landfill in 2018, therefore, no actions to resolve problems were required.

2.2.5 Project Key Activities for Upcoming Year

Key activities planned for 2019 include the 2018 Annual Groundwater Monitoring and Corrective Action Report, statistical analysis of detection monitoring analytical data collected in September 2018, and semi-annual detection monitoring and subsequent statistical analysis.

2.3 40 CFR § 257.90(e) – INFORMATION

At a minimum, the annual groundwater monitoring and corrective action report must contain the following information, to the extent available:

2.3.1 40 CFR § 257.90(e)(1)

A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit;

As required by § 257.90(e)(1), a map showing the locations of the CCR unit and associated upgradient and downgradient monitoring wells for the 847 Landfill is included in this report as Figure 1.

2.3.2 40 CFR § 257.90(e)(2) – Monitoring System Changes

Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken;

No monitoring wells were installed or decommissioned during 2018.

2.3.3 40 CFR § 257.90(e)(3) – Summary of Sampling Events

In addition to all the monitoring data obtained under §257.90 through §257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs;

In accordance with § 257.94(b), two independent detection monitoring samples from each background and downgradient monitoring well were collected during 2018. A summary table including the sample names, dates of sample collection, and monitoring data obtained for the groundwater monitoring program for the 847 Landfill is presented in Table I of this report.

2.3.4 40 CFR § 257.90(e)(4) – Monitoring Transition Narrative

A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels); and

Initial detection monitoring statistical analyses were completed in January 2018, in accordance with § 257.94(b). The analyte concentrations from the downgradient wells for each of the Appendix III constituents from the 2017 detection monitoring sampling event from each location were compared to their respective prediction limit (PL). Once data is validated, a sample concentration greater than the PL is considered to represent a SSI. A SSI over background levels for one or more constituents listed in Appendix III were identified. A summary of the Appendix III SSIs identified in January 2018 is provided in Table II.

A successful demonstration that a source other than the CCR unit caused the SSI over background levels was completed within 90 days of the SSI determination in accordance with 40 CFR §257.94(e)(2), and the 847 Landfill remained in detection monitoring.

2.3.5 40 CFR § 257.90(e)(5) – Other Requirements

Other information required to be included in the annual report as specified in §257.90 through §257.98.

This Annual Report documents activities conducted to comply with § 257.90 through § 257.95 of the Rule. It is understood that there are supplemental references in § 257.90 through § 257.98 to information that must be placed in the Annual Report. The following requirements include relevant and required information in the Annual Report for the activities completed in calendar year 2018.

2.3.5.1 40 CFR § 257.94(d)(3) – Demonstration for Alternative Detection Monitoring Frequency

The owner or operator must obtain a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority stating that the demonstration for an alternative groundwater sampling and analysis frequency meets the requirements of this section. The owner or operator must include the demonstration providing the basis for the alternative monitoring frequency and the certification by a qualified professional engineer or the approval from the Participating State Director or approval from EPA where EPA is the permitting authority in the annual groundwater monitoring and corrective action report required by § 257.90(e).

An alternative groundwater detection monitoring sampling and analysis frequency has not been established for this CCR unit; therefore, no demonstration or certification is applicable.

2.3.5.2 40 CFR § 257.94(e)(2) – Detection Monitoring Alternate Source Demonstration

The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority verifying the accuracy of the information in the report verifying the accuracy of the information in the report. If a successful demonstration is completed within the 90-day period, the owner or operator of the CCR unit may continue with a detection monitoring program under this section. If a successful demonstration is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under § 257.95. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority.

An ASD was completed and certified on 13 April 2018, which is within 90 days of the completion of statistical analyses that indicated the SSI. Because the ASD was completed and certified within 90 days of the SSI being identified, 847 Landfill remained in the detection monitoring program. The ASD is included as Attachment 1 to this report.

2.3.5.3 40 CFR § 257.95(c)(3) – Demonstration for Alternative Assessment Monitoring Frequency

The owner or operator must obtain a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority stating that the demonstration for an alternative groundwater sampling and analysis frequency meets the requirements of this section. The owner or operator must include the demonstration providing the basis for the alternative monitoring frequency and the certification by a qualified professional engineer or the approval from the Participating

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State Director or approval from EPA where EPA is the permitting authority in the annual groundwater monitoring and corrective action report required by § 257.90(e).

847 Landfill remains in detection monitoring and an alternative groundwater assessment monitoring sampling and analysis frequency has not been established for this CCR unit; therefore, no demonstration or certification is applicable.

2.3.5.4 40 CFR § 257.95(d)(3) – Assessment Monitoring Concentrations and Groundwater Protection Standards

Include the recorded concentrations required by paragraph (d)(1) of this section, identify the background concentrations established under § 257.94(b), and identify the groundwater protection standards established under paragraph (d)(2) of this section in the annual groundwater monitoring and corrective action report required by § 257.90(e).

847 Landfill has not transitioned into assessment monitoring, and no assessment monitoring samples were collected or analyzed in 2018. Consequently, Westar is not required to establish groundwater protection standards for this CCR unit and this criterion is not applicable.

2.3.5.5 40 CFR § 257.95(g)(3)(ii) – Assessment Monitoring Alternate Source Demonstration

Demonstrate that a source other than the CCR unit caused the contamination, or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Any such demonstration must be supported by a report that includes the factual or evidentiary basis for any conclusions and must be certified to be accurate by a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority. If a successful demonstration is made, the owner or operator must continue monitoring in accordance with the assessment monitoring program pursuant to this section, and may return to detection monitoring if the constituents in appendices III and IV to this part are at or below background as specified in paragraph (e) of this section. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer or the approval from the Participating State Director or approval from EPA where EPA is the permitting authority.

Assessment monitoring statistical analyses were not completed in 2018. Therefore, this criterion is not applicable.

2.3.5.6 40 CFR § 257.96(a) – Demonstration for Additional Time for Assessment of Corrective Measures

Within 90 days of finding that any constituent listed in appendix IV to this part has been detected at a statistically significant level exceeding the groundwater protection standard defined under § 257.95(h), or immediately upon detection of a release from a CCR unit, the owner or operator must initiate an assessment of corrective measures to prevent further releases, to remediate any releases and to restore affected area to original conditions. The assessment of corrective measures must be completed within 90 days, unless the owner or

operator demonstrates the need for additional time to complete the assessment of corrective measures due to site-specific conditions or circumstances. The owner or operator must obtain a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority attesting that the demonstration is accurate. The 90-day deadline to complete the assessment of corrective measures may be extended for no longer than 60 days. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer or the approval from the Participating State Director or approval from EPA where EPA is the permitting authority.

Assessment monitoring statistical analyses were not completed in 2018. Therefore, this criterion is not applicable.

TABLES

TABLE I

SUMMARY OF ANALYTICAL RESULTS - DETECTION MONITORING

WESTAR ENERGY, INC.

LAWRENCE ENERGY CENTER

847 LANDFILL

LAWRENCE, KANSAS

Location	**Upgradient**					**Downgradient**					
	MW-32		**MW-35**			**MW-31R**		**MW-33**		**MW-34**	
Measure Point (TOC)	861.96		862.52			857.67		855.4		871.96	
Sample Name	MW-32-030718	MW-32-090418	MW-35-030718	MW-35-090418	MW-35-111518	MW-31R-030718	MW-31R-090418	MW-33-030718	MW-33-090418	MW-34-030718	MW-34-090418
Sample Date	3/7/2018	9/4/2018	3/7/2018	9/4/2018	11/15/2018	3/7/2018	9/4/2018	3/7/2018	9/4/2018	3/7/2018	9/4/2018
Lab Data Reviewed and Accepted	4/16/2018	10/15/2018	4/16/2018	10/15/2018	12/15/2018	4/16/2018	10/15/2018	4/16/2018	10/15/2018	4/16/2018	10/15/2018
Depth to Water (ft btoc)	46.38	47.53	48.70	49.85	48.87	42.77	43.80	40.63	41.59	56.85	57.77
Temperature (Deg C)	10.78	17.52	11.61	17.21	--	12	16.74	11.28	17.45	12.06	18.64
Conductivity (µS/cm)	823	826	33850	35400	--	10810	9590	18520	19100	16450	16800
Turbidity (NTU)	0.14	0.11	0.67	2.86	--	0.20	0.06	0.82	0.45	0.97	1.13
Boron, Total (mg/L)	**0.18**	**0.182**	**1.9**	**2.05**	--	**0.63**	**0.538**	**1.7**	**1.68**	**2.1**	**2.13**
Calcium, Total (mg/L)	**59.6**	**58.1**	**530**	**527**	--	**234**	**213**	**249**	**242**	**210**	**205**
Chloride (mg/L)	**102**	**103**	**13100**	**14900**	--	**4280**	**3550**	**7820**	**6810**	**6110**	**6060**
Fluoride (mg/L)	**0.26**	**0.31**	<0.20	<10.0*	**1.7**	**0.53**	**0.45**	**1.1**	**1.5**	**1.6**	**1.9**
Sulfate (mg/L)	**7.0**	**6.6**	**614**	**612**	--	**146**	**117**	**331**	**289**	**482**	**438**
pH (su)	**7.4**	**7.5**	**7.1**	**7.2**	--	**7.3**	**7.3**	**7.4**	**7.4**	**7.9**	**7.6**
TDS (mg/L)	**480**	**505**	**23100**	**27100**	--	**6050**	**6520**	**10700**	**14100**	**11400**	**12200**

Notes:

µS/cm = micro Siemens per centimeter

ft btoc = feet below top of casing

Deg C = degrees Celsius

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Unit

su = standard unit

TDS = total dissolved solids

TOC = top of casing

Bold value: Detection above laboratory reporting limit

* Resampled due to laboratory reporting limit error.

TABLE II
SUMMARY OF APPENDIX III SSIs
WESTAR ENERGY, INC.
LAWRENCE ENERGY CENTER
847 LANDFILL
LAWRENCE, KANSAS

Well ID	Statisical Analysis Completed	Constituent
MW-34	January 2018	Boron
	January 2018	Fluoride

Notes:
SSIs = statistically significant increases

FIGURE

LEGEND

- MONITORING WELL
- ASH LANDFILL ACTIVE AREA
- ASH LANDFILL LIMITS OF DISPOSAL AREA

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 7 NOVEMBER 2015.

N

0 350 700

SCALE IN FEET

HALEY ALDRICH

WESTAR ENERGY
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

847 LANDFILL MONITORING
WELL LOCATION MAP

JANUARY 2019
SCALE: AS SHOWN

FIGURE 1

GIS FILE PATH: G:\Projects\Westar\Lawrence Energy Center (LEC)\GIS\MXDs\2016_06_SAP\LEC_MW_LOCA_MAP_REV1.mxd — USER: DZinsmaster — LAST SAVED: 3/16/2018 10:09:45 AM

ATTACHMENT 1

Appendix III SSI Alternate Source Demonstration for Ash Landfill 847

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SUMMARY REPORT
APPENDIX III SSI ALTERNATE SOURCE DEMONSTRATION
FOR ASH LANDFILL 847
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

By Haley & Aldrich, Inc.
Cleveland, Ohio

For Westar Energy, Inc.
Topeka, Kansas

File No. 129778-016
April 2018

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1. Introduction

Haley & Aldrich, Inc. (Haley & Aldrich) was retained by Westar Energy Inc. (Westar) to perform an evaluation of groundwater quality at Ash Landfill 847 at the Lawrence Energy Center (LEC) located in Lawrence, Kansas. The purpose of that evaluation was to identify the source of statistically significant increases (SSIs) for boron and fluoride concentrations detected in monitoring wells located down gradient of Ash Landfill 847. The exercise is in support of the coal combustion residuals (CCR) Rule, specifically §257.94(e)(2), groundwater detection monitoring program, and a SSI alternative source demonstration (ASD) for the Appendix III constituents identified.

1.1 BACKGROUND

Consistent with Code of Federal Regulations Title 40 (40 CFR) §257.90 through §257.94, Westar has installed and certified a groundwater monitoring network at Ash Landfill 847 at LEC and has collected baseline groundwater samples in accordance with the CCR Rule. Westar conducted statistical analyses of the groundwater quality results to determine if any Appendix III constituents are present in groundwater samples collected from down-gradient monitoring wells at concentrations that are considered to have exhibited SSIs. The analysis of the Appendix III constituents resulted in a calculated SSI for boron and fluoride down gradient of Ash Landfill 847 at monitoring well MW-34. The analyses described in this report were conducted to determine if alternate sources existed for the SSIs identified down gradient of Ash Landfill 847.

Pursuant to 40 CFR §257.94(e)(2), ***"The owner or operator may demonstrate that a source other than the CCR unit [1] caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality."*** The CCR Rule provides 90 days from determination of an SSI to complete an ASD for applicable Appendix III constituents [2]. If a successful ASD is completed and certified by a qualified professional engineer, the CCR unit may continue in detection monitoring. If, however, an alternate source of the Appendix III SSI is not identified, the owner or operator must initiate an assessment monitoring program within 90 days following the ASD evaluation period. This report documents the findings and conclusions associated with ASDs completed for the boron and fluoride SSIs at Ash Landfill 847.

1.2 SITE SETTING

The LEC is located adjacent to the Kansas River, northwest of the City of Lawrence in Douglas County, Kansas (Figure 1). The site is located within the Central Lowland physiographic province which includes rolling hills overlying nearly horizontal thin beds of alternating shale and limestone. Ash Landfill 847 is a CCR landfill that encompasses approximately 50 acres and is located approximately 0.25 miles east of the LEC plant site. The LEC plant site and Ash Landfill 847 are in an area characterized by natural ground surface elevations varying from 850 and 885 feet above mean sea level.

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[1] Referred to in this documents as an "alternate source," and the demonstration for such is referred to as an ASD.

[2] For simplicity, this report utilizes the term ASD to account for any of the three possible explanations (allowed for in the CCR Rule) for why a calculated SSI is not related to the CCR unit being evaluated. Those include: 1) The source for the SSI originates from something other than the CCR unit in question; 2) the SSI resulted from an error in sampling, analysis, or statistical evaluation, or 3) the SSI resulted from a natural variation in groundwater quality.

1.3 SITE DESCRIPTION

The LEC is a 530-megawatt energy production facility that was commissioned in 1938 and generates electricity through combustion of coal. The source fuel for LEC is Powder River Basin coal which is delivered via rail to the facility from Wyoming. LEC operates three coal-fired power generation units: Unit 3 was installed in 1954, Unit 4 was installed in 1960, and Unit 5 was installed in 1971. Units 1 and 2 have been decommissioned. The LEC Ash Landfill 847 and associated groundwater monitoring well network is shown on Figure 2. The LEC Ash Landfill 847 receives fly ash, bottom ash, and flue gas desulfurization (FGD) materials generated by the LEC.

2. Site Geology and Hydrogeology

Geologic and hydrogeologic conditions beneath Ash Landfill 847 have been characterized based on information obtained during installation and testing of the monitoring wells installed for the Solid Waste Disposal Area Operating Permit (Kansas Department of Health and Environment [KDHE] Permit No. 359) and monitoring wells installed as part of the CCR groundwater monitoring network.

2.1 SITE GEOLOGY

The LEC facility and Ash Landfill 847 lie within an area of Pleistocene glacial activity in the Dissected Till Plains region of the Central Lowlands geomorphic province. Geologic units that underlie Ash Landfill 847 are roughly horizontal with a regional dip northwest and consist of glacial till deposits and members of the Stranger Formation. The members of the Stranger Formation that underlie Ash Landfill 847, in order of increasing depth, include the Vinland Shale member, Westphalia Limestone member, Tonganoxie Sandstone member, and the Weston Shale.

The Pleistocene glacial till deposits are underlain by strata representing transgressions and regressions of marine and near-shore depositional environments. The shale units represent deposition of fine grain silt and clay materials in an off-shore marine environment. The silt and clay were later buried at depth and compressed to form the relatively hard and impermeable shale observed underlying Ash Landfill 847. The limestone units represent deposition of chemically precipitated calcium carbonate in an environment further from shore in comparison with the shale depositional environment. The sandstone units represent deposition of near-shore sand. After deposition, the chemically precipitated calcium carbonate was also buried at depth and compressed to form the limestone units observed underlying Ash Landfill 847.

2.2 SITE HYDROGEOLOGY AND HYDROLOGY

The unsaturated glacial till material overlying the uppermost aquifer is composed of poorly sorted glacial clay, sand, and gravel, which is underlain by the Vinland Shale member of the Stranger Formation, and the Westphalia Limestone member of the Stranger Formation. The thickness of the unsaturated glacial till material is based on ground surface elevation and the lowermost elevation of the Westphalia Limestone of the Stranger Formation. Based on direct observations during drilling of MW-31R through MW-35, the thickness of the unsaturated material overlying the uppermost aquifer at the site is approximately 34 to 56 feet. These materials were observed during drilling conducted in 2016 and 2017.

A thin surficial saturated zone exists within the glacial till material above the Vinland Shale member of the Stranger Formation. Hydraulic conductivity of the overlying shale was calculated to be $1x10^{-6}$ centimeters per second (cm/sec) using data obtained from falling head packer tests conducted within the shale. The results of the falling head packer test indicate that the Vinland Shale member of the Stranger Formation acts as an aquitard. This thin saturated zone contains discontinuous perched water in quantities insufficient to yield groundwater to wells or springs and insufficient to accommodate consistent groundwater sampling, and therefore is not considered to be an aquifer. Based on discussions with the KDHE, they do not consider this perched zone to meet the definition of an aquifer provided in the CCR Rule.

Therefore, the water-bearing geologic formation nearest the natural ground surface at Ash Landfill 847 was identified as the Tonganoxie Sandstone member of the Stranger Formation. This regional sandstone aquifer is characterized as a fine to coarse grain sandstone, with shale and siltstone strata included in the upper portion of the member. Natural groundwater quality in the Tonganoxie Sandstone member of the Stranger Formation includes water that is highly mineralized and is unsuitable for human consumption or irrigation (O'Connor, 1960). The Tonganoxie Sandstone is confined beneath the Vinland Shale member of the Stranger Formation at Ash Landfill 847. The shale and siltstone strata of the upper Tonganoxie Sandstone member create the confining conditions observed in the lower sandstone member. The piezometric surface representing groundwater within the Tonganoxie Sandstone rises above the top of the Tonganoxie Sandstone beneath Ash Landfill 847, yielding groundwater elevations above the top of the sandstone. The saturated thickness of the uppermost aquifer beneath Ash Landfill 847 is approximately 97 to 161 feet based on observations made during drilling conducted at Ash Landfill 847 in May and June 2016 and March 2017.

Based on groundwater elevations measured between April 2016 and August 2017, the groundwater gradient within the Tonganoxie Sandstone is nearly flat, exhibiting approximately 0.5 foot of elevation change across the site. A relatively flat groundwater gradient is a characteristic of confined aquifer conditions in areas where there is little or no pumping from the subject aquifer. There is no known pumping from the Tonganoxie Sandstone in the vicinity of LEC due to the extremely poor groundwater quality exhibited in that formation. Since the gradient is nearly flat, small differences in surface topography, well survey, well construction, depth of screened intervals, and piezometric pressure have the potential to materially affect the apparent groundwater gradient. Small changes in aquifer conditions affecting water levels by as little as 0.1 foot may have the effect of reversing the apparent groundwater gradient.

Hydraulic conductivity of the uppermost aquifer was calculated using data generated from slug tests conducted after the newly installed monitoring wells were completed and developed. Based on slug test results, the hydraulic conductivity of the Tonganoxie Sandstone was calculated to be 1.1×10^{-3} cm/sec.

The regional groundwater flow direction in the Tonganoxie Sandstone is reported to be toward the northeast (O'Connor, 1960). Based on groundwater elevations measured between August 2016 and August 2017, the groundwater gradient within the uppermost aquifer at Ash Landfill 847 ranges from 0.0003 feet per foot (feet/foot) to 0.0009 feet/foot, with groundwater flow toward the northeast, consistent with available published information. The shallow groundwater gradient means that minor changes in conditions during measurement or sampling have the potential to affect the apparent groundwater flow direction at each sampling event. Confined aquifers are very sensitive to pumping effects from both production wells and monitoring wells pumped during sampling. The down-gradient monitoring wells were sited at locations that are down gradient of Ash Landfill 847 based on observed groundwater elevation conditions and published information. These wells are also sited directly between Ash Landfill 847 and the Kansas River.

Monitoring wells MW-32 and MW-35 are a paired set of up-gradient monitoring wells installed approximately 70 feet apart. The top of the screened interval in MW-35 is 40 feet deeper than the bottom of the screened interval in MW-32. Well MW-32 is screened in the upper portion of the Tonganoxie Sandstone, and well MW-35 is screened in the lower portion of the Tonganoxie Sandstone. The water levels differ by approximately 1.8 feet, with MW-35 yielding deeper water levels. The water level in MW-32 represents piezometric pressure in the upper portion of the Tonganoxie Sandstone and is most closely related to water levels measured in wells MW-31R, MW-33, and MW-34 which are also screened through the upper portion of the Tonganoxie Sandstone. Because MW-32, MW-31R, MW-33, and MW-34 are all screened in the upper portion of the Tonganoxie Sandstone (the uppermost aquifer beneath Ash Landfill 847), the water levels measured in these wells represent the piezometric surface and groundwater flow direction beneath Ash Landfill 847. The difference in water levels observed between wells MW-32 and MW-35 represent an apparent downward groundwater gradient. The groundwater gradient flow direction derived from the water levels in MW-31R, MW-32, MW33, and MW-34 reflect the regional groundwater flow direction reported by O'Connor (1960).

Although a vertical groundwater gradient may exist between wells MW-32 and MW-35, the combination of these two wells represent groundwater quality for the entire thickness of the Tonganoxie Sandstone at the up-gradient side of Ash Landfill 847 and are directly comparable to wells M31R, MW-33, and MW-34 which penetrate a majority of the Tonganoxie Sandstone. The Tonganoxie Sandstone thins to the north-northeast, forcing water from the deeper and shallower Tonganoxie Sandstone to mix as it approaches wells M31R, MW-33, and MW-34. The groundwater quality observed in wells MW-31R, MW-32, MW33, MW-34, and MW-35 all reflect groundwater quality known to exist in the Tonganoxie Sandstone as reported by O'Connor (1960).

The Weston Shale member of the Stranger Formation is the confining unit underlying the Tonganoxie Sandstone member. A core hole was drilled into the underlying shale and a falling head packer test was conducted at the MW-31R location. Drilling was stopped when a sufficient thickness of competent shale had been intersected to facilitate completion of a representative falling head packer test. Based on observations made during drilling, the thickness of the underlying confining layer (aquitard) below the uppermost aquifer is greater than 5 feet in this area. Hydraulic conductivity of the underlying shale was calculated to be 8×10^{-7} cm/sec using data obtained from the falling head packer test conducted within the shale. The results of the falling head packer test indicate that the Weston Shale member of the Stranger Formation acts as an aquitard.

3. Alternative Source Demonstration

Haley & Aldrich conducted an evaluation of potential alternative sources that included review of the three possible alternative sources (allowed for in the CCR Rule) for the apparent SSIs for boron and fluoride related to the Ash landfill 847 baseline groundwater monitoring program. These possible alternative sources include:

1. The source for the SSI originates from something other than the CCR unit in question;
2. The SSI resulted from an error in sampling, analysis, or statistical evaluation; or
3. The SSI resulted from a natural variation in groundwater quality.

As part of that evaluation, Haley & Aldrich evaluated potential point and non-point sources of the subject Appendix III SSIs in the vicinity of Ash Landfill 847 and evaluated natural geologic conditions and the effect of those conditions on native groundwater chemistry. Each of these analyses and the resulting findings are described below.

3.1 REVIEW OF FIELD SAMPLING, LABORATORY ANALYSIS, AND STATISTICAL PROCEDURES

3.1.1 Field Sampling Procedures

Westar and Haley & Aldrich conducted the field sampling activities in accordance with the Groundwater Sampling and Analysis Plan (SAP; Haley & Aldrich, 2017) that was prepared in accordance with §257.93 of the CCR Rule. The SAP prescribes the site-specific activities and methods for groundwater sampling and included procedures for field data collection, sample collection, sample preservation and shipment, interpretation, laboratory analytical methods, and reporting for groundwater sampling for Ash Landfill 847. The administrative procedures and frequency for collection of groundwater elevation measurements, determination of flow directions, and gradients were also provided in the SAP.

Haley & Aldrich reviewed the field sampling and equipment calibration logs and the field indicator parameters and did not identify any apparent deviations or errors in sampling that would result in potential SSIs downgradient of Ash Landfill 847.

3.1.2 Laboratory Analysis

The groundwater samples collected down gradient of Ash Landfill 847 were analyzed by Pace Analytical Services (Pace) using promulgated U.S. Environmental Protection Agency (USEPA) analytical methods in accordance with the SAP (Haley & Aldrich, 2017) that was prepared in accordance with §257.93 of the CCR Rule. The data generated from these laboratory analyses are stored in a project database that incorporates hydrogeologic and groundwater quality data and was established to allow efficient management of chemical and physical data collected in the field and produced in the laboratory.

Haley & Aldrich conducted a quality assurance/quality control review of each groundwater quality dataset generated for Ash Landfill 847 and has not identified any apparent errors that would result in potential SSIs downgradient of Ash Landfill 847.

3.1.3 Statistical Evaluation

Westar and Haley & Aldrich collected a total of eight baseline groundwater samples from each of the up-gradient (MW-32 and MW-35) and down-gradient (MW-31R, MW-33, and MW-34) monitoring wells at Ash Landfill 847 over a period spanning from August 2016 through June 2017 as required by the CCR Rule. Statistical analysis of the analytical results was completed as documented in previous reports.

Haley & Aldrich has reviewed the statistical analysis of groundwater quality data for the up-gradient and down-gradient wells at Ash Landfill 847 and has not identified any apparent errors that would result in potential SSIs downgradient of Ash Landfill 847. The statistical test method used, met the performance standard established in the CCR Rule, and statistical evaluation complies with the requirements of the CCR Rule.

3.2 POTENTIAL SOURCES OTHER THAN ASH LANDFILL 847

Haley & Aldrich conducted a review of potential sources (both point and non-point) of boron and fluoride in the vicinity of Ash Landfill 847 to determine if previous or adjacent site activities, land uses, or practices might have caused (or are currently causing) elevated concentrations of these constituents to occur down gradient of Ash Landfill 847. Potential point sources would include discharging activities or other activities occurring at a discrete location in the vicinity of the observed SSIs that may potentially concentrate boron or fluoride in that area. Non-point sources would include diffuse discharging activities or practices that may result in a low level but wide-spread increase in boron or fluoride concentrations detected at the down-gradient side of Ash Landfill 847.

3.2.1 Point Sources

Prior to construction of Ash Landfill 847, the landfill site and surrounding vicinity was used as agricultural land followed by light industrial. Buildings were constructed on the site as early as 1967. The potential for the agricultural and light industrial land use of the site prior to construction of Ash Landfill 847 to constitute a point source is minimal due to the depth of the aquifer being monitored at the site and the fact that the Tonganoxie Sandstone aquifer is confined. The Vinland Shale member of the Stranger Formation overlies the Tonganoxie Sandstone and acts as an aquitard, reducing the potential for past land use at the site to constitute a point source to concentrate boron and fluoride at Ash Landfill 847 prior to construction of the landfill. No point sources have been identified that may constitute an alternative source of boron or fluoride at Ash Landfill 847.

3.2.2 Non-Point Sources

No mining or other activities have been documented in the vicinity of Ash Landfill 847 that might constitute a non-point source of boron or fluoride at the location of the observed SSIs. Agricultural land use was observed approximately 600 feet to the south and up gradient of Ash Landfill 847. No agricultural activities have been identified down gradient of Ash Landfill 847. Records reviewed included historical aerial photographs and historical topographic maps. No non-point sources have been identified that may constitute an alternative source of boron or fluoride at Ash Landfill 847.

3.3 HISTORICAL LAND USE REVEIW

Haley & Aldrich assessed past usage of the site and adjoining properties through a review of the following records:

- Environmental Risk Information Services (ERIS) – Aerial Photographs dated 1937, 1948, 1950, 1950, 1967, 1977, 1982, 1985, 1991, 2003, 2004, 2005, 2006, 2008, 2010, 2012, 2014, 2015, 2017 (Appendix A); and
- ERIS – Topographic Maps dated 1949, 1950, 1967, 1978, 2012 (Appendix B).

Unless otherwise noted below, sources were reviewed dating back to 1940 or first developed use, whichever is earlier, and at 5-year intervals if the use of the property has changed within the time period.

3.3.1 Historical Aerial Photographs

Haley & Aldrich reviewed aerial photographs depicting the development of the site and vicinity, as summarized in Table I. The historical aerial photograph search includes photographs from the Army Mapping Service, United States Geological Survey (USGS), National High-Altitude Photography, and the National Agriculture Information Program (ERIS, 2018) and are included in Appendix A.

Photographs show that the site was undeveloped in 1937. Development of buildings at Ash Landfill 847 started prior to 1948. The structures located at Ash Landfill 847 were further developed and expanded through 2006. Development of Ash Landfill 847 began prior to 2008.

3.3.2 Historical Topographic Maps

Haley & Aldrich reviewed historical topographic maps depicting the development of the site and vicinity, as summarized in Table II. The topographic maps were provided for review by ERIS. Copies of the topographic maps are included in Appendix B.

3.4 REGIONAL WATER QUALITY AND NATURAL VARIABILITY IN GROUNDWATER

Review of the Kansas Geological Survey Water Well Completion Records (WWC-5) Database indicates that the Tonganoxie Sandstone is not used as a groundwater source for water supply wells in the vicinity of Ash Landfill 847. Natural groundwater quality in the Tonganoxie Sandstone member of the Stranger Formation ranges from good, to highly mineralized/unsuitable for human consumption or irrigation (O'Connor, 1960). Analyses of samples of groundwater from the Tonganoxie Sandstone and undifferentiated Stranger Formation are provided in Table III. Groundwater in this aquifer becomes more brackish toward the northeast in the down-gradient direction and westward downdip. Consequently, the Stranger Formation in the vicinity of the site is anticipated to be more brackish than at other locations (O'Connor, 1960). This is consistent with the high concentrations of total dissolved solids (TDS) observed in all of the CCR monitoring wells completed at Ash Landfill 847, both up gradient and down gradient.

Fluoride concentrations in groundwater reported by O'Connor (1960) for the Stranger Formation include a range of concentrations from 0.1 to a maximum concentration of 4.8 milligrams per liter (mg/L). The highest fluoride concentration in groundwater (1.9 mg/L) observed at Ash Landfill 847 occurred at monitoring well MW-34, which is completed in the Stranger Formation. The observed fluoride concentration at MW-34 (1.9mg/L) is only slightly higher and generally comparable with the concentrations observed at up-gradient monitoring well MW-35 (1.6 mg/L), both of which are substantially less than the maximum fluoride concentration (4.8 mg/L) as reported in industry literature for groundwater in the Stranger Formation (O'Connor (1960). Based on this information, all of the fluoride concentrations observed in groundwater in the uppermost aquifer at Ash Landfill 847 fall within the range of naturally occurring concentrations reported in Stranger Formation groundwater. The maximum fluoride concentration observed at monitoring well MW-34 is well below the maximum contaminant level for drinking water (4.0 mg/L) established by the USEPA.

Boron is found in the environment primarily in the form of borates and are naturally occurring within sedimentary rocks, coal, and shale deposits (EPA 2008). O'Connor (1960) reports that coal seams are present in the Tonganoxie Sandstone member of the Stranger Formation. Consequently, the presence of coal seams in the Stranger Formation likely contributes to the variability of boron concentrations observed in the groundwater samples within this formation; and therefore, both wells have in like manner been influenced by those same coal seams reported to exist in the Tonganoxie Sandstone.

The detected boron concentrations within the monitoring wells installed within the Stranger Formation range from 0.17 to 2.1 mg/L. The maximum boron concentrations detected in the upgradient (1.9 mg/L) and down-gradient monitoring wells (2.1 mg/L) are within 10 percent replicate percent difference. Since the acceptable precision of environmental analysis is generally 20 percent, the boron concentrations observed across the monitoring well network are within the normal range of variability for environmental sampling and analysis (USEPA, 2004).

Boron concentrations have been reported by the USGS for one well (Well USGS-385953095152001) drilled within approximately 1,500 feet of Ash Landfill 847. The USGS National Water Information System database includes boron concentrations for both groundwater and for Pleistocene-age sediments that overlie the Lawrence Shale and the Tonganoxie Sandstone (USGS, 2018). The boron concentration in the overlying Pleistocene-age sediments at this location was reported at a level of 330 milligrams per kilogram which represents a potential source of boron in groundwater. The dissolved boron concentration in groundwater reported by the USGS at this well location is comparable (slightly lower) than the total boron concentrations observed in groundwater samples collected at Ash Landfill 847. The dissolved boron concentrations of 0.59 and 1.4 mg/L were reported in the database for two groundwater samples collected from the well referenced in the USGS database. The dissolved boron concentration is likely significantly lower than the total boron concentrations for this groundwater-bearing unit. Total metal concentrations typically represent the presence of suspended sediments in the turbid water produced during purging monitoring wells.

4. Findings and Conclusions

Haley & Aldrich conducted an evaluation of groundwater quality at the LEC Ash Landfill 847 to identify the potential alternative sources of SSIs of boron and fluoride concentrations detected in groundwater samples collected from monitoring well MW-34 located down gradient of Ash Landfill 847. The evaluation included review of sampling procedures, laboratory procedures, and statistical analyses to determine if potential errors may have been made that would result in the apparent SSIs. Haley & Aldrich also evaluated potential point and non-point sources of contamination in the vicinity of Ash Landfill 847 and evaluated natural geologic conditions and the effect of those conditions on native groundwater chemistry.

Haley & Aldrich found no apparent errors in sampling, laboratory analysis, data management, or statistical analysis that would result in potential Appendix III SSIs downgradient of Ash Landfill 847. Haley & Aldrich also found no evidence of historical point or non-point sources of potential boron or fluoride contamination in the vicinity of Ash Landfill 847.

Haley & Aldrich evaluated data and information describing the regional water quality of the Stranger Formation to better understand the potentials for natural variability of groundwater quality in the uppermost aquifer beneath Ash Landfill 847. Key findings regarding the depositional characteristics of the uppermost aquifer and the associated natural variability of groundwater quality in that same uppermost aquifer are summarized below:

- The uppermost aquifer beneath Ash Landfill 847 is composed of the Tonganoxie Sandstone member of the Stranger Formation, which includes a thick sequence of shale, limestone, sandstone. The Tonganoxie Sandstone is overlain by the Vinland Shale member of the Stranger Formation.
- The Vinland Shale has been shown to be a confining layer, limiting the downward flow of groundwater from ground surface to the uppermost aquifer.
- The Vinland Shale overlies the Tonganoxie Sandstone and acts as an aquitard, precluding the possibility that infiltration may reach the uppermost aquifer from Ash Landfill 847 within the period since the landfill has been in operation[3].
- Groundwater from the Stranger Formation is documented to be naturally highly mineralized and unsuitable for human consumption or irrigation in the vicinity of Ash Landfill 847. Naturally occurring dissolved mineral constituents in groundwater in the Tonganoxie Sandstone include constituents listed in Appendix III of the CCR Rule.
- Due to poor water quality, the Tonganoxie Sandstone member of the Stranger Formation is not used as a water supply source in the vicinity of Ash Landfill 847.
- The maximum fluoride concentrations observed at the monitoring well with SSIs (MW-34) down gradient of Ash Landfill 847 are comparable (slightly lower) than natural concentrations reported in the region for wells completed in the Stranger Formation in the vicinity of Ash Landfill 847.

[3] Furthermore, it is worth noting that Ash Landfill 847 has a clay liner, further reducing the velocity and likelihood that water may have infiltrated from the surface to the uppermost aquifer within the period since the landfill has been in operation.

- The USGS has reported a substantial concentration of boron in sediments overlying the uppermost aquifer in the vicinity of Ash Landfill 847. The USGS reported concentrations of boron in groundwater wells similar to those observed at Ash Landfill 847.
- Boron is naturally occurring within sedimentary rock such as the shale and coal seams identified as present within the groundwater bearing unit used in the baseline monitoring program.

Based on these findings, it is evident that there is little likelihood of infiltration of significant quantities to the uppermost aquifer underlying Ash Landfill 847. Extremely poor water quality observed up gradient and down gradient of Ash Landfill 847 closely matches and is comparable with the overall poor water quality observed regionally in the Stranger Formation. Fluoride concentrations in the Stranger Formation are reported to be higher than those detected in MW-34.

In addition, it is also evident that potential substantial sources of boron exist in the shallow Pleistocene sediments that overlie the uppermost aquifer. Furthermore, concentrations of boron in groundwater have been reported near Ash Landfill 847 which are similar to those observed in the uppermost aquifer beneath the landfill. The total boron concentrations observed in the up and down gradient CCR groundwater wells for Ash Landfill 847 are also within the range of variability typical of environmental sampling and analysis.

Based on the data, information, research, and analyses conducted to date and presented in this document, Haley & Aldrich concludes that the source of fluoride and boron resulting in a SSI at MW-34 (down gradient of Ash Landfill 847), represents natural variability in the groundwater quality in the uppermost aquifer underlying Ash Landfill 847.

5. Certification

Pursuant to 40 CFR §257.94(e)(2), Westar conducted an alternate source evaluation to demonstrate that a source other than the Ash Landfill 847 caused the statistically significant increases (SSIs) over background identified during detection monitoring. I certify that this report and all attachments were prepared by me or under my direct supervision. I am a professional engineer who is registered in the State of Kansas.

This certification and the underlying data and evaluation performed in this report support the conclusion that a source other than the CCR unit is the cause of the SSIs over background levels for Appendix III constituents found during detection monitoring of this unit (i.e., fluoride and boron resulting in SSIs at MW-34 downgradient of Ash Landfill 847). That source has been identified as the natural variations in groundwater quality within the uppermost aquifer underlying Ash Landfill 847.

The information contained in this evaluation is, to the best of my knowledge, true, accurate and complete.

HALEY & ALDRICH, INC.

Signed:____
Certifying Engineer

Print Name:	Steven F. Putrich
Kansas License No.:	PE24363
Title:	Project Principal
Company:	Haley & Aldrich, Inc.

Professional Engineer's Seal:

6. References

1. Environmental Risk Information Services. 2018. Database Report, March 2018.

2. Haley & Aldrich, 2017. Groundwater Sampling and Analysis Pan, Lawrence Energy Center. October.

3. O'Connor, 1960. Geology and Ground-Water Resources of Douglas County, Kansas. State Geological Survey of Kansas Bulletin 148.

4. United States Geological Survey, 1964. Topographic Map, Laclede, 7.5-minute series.

5. United States Geological Survey, 1978. Topographic Map, Laclede, 7.5-minute series.

6. United States Geological Survey, 2012. Topographic Map, Laclede, 7.5-minute series.

7. United States Geological Survey, 2018. National Water Quality Information System Database search, USGS-385953095152001, 12S 19E 24BAB 01. https://nwis.waterdata.usgs.gov/nwis/qwdata?

8. United States Environmental Protection Agency, 2004. USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review. EPA Report 540-R-04-004.

9. United States Environmental Protection Agency, 2008. Regulatory Determinations Support Document for Selected Contaminants from the Second Drinking Water Contaminant Candidate List (CCL 2). EPA Report 815-R-08-012.

TABLES

TABLE I
HISTORICAL AERIAL PHOTOGRAPH REVIEW SUMMARY
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Dates	Description of Site	Sources
1937	Site area appears to be agricultural land; main roads visible.	Aerial photos – ASCS
1948 – 1950	Development of buildings at plant site. Areas to west and south appear to be agricultural land.	Aerial photos – ASCS, AMS
1967 – 1977	Development of plant site structures; roads and structures visible at Ash Landfill 847 location. Areas to west and south appear to be agricultural land. Increase in structures to the south.	Aerial photos – USGS
1982 – 2006	Development of plant site structures; roads and structures visible at Ash Landfill 847 location. Plant site development to the west of Ash Landfill 847. Increase in structures to the south.	Aerial photos – NHAP; USGS; NAIP
2008 – 2017	Development of Ash Landfill 847.	Aerial photos – NAIP

Notes:
AMS = Army Mapping Service
ASCS = Agricultural and Soil Conservation Service
NAIP = National Agriculture Information Program
NHAP = National High-Altitude Photography
USGS = United States Geological Survey

TABLE II
HISTORICAL TOPOGRAPHIC MAP REVIEW SUMMARY
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Dates	Description of Site and Adjacent Properties	Map Name
1949 – 1950	Power plant is depicted on the map. Little development at Ash Landfill 847 site or adjacent areas; several unnamed roads. Area south of site not depicted on 1949 map.	7.5-Minute Series, Williamstown, KS Quadrangle
1967 – 1978	Significant development of industrial buildings at Ash Landfill 847 site to the south and southwest.	7.5-Minute Series, Williamstown, KS Quadrangle
2012	Minor road development in area west of site.	7.5-Minute Series, Williamstown, KS Quadrangle

TABLE III

ANALYSES OF WATER FROM TYPICAL WELLS, TEST HOLES, AND SPRINGS IN DOUGLAS COUNTY

CCR GROUNDWATER MONITORING NETWORK DESCRIPTION

LAWRENCE ENERGY CENTER

LAWRENCE, KANSAS

Well Number[c]	Depth (feet)	Geologic Source	Date of Collection	Temperature (F)	Dissolved Solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$		
																Calcium, Magnesium	Carbonate	Non-Carbonate
12-19-26ab	134.5	Stranger Formation	3/11/1950		21,400	15	20	615	257	7,340	237	279	12,800	0.9	8.8	2,590	194	2,400
12-20-17dd	73	Stranger Formation	11/20/1940				2				420		32	0.4		330	330	0
13-18-28ba	350	Stranger Formation	5/28/1953		4,840	22	0.86	212	90	1,480	466	565	2,210	1.2	29	899	382	517
13-19-1cc2	118	Stranger Formation	1/8/1955										4,030					
13-19-7dd	96-146	Stranger Formation	6/6/1955		1,720	9.5	0.74	31	16	621	370	59	795	1.4	4.1	144	144	0
13-19-11da1	110	Stranger Formation	5/28/1954										1,410					
13-19-12aad	78-127	Stranger Formation	6/21/1954		2,980	9.6	0.55	103	31	1,020	434	58	1,540	0.3	4.9	384	356	28
13-19-13aa	70	Stranger Formation	6/1/1953		2,170	5.8	3.6	105	30	705	378	0	1,140	0	0.4	386	310	76
13-19-21bb	98.9	Stranger Formation	7/28/1952		360	12	0.89	81	13	41	386	11	10	0.3	1.5	256	256	0
13-19-23da	140	Stranger Formation	5/28/1952	59	1,620	23	1.3	38	15	571	577	127	555	3.6	0	156	156	0
13-19-27dd	312	Stranger Formation	4/23/1956										670					
13-19-28cb2	107	Stranger Formation	10/18/1954										1,630					
13-20-5caa	160	Stranger Formation	6/11/1954		476	7.6	0.25	90	26	44	333	129	14	0.1	1.5	332	273	59
13-20-8ad	160	Stranger Formation	5/2/1953		396	4	11	74	24	46	399	43	8	0.2	0.3	283	283	0
13-20-13cc	63	Stranger Formation	5/25/1953		222	7.8	0.39	50	8.2	23	227	5.3	8	0.2	7.1	158	158	0
13-20-35cd	140	Stranger Formation and Stanton Limestone	6/22/1954		587	3.8	0.18	106	28	68	378	156	38	0.3	1.3	380	310	70
14-17-25ca	458	Stranger Formation	3/9/1956										168					
14-17-26ad	405	Stranger Formation	3/19/1956		2,060								822					
14-18-10bd	325	Stranger Formation	1/11/1954										1,130					
14-18-11db	160	Stranger Formation	6/21/1954		3,390	12	0.23	30	17	1,260	556	235	1,540	3	7.5	145	145	0
14-18-23aa1	377	Stranger Formation	1/5/1948										655	3.6		50		
14-18-24cc	335	Stranger Formation (?)	6/6/1955		1,200	4	0.31	5.5	1.3	434	486	285	130	3.2	93	19	19	0
14-18-30ad	428-475	Stranger Formation	10/10/1954		1,540	6	0.74	5.7	2.9	608	461	15	670	3.1	1.3	26	26	0
14-19-3dd	121	Stranger Formation	5/5/1955										361					
14-19-4bb	142	Stranger Formation	6/22/1954		5,190	11	2	73	44	1,900	483	58	2,860	2.1	3.8	363	363	0
14-19-16bc	304	Stranger Formation	5/28/1953		4,820	23	0.37	52	26	1,800	550	151	2,500	3	0.2	236	236	0
14-20-14dc	37	Stranger Formation	5/25/1953	58	520	5	0.22	130	18	40	460	84	12	0.1	4.4	398	377	21
15-17-1ac2	497	Stranger Formation	4/1/1953		604	9	0.62	40	15	176	350	37	154	0.8	0.3	162	162	0
15-17-1ac2	497	Stranger Formation	12/12/1955		565		0.32	38	38	173	346	31	144	0.7	0.4	144	144	0
15-17-13dc	315	Stranger Formation	2/1/1950										152					
15-18-7ad	350	Stranger Formation	5/26/1953		2,670	16	0.08	14	14	970	720	688	590	4.8	29	66	66	0

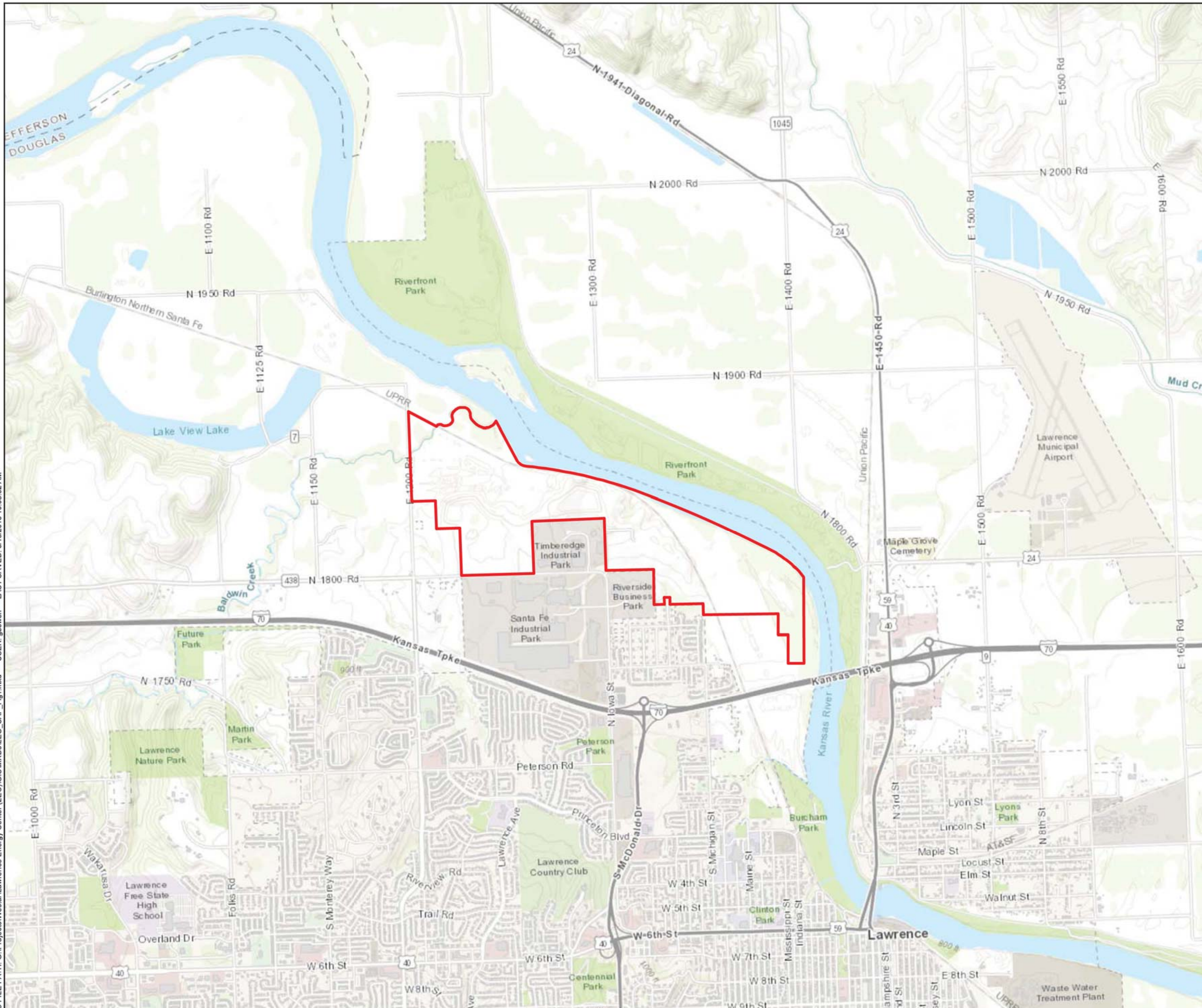
Notes:

a. One part per million is equivalent to 1 pound of substance per million pounds of water or 8.33 pounds per million gallons of water.

b. Data from O'Connor (1960) - http://www.kgs.ku.edu/General/Geology/Douglas/table4.html

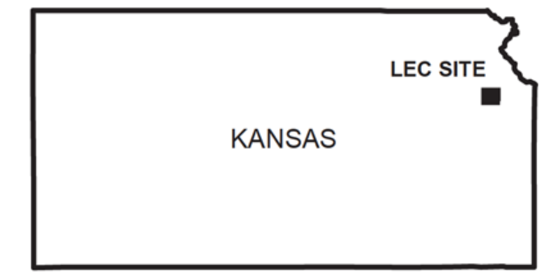
c. The well name denotes the approxiamte location of the well according to the Township and Range Survey system.

FIGURES



LEGEND

PROPERTY BOUNDARY



NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SITE COORDINATES: 39°0'25"N, 95°15'56"W
3. TOPOGRAPHIC IMAGERY SOURCE: ESRI

0 2,800 5,600
SCALE IN FEET

HALEY ALDRICH

WESTAR ENERGY
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

SITE LOCATION

APRIL 2018
SCALE: AS SHOWN

FIGURE 1

GIS FILE PATH: G:\Projects\Westar\Lawrence Energy Center (LEC)\GIS\MXDs\LEC_SAP_Fig1.mxd — USER: gbowen — LAST SAVED: 3/16/2018 10:05:52 AM

LEGEND

- MONITORING WELL
- ASH LANDFILL ACTIVE AREA
- ASH LANDFILL LIMITS OF DISPOSAL AREA

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 7 NOVEMBER 2015.

N

0 350 700
SCALE IN FEET

HALEY ALDRICH

WESTAR ENERGY
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

ASH LANDFILL 847 MONITORING WELL LOCATION MAP

APRIL 2018
SCALE: AS SHOWN

FIGURE 2

GIS FILE PATH: G:\Projects\Westar\Lawrence Energy Center (LEC)\GIS\MXDs\2016_06_SAP\LEC_MW_LOCA_MAP_REV1.mxd — USER: gbowen — LAST SAVED: 3/16/2018 10:09:10 AM

APPENDIX A

ERIS Historical Aerial Report

HISTORICAL AERIAL REPORT

for the site:
LEC
1250 N 1800 Road
Lawrence, KS 66049
PO #:

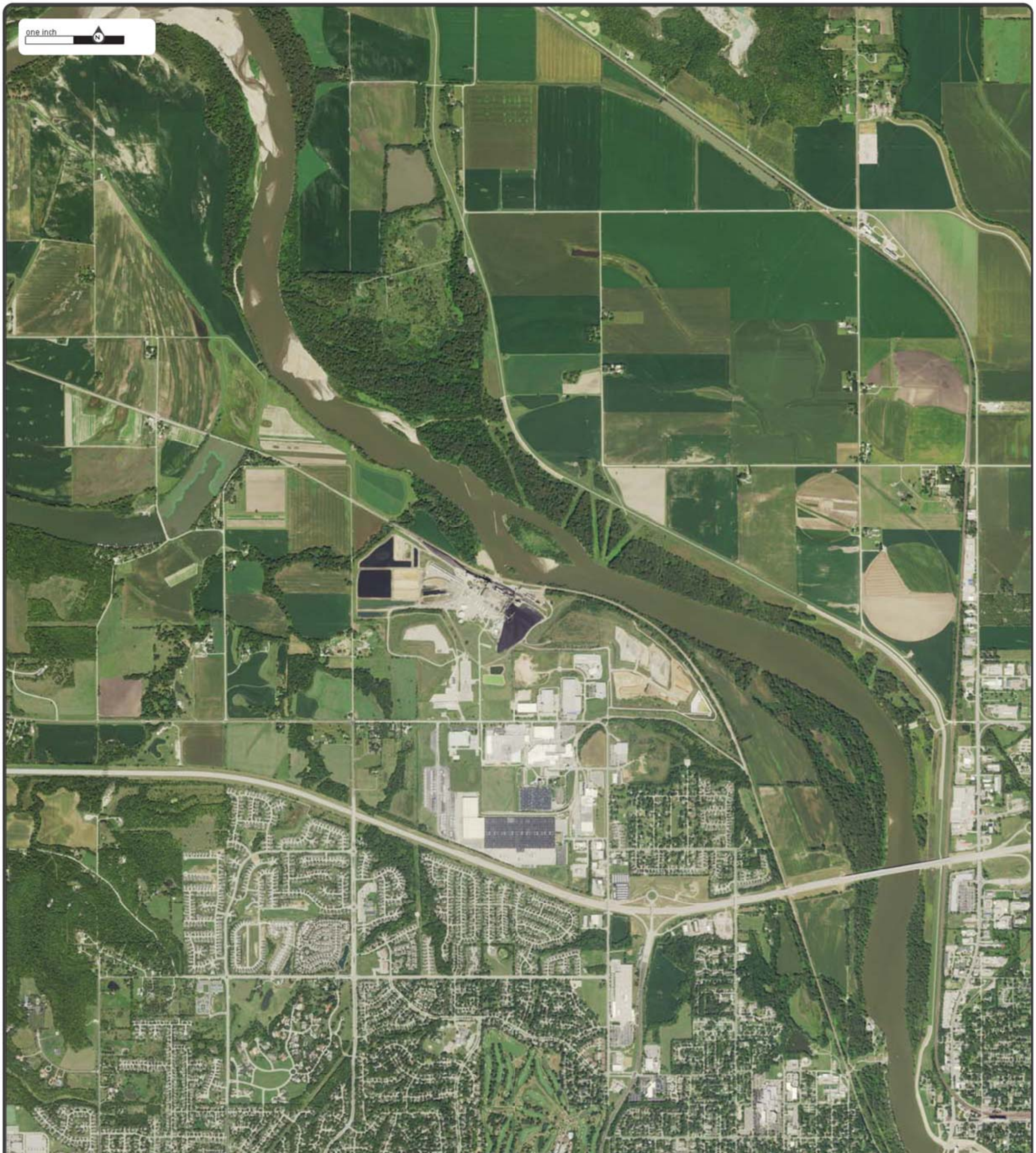
Report ID: 20180302341
Completed: 3/13/2018

ERIS Information Inc.
Environmental Risk Information Services (ERIS)
A division of Glacier Media Inc.
T: 1.866.517.5204
E: info@erisinfo.com

www.erisinfo.com

Search Results Summary

Date	Source	Scale	Comment
2017	**NAIP** - National Agriculture Information Program	1"=2500'	
2015	**NAIP** - National Agriculture Information Program	1"=2500'	
2014	**NAIP** - National Agriculture Information Program	1"=2500'	
2012	**NAIP** - National Agriculture Information Program	1"=2500'	
2010	**NAIP** - National Agriculture Information Program	1"=2500'	
2008	**NAIP** - National Agriculture Information Program	1"=2500'	
2006	**NAIP** - National Agriculture Information Program	1"=2500'	
2005	**NAIP** - National Agriculture Information Program	1"=2500'	
2004	**NAIP** - National Agriculture Information Program	1"=2500'	
2003	**NAIP** - National Agriculture Information Program	1"=2500'	
1991	**USGS** - US Geological Survey	1"=2500'	
1985	**NHAP** - National High Altitude Photography	1"=2500'	*BEST COPY AVAILABLE*
1982	**NHAP** - National High Altitude Photography	1"=2500'	
1977	**USGS** - US Geological Survey	1"=2500'	
1967	**USGS** - US Geological Survey	1"=2500'	
1950	**AMS** - Army Mapping Service	1"=2500'	
1948	**ASCS** - Agriculture and Soil Conservation Service	1"=2500'	
1937	**ASCS** - Agriculture and Soil Conservation Service	1"=2500'	*PHOTO INDEX-BEST AVAIL*



Date: **2017**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
www.erisinfo.com | 1.866.517.5204

Date: **2015**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

www.erisinfo.com | 1.866.517.5204

Date: **2014**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
www.erisinfo.com | 1.866.517.5204

Date: 2012
Source: NAIP
Scale: 1" to 2500'
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
www.erisinfo.com | 1.866.517.5204

Date: **2010**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
www.erisinfo.com | 1.866.517.5204

Date: **2008**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
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Date: **2006**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

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Date: **2005**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
www.erisinfo.com | 1.866.517.5204

Date: **2004**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

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Date: **2003**
Source: **NAIP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

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ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
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Date: **1991**
Source: **USGS**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

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ERIS
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Date: **1985**
Source: **NHAP**
Scale: **1" to 2500'**
Comments: *BEST COPY AVAILABLE*

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

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ERIS
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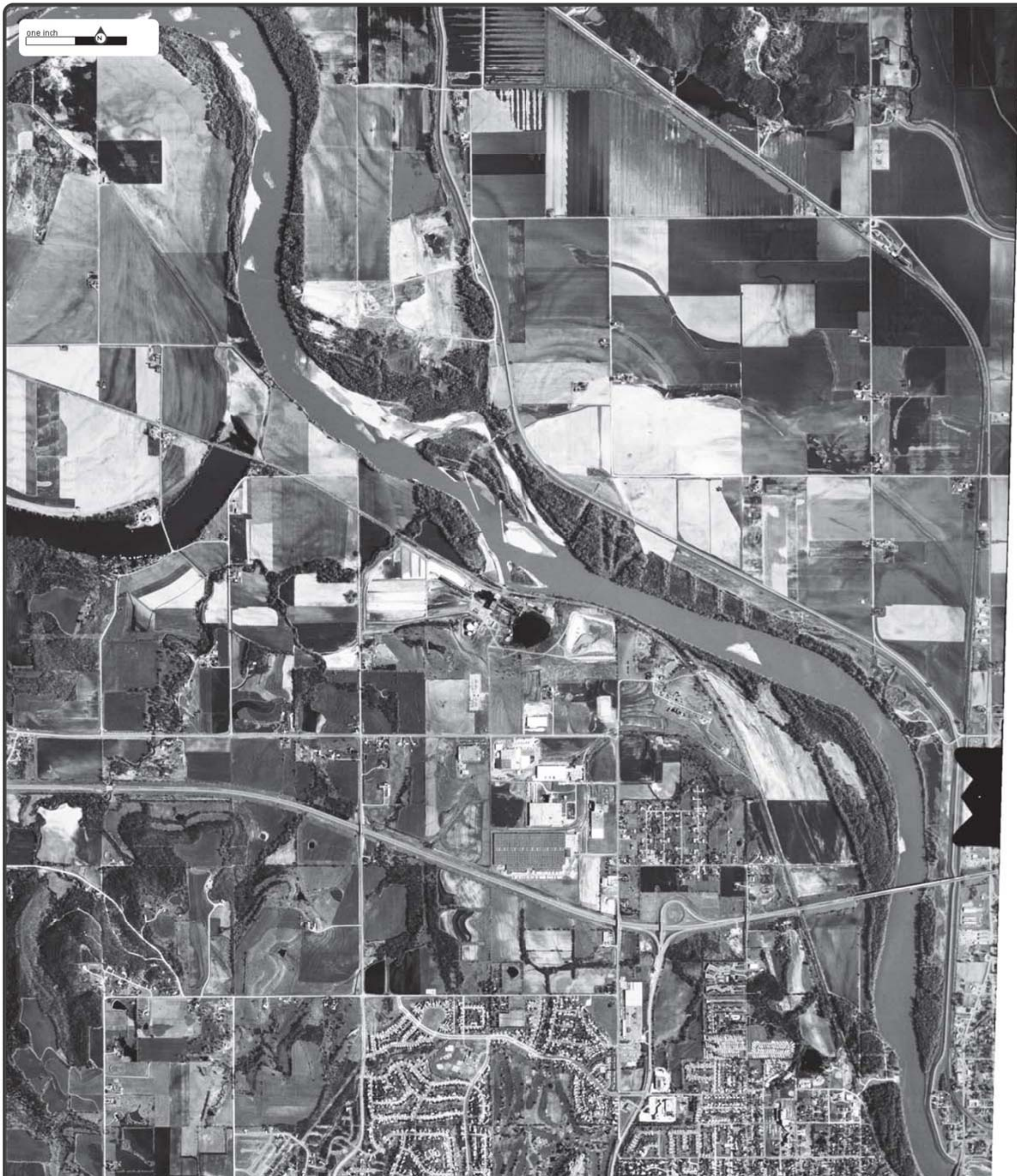

Date: **1982**
Source: **NHAP**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

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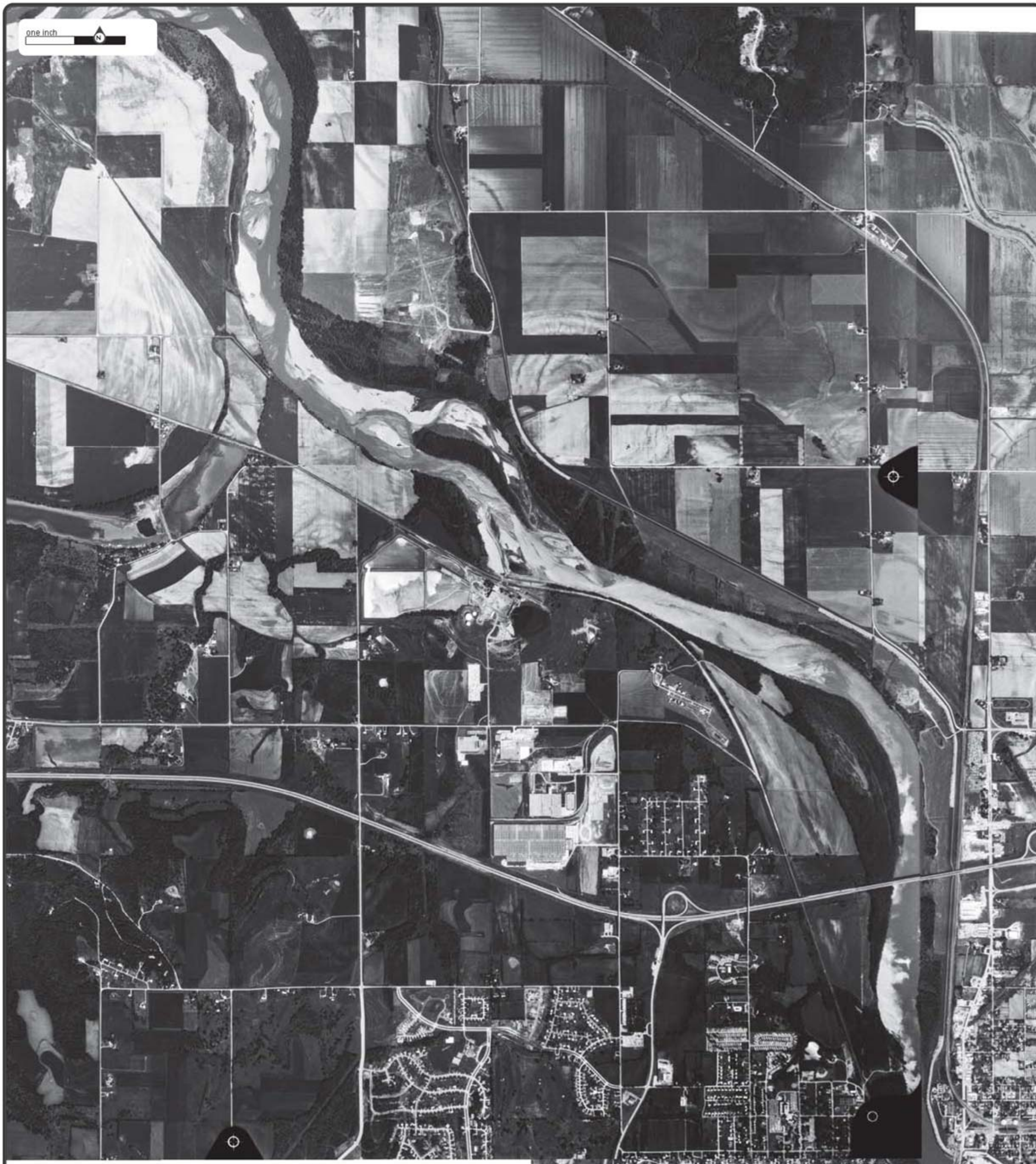

Date: **1977**
Source: **USGS**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
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Date: **1967**
Source: **USGS**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

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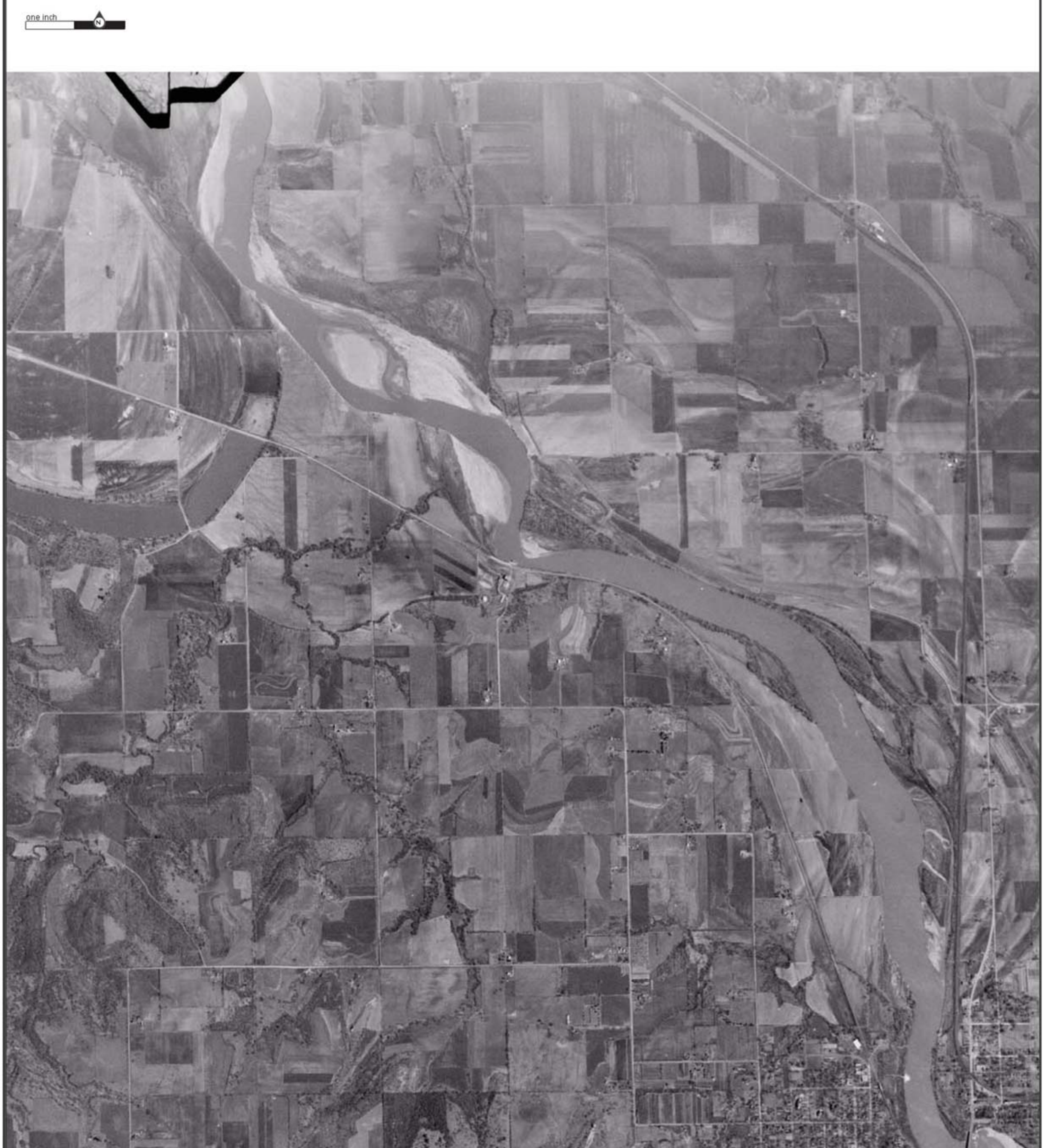

Date: 1950
Source: AMS
Scale: 1" to 2500'
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
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Date: **1948**
Source: **ASCS**
Scale: **1" to 2500'**
Comments:

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

N

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES
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Date: **1937**
Source: **ASCS**
Scale: **1" to 2500'**
Comments: *PHOTO INDEX-BEST AVAIL*

Subject: 1250 N 1800 Road Lawrence KS
Approx Center: 39.00357 / -95.26697

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ENVIRONMENTAL RISK INFORMATION SERVICES
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APPENDIX B

ERIS Topographic Map Research Results

TOPOGRAPHIC MAP RESEARCH RESULTS

Date: 2018-03-02

Project Property: 1250 N 1800 Road, Lawrence, KS

ERIS Order Number: 20180302341

We have searched USGS collections of current topographic maps and historical topographic maps for the project property. Below is a list of maps found for the project property and adjacent area. Maps are from 7.5 and 15 minute topographic map series, if available.

Year	Map Series
2012	7.5
1978	7.5
1967	7.5
1950	7.5
1949	7.5

Topographic Maps included in this report are produced by the USGS and are to be used for research purposes including a phase I report. Maps are not to be resold as commercial property.

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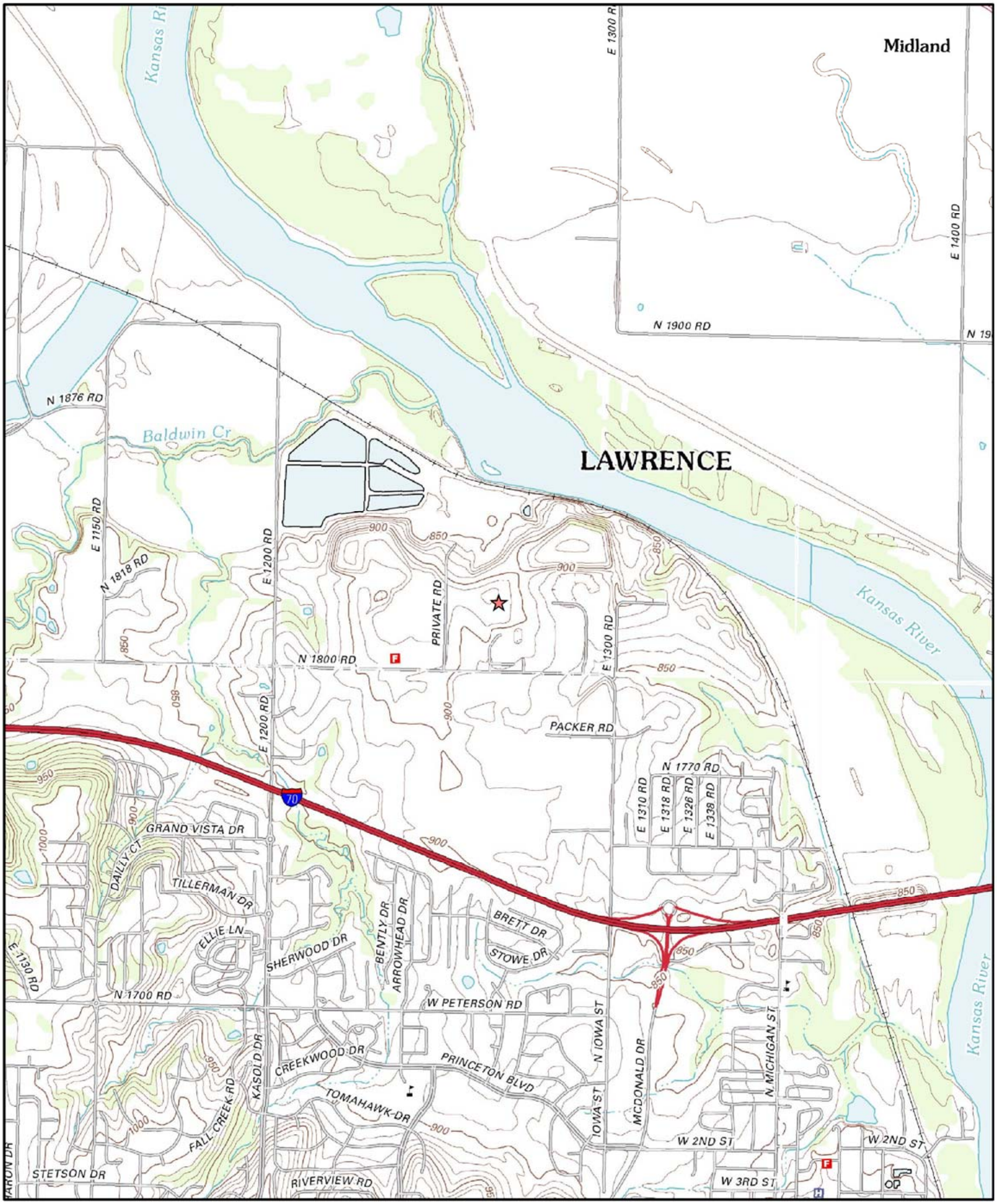


Miles

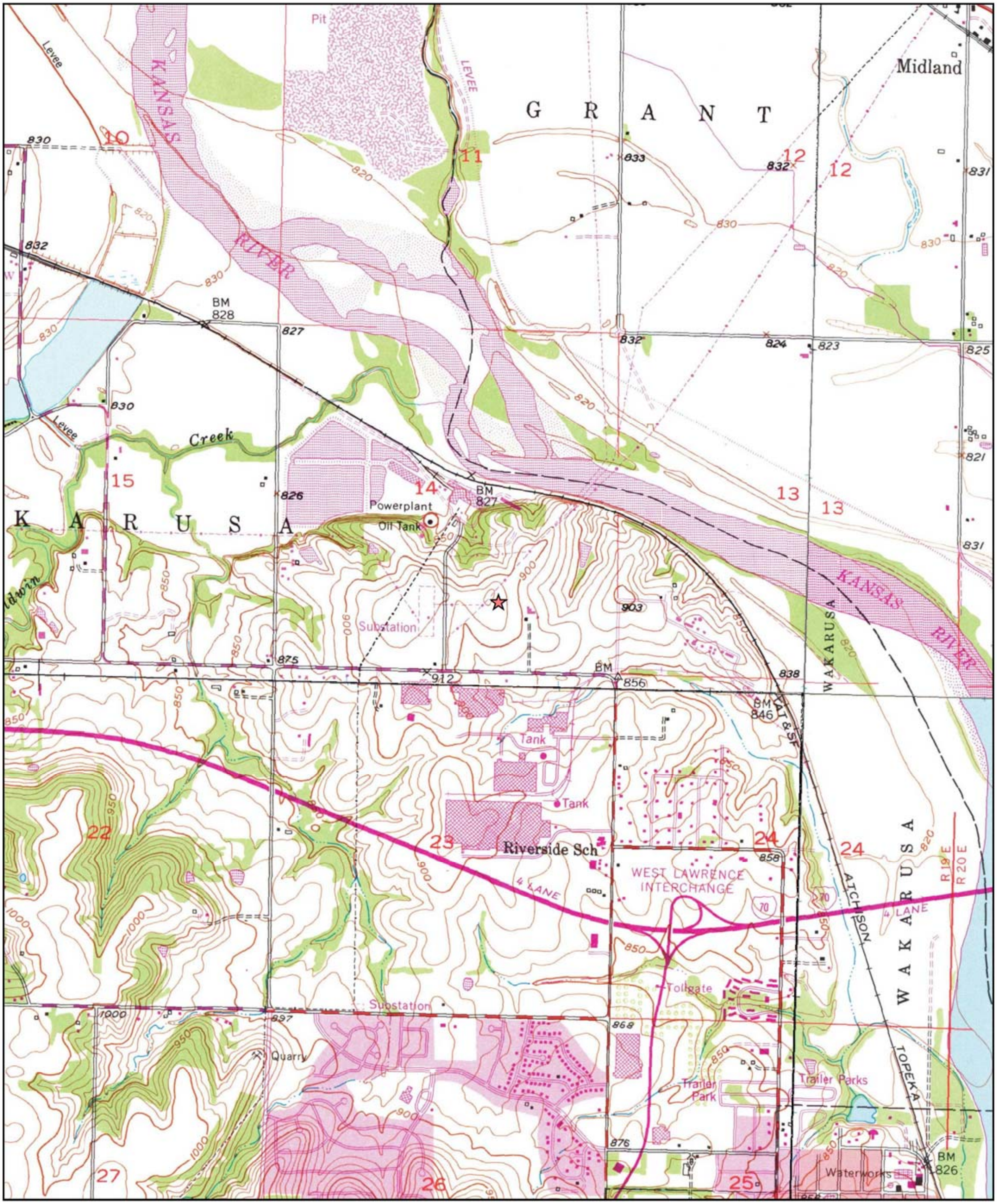
0 0.2 0.4 0.8

Order No. 20180302341

2012

Quadrangle(s): Williamstown,KS

Source: USGS 7.5 Minute Topographic Map



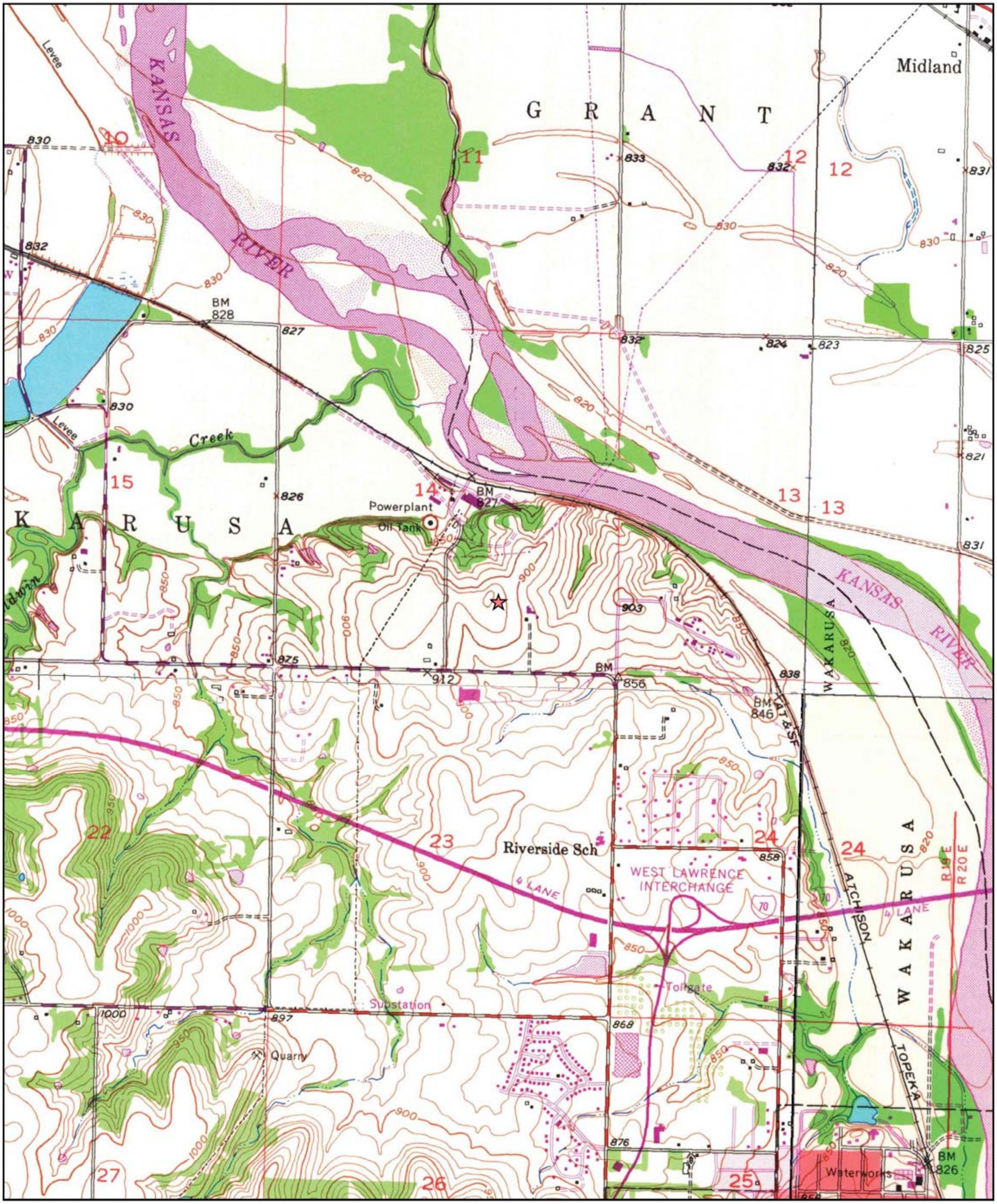
1978

Miles 0 0.2 0.4 0.8

Order No. 20180302341

Quadrangle(s): Williamstown,KS

Source: USGS 7.5 Minute Topographic Map



Miles

0 0.2 0.4 0.8

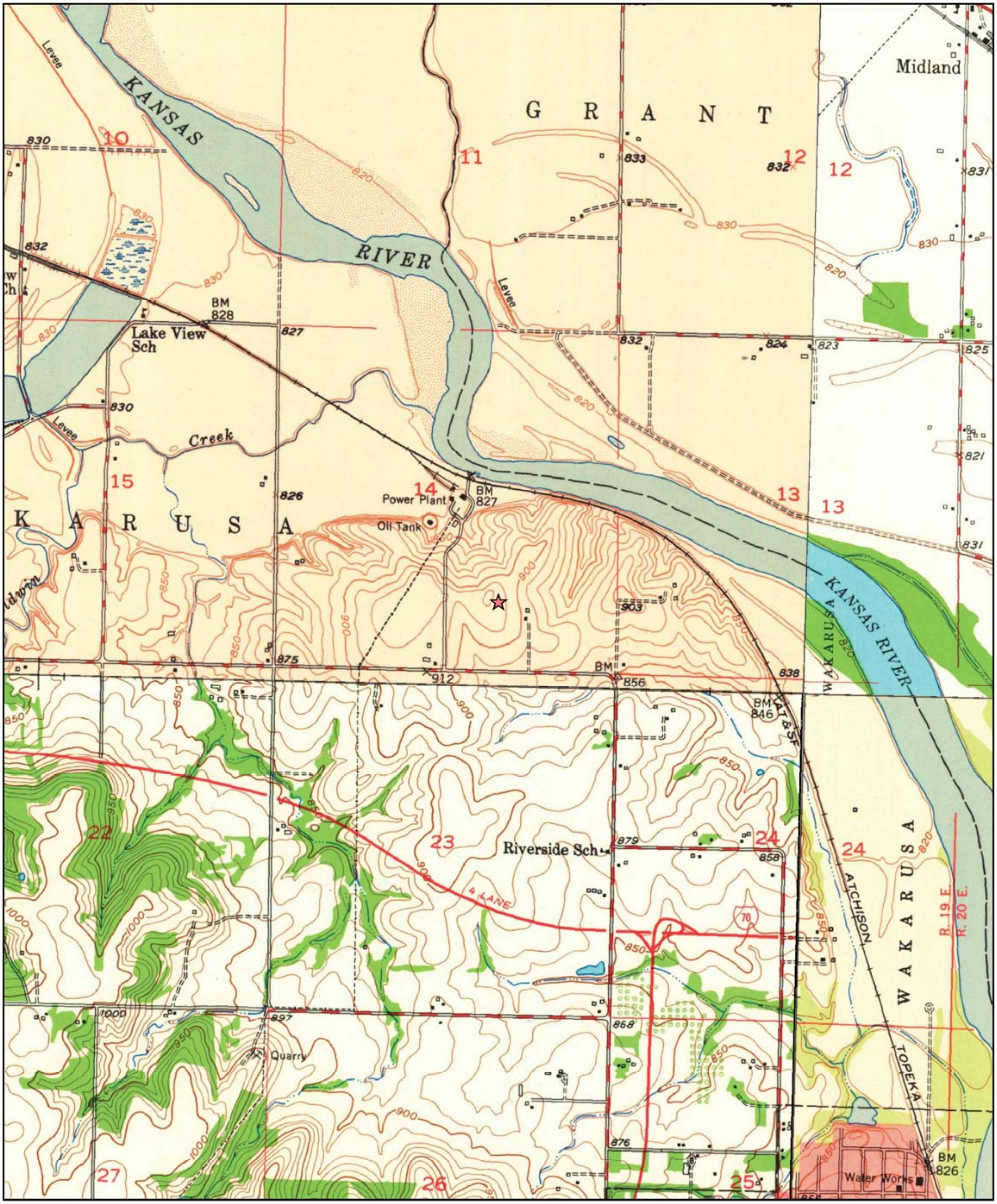
Order No. 20180302341

1967

Quadrangle(s): Williamstown,KS

Source: USGS 7.5 Minute Topographic Map

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICE



Miles
0 0.2 0.4 0.8

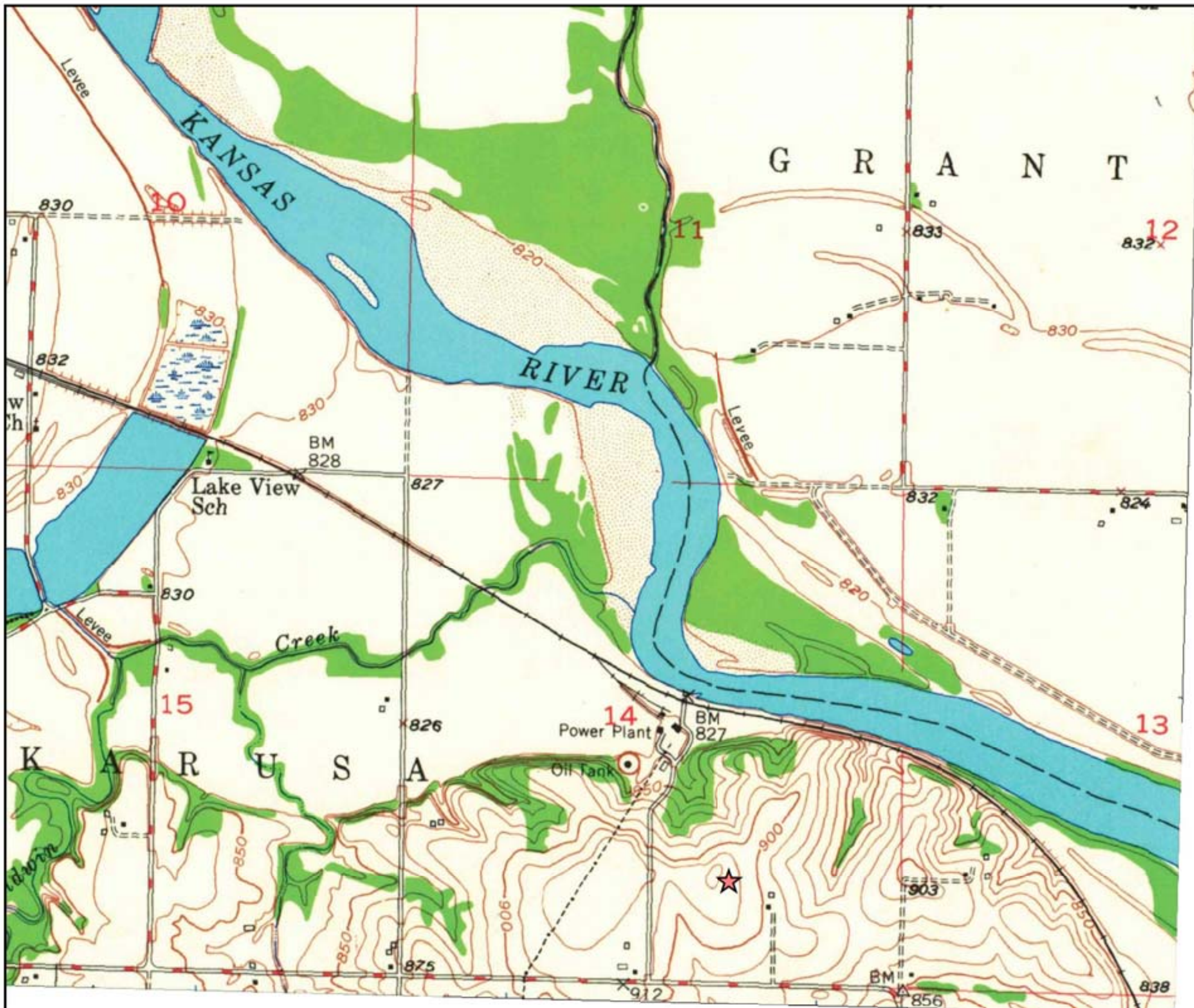
1950

Order No. 20180302341

Quadrangle(s): Williamstown,KS

Source: USGS 7.5 Minute Topographic Map

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICE



1949

0 0.2 0.4 0.8 Miles

Order No. 20180302341

Quadrangle(s): Williamstown,KS

Source: USGS 7.5 Minute Topographic Map