FINAL

Remedial Investigation Work Plan
Former Schilling Air Force Base
Salina, Kansas

Prepared for

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July 15, 2014

TABLE OF CONTENTS

TITLE **PAGE**

LIST OF FIGURES iv
LIST OF TABLES v
LIST OF APPENDICES vii
1.0 REMEDIAL INVESTIGATION WORK PLAN 1
1.1 Brief History 1
1.2 Pathways, Receptors, and Standards 3
1.3 Sample and Location Designations 3
1.4 QA/QC Samples 4
1.5 Miscellaneous Notes and Assumptions 5
2.0 OU1 FIELD INVESTIGATIONS 6
2.1 Delineation of Plume D 7
2.2 Source Area Investigations 7
2.2.a. Plume A 7
2.2.b. 99M08 (Plume B) 10
2.2.c. Building 837 Area (Plume C) 12
2.2.d. LOX Plant (Plume D source area) 15
2.2.e. Plume E 18
2.3 Aquifer Testing 21
2.4 Surface Water and Sediment Sampling 23
2.5 Investigation of Vapor Intrusion to Indoor Air 25
2.6 Investigation/Documentation of Water Use 26
2.7 Data Validation/QCSR 26
3.0 OU2 FIELD INVESTIGATIONS 26
3.1 North Zone 26
3.2 Central Zone 29
3.3 South Zone 34
3.4 OU 2-wide Previously Investigated Area Borings 38
3.5 Aquifer Testing 40
3.6 Surface Water and Sediment Sampling 42
3.7 Investigation of Vapor Intrusion to Indoor Air 44

3.8 Data Validation/QCSR 44
4.0 OU3 FIELD INVESTIGATIONS 44
4.1 Landfill #1 44
4.2 Landfill #3 48
4.3 Debris Landfill 52
4.4 OU3-wide Previously Investigated Area Borings 54
4.5 Surface Water and Sediment Sampling 56
4.6 Data Validation/QCSR 58
5.0 GROUNDWATER MONITORING 58
5.1 1st Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR) 58
5.2 2nd Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR) 61
5.3 3rd Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR) 62
5.4 4th Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR) 62
6.0 INVESTIGATION AND MONITORING OF GROUNDWATER/SURFACE WATER INTERACTION 62
7.0 MONITORING WELL MAINTENANCE, ABANDONMENT, REPLACEMENT 63
8.0 FIELD SAMPLING PLAN 65
8.1 Drilling Methods and Subsurface Investigation Accessories 67
8.1.a Direct-Push Drilling 67
8.1.b Sonic Drilling 68
8.1.c Hollow-stem Auger Drilling 68
8.1.d Hand Auguring 68
8.1.e Geoprobe Hydraulic Profiling Tool (HPT): 69
8.2 Soil Sampling Methods 69
8.2.a Soil Sampling for VOCs and COCs 70
8.2.b Soil Sampling for Fraction Organic Carbon 70
8.2.c Soil Sampling for Engineering Properties 70
8.2.d Sediment Sampling 70
8.2.e Suspected Separate Phase 71
8.3 Monitoring Wells 71
8.3.a Types of Monitoring Wells 71
8.3.b Permanent Monitoring Wells 71
8.3.c Temporary Monitoring Wells 73

8.3.d Double-cased Monitoring Wells 73
8.4 Groundwater and Separate-Phase Level Measurements 74
8.5 Groundwater Sampling 75
8.5.a Preparation for Sampling 75
8.5.b Groundwater Purging and Sampling 75
8.5.c Low Recovery Monitoring Wells 76
8.5.d Natural Attenuation Parameters 76
8.5.e Suspected Separate Phase 76
8.6 Groundwater - Surface Water Interaction 76
8.7 Surface Water Sampling 77
8.8 Single-Well Tests 77
8.9 Aquifer Tests 78
8.10 Well Abandonment 78
8.11 Summary of Analytical Requirements 78
8.12 Professional Supervision 78
9.0 REMEDIAL INVESTIGATION SCHEDULE 79
9.1 Field Investigations 79
9.2 Deliverables 79
10.0 REFERENCES 80

LIST OF FIGURES

FIGURE	TITLE
1	Site Location Map
2	Site Plan
3	Areas of Interest
4	Groundwater Plume Map
5	Investigation Areas
6	Proposed Boring Locations, Plume A and Plume B
7	Proposed Boring Locations, Plume C
8	Proposed Boring Locations, Plume D - Former LOX Plant
9	Proposed Boring Locations, Plume E
10	Proposed Surface Water and Sediment Sampling Locations, OU1
11	Proposed Boring Locations, North Zone OU2
12	Proposed Boring Locations, Central Zone OU2
13	Proposed Boring Locations, South Zone OU2
14	Proposed Boring Locations, Landfill #1, OU3
15	Proposed Boring Locations, Landfill #3, OU3
16	Debris Landfill, OU3
17	OU3-Wide Previously Investigated Areas
18	Long-Term Monitoring Wells

LIST OF TABLES

TABLE	TITLE
Table 2.2.a.1	Task 2.2.a Soil Boring and Monitoring Well Details – Plume A
Table 2.2.a.2	Task 2.2.a Samples and Analyses – Plume A
Table 2.2.a.3	Task 2.2.a Schedule – Plume A
Table 2.2.b.1	Task 2.2.b Soil Boring Details – Plume B
Table 2.2.b.2	Task 2.2.b Samples & Analyses – Plume B
Table 2.2.b.3	Task 2.2.b Schedule – Plume B
Table 2.2.c.1	Task 2.2.c Soil Borings and Monitoring Well Details – Plume C
Table 2.2.c.2	Task 2.2.c Samples and Analyses – Plume C
Table 2.2.c.3	Task 2.2.c Schedule – Plume C
Table 2.2.d.1	Task 2.2.d Borings/Monitoring Wells – LOX Plant (Plume D)
Table 2.2.d.2	Task 2.2.d Samples & Analyses – LOX Plant (Plume D)
Table 2.2.d.3	Task 2.2.d Schedule – LOX Plant (Plume D)
Table 2.2.e.1	Task 2.2.e Soil Borings and Monitoring Well Details – Plume E
Table 2.2.e.2	Task 2.2.e Samples and Analyses – Plume E
Table 2.2.e.3	Task 2.2.e Schedule – Plume E
Table 2.3.a	Task 2.3 Borings/Monitoring Wells – Aquifer Test
Table 2.3.b	Task 2.3 Samples & Analyses – Aquifer Test
Table 2.3.c	Task 2.3 Schedule – Aquifer Test
Table 2.4.a	Task 2.4 Sampling Locations – Surface Water and Sediment
Table 2.4.b	Task 2.4 Samples & Analyses – Surface Water and Sediment
Table 2.4.c	Task 2.4 Schedule – Surface Water and Sediment
Table 3.1.a	Task 3.1 Soil Borings and Monitoring Well Details – North Zone Plume
Table 3.1.b	Task 3.1 Samples and Analyses – North Zone Plume
Table 3.1.c	Task 3.1 Schedule – North Zone Plume
Table 3.2.a	Task 3.2 Borings/Monitoring Well Details – Central Zone
Table 3.2.b	Task 3.2 Samples and Analyses – Central Zone
Table 3.2.c	Task 3.2 Schedule – Central Zone
Table 3.3.a	Task 3.3 Soil Borings and Monitoring Well Details – South Zone
Table 3.3.b	Task 3.3 Samples and Analyses – South Zone
Table 3.3.c	Task 3.3 Schedule – South Zone
Table 3.4.a	Task 3.4 Proposed Sampling Locations and Rationale – OU2 Wide
Table 3.4.b	Task 3.4 Borings/Monitoring Wells – OU2 Wide
Table 3.4.c	Task 3.4 Samples & Analyses – OU2 Wide
Table 3.4.d	Task 3.4 Schedule – OU2 Wide
Table 3.5.a	Task 3.5 Borings/Monitoring Wells – OU2 Aquifer Test
Table 3.5.b	Task 3.5 Samples & Analyses – OU2 Aquifer Test
Table 3.5.c	Task 3.5 Schedule – OU2 Aquifer Test
Table 3.6.a	Task 3.6 Sampling Locations – OU2 Surface Water and Sediment Sampling

Table 3.6.b	Task 3.6 Samples & Analyses – OU2 Surface Water and Sediment Sampling
Table 3.6.c	Task 3.6 Schedule – OU2 Surface Water and Sediment Sampling
Table 4.1.a	Task 4.1 Soil Borings and Monitoring Well Details – OU3 Landfill #1
Table 4.1.b	Task 4.1 Samples and Analyses – OU3 Landfill #1
Table 4.1.c	Task 4.1 Schedule – OU3 Landfill #1
Table 4.2.a	Task 4.2 Soil Borings and Monitoring Well Details – OU3 Landfill #3
Table 4.2.b	Task 4.2 Samples and Analyses –OU3 Landfill #3
Table 4.2.c	Task 4.2 Schedule – OU3 Landfill #3
Table 4.3.a	Task 4.3 Soil Borings and Monitoring Well Details – Debris Landfill
Table 4.3.b	Task 4.3 Samples and Analyses – Debris Landfill
Table 4.3.c	Task 4.3 Schedule – Debris Landfill
Table 4.4.a	Task 4.4 Borings/Monitoring Wells – OU3 Wide
Table 4.4.b	Task 4.4 Samples & Analyses – OU3 Wide
Table 4.4.c	Task 4.4 Schedule – OU3 Wide
Table 4.5.a	Task 4.5 Sampling Locations – OU3 Surface Water and Sediment Sampling
Table 4.5.b	Task 4.5 Samples & Analyses - OU3 Surface Water and Sediment Sampling
Table 4.5.c	Task 4.5 Schedule - OU3 Surface Water and Sediment Sampling
Table 5.1.a	Task 5.1 Planned Samples and Analyses – Groundwater Monitoring
Table 5.1.b	Task 5.1 Groundwater Samples Collected
Table 6.1	Task 6.0 Schedule – Groundwater/Surface Water Interaction
Table 7.1	Task 7.0 Soil Boring and Monitoring Well Details – Monitoring Wells
Table 7.2	Task 7.0 Schedule – Monitoring Wells
Table 8.0	SOP Summary
Table 8.1	Typical Monitoring Well Construction
Table 8.2	Other Monitoring Well Considerations
Table 9.1	Remedial Investigation Schedule

LIST OF APPENDICES

APPENDIX	TITLE
A	USACE Remedial Investigation Work Plans
B	Historical Soil and Groundwater Quality Data
C	CAFO Exhibit 2 - Scope of Work
D	Final Health and Safety Plan
E	Standard Operating Procedures
F	Final Quality Assurance Project Plan
G	Field Forms
H	Summary of Analytical Requirements

1.0 REMEDIAL INVESTIGATION WORK PLAN

1.1 Brief History

The Former Schilling Air Force Base (Base or SAFB or Site) was originally built in 1942 and named the "Smoky Hill Army Airfield" for U.S. military activities. These military activities lasted until 1966 and included: airbase operations of various military aircraft, maintenance and repair of military aircraft and armaments, and provision of necessary aircraft and Army Air Corps and Air Force supplies.

The Base changed its name from Smoky Hill Army Airfield to Schilling Air Force Base in the 1950's. The U.S. Air Force then used the Base as a Strategic Air Command base for bomber and intercontinental ballistic missile operations. Military aircraft flew in and out of SAFB on a daily basis.

After Base closure in 1966, the U.S. transferred ownership of the land and buildings at the former SAFB to the Salina Airport Authority, Unified School District No. 305, the City of Salina, and Kansas State University (Salina Public Entities). The Salina Public Entities have used their respective properties for the Salina Regional Airport and for governmental, commercial, and educational activities. The area surrounding the Site is a mixture of residential, agricultural, and commercial/industrial operations (Figures 1 and 2).

The military activities left widespread impacted soil, groundwater, and sediments. The US Army Corps of Engineers (USACE) was tasked with investigating and remediating the Site. The remedial investigation work plans prepared by USACE (Appendix A) include detailed discussions of the site history and previous investigations. As such, this information will not be reproduced within the text of this Work Plan.

During the Site Investigation (Rust Environment and Infrastructure, 1996) commissioned by USACE, 39 Areas of Interest (AOIs) were identified (Figure 3). Through the various subsequent investigations completed at the Site, a number of these AOIs have been determined to require no further investigation. AOIs for which the investigation is incomplete are included in this Work Plan.

The Superfund Technical Assessment and Response Team (START) of Ecology and Environment, Inc. (E&E) was tasked by the U.S. Environmental Protection Agency (EPA) to conduct an Expanded Site Inspection (ESI) at the SAFB. In March 2001, E&E prepared for EPA and issued its Expanded Site Inspection Report. The objectives for the ESI were to confirm the presence of and quantify the concentrations of VOCs in the ground water and to determine the source(s) of the VOCs and other contaminants. The ESI Report confirmed the presence of and quantified VOCs and determined that the source of the VOCs and other contaminants was the U.S. military operations at SAFB.

Several documents, including Burns and McDonnell (2007a, b, and c, Appendix A) and Dragun (2008), detail the extent of historical soil, groundwater, and sediment impact. However, other than limited property specific assessments, the only new environmental data since 2008 have been from the Site-wide, long-term groundwater monitoring program. USACE instituted this program in 2006, which, at its peak, included almost 150 monitoring wells. Since 2011, only a few wells have been monitored.

Appendix B includes summaries of the historical soil and groundwater quality data from the Site, as well as the long-term groundwater monitoring data. These data summarize what is currently known about the nature and extent of chemical impact at the Site.

On July 17, 2013, the Salina Public Entities and the U.S. took the depositions of four former U.S. Air Force airmen that served at SAFB: George Smolich, Don Kneubuhl, Roy Whitaker, and Joe Bermudez. They confirmed the presence, use, and disposal of the chemicals of concern during their military service at SAFB.

During 2007, the USACE approached the Salina Public Entities about transferring the project responsibility. During 2011, the Parties negotiated the transfer, but could not agree on all aspects of the investigation and remediation. Technical representatives of the Salina Public Entities (Dragun), the USACE (with Burns and McDonnell), and Kansas Department of Health and Environment (KDHE) discussed, then agreed to have the Salina Public Entities complete the remedial investigation, the remedial feasibility study, and the development of a Corrective Action Decision (CAD) with KDHE.

The Parties used the existing data and a series of work plans prepared by Burns and McDonnell (2007a, b, and c, Appendix A) to identify data gaps that needed to be addressed before discussing remedial approaches. Exhibit 2 of the Consent Agreement and Final Order (CAFO) (see Appendix C) outlines the agreed-upon scope of work required to fill the data gaps and to determine the best remedial approach(es).

The following sections of this work plan expand on the scope of work outlined in the CAFO. The organization of this work plan follows that of Exhibit 2 in the CAFO. As in Exhibit 2 of the CAFO, this document addresses specific areas in each of the three Operable Units (OU1 through OU3).

The Quality Assurance/Quality Control (QA/QC) measures in this work plan are consistent with the Draft Final Quality Assurance Project Plan (QAPP) that was previously provided to KDHE in a separate document (Dragun, 2013c). These QA/QC measures are discussed briefly later in this section.

Similarly, waste handling and disposal will be consistent with the methods outlined in the Interim Soil Management Plan (ISMP) that was previously provided to KDHE in a separate document (Dragun, 2013a). This work plan will be conducted in accordance with the Final Health and Safety Plan (Dragun, 2013b, Appendix D).

Please note that the number and/or nature of borings, wells, samples, analyses, and methods outlined in this work plan may be revised based on (1) the results obtained during this investigation and/or (2) consultation with KDHE. At selected locations, Dragun may choose to use (1) a mobile laboratory or field gas chromatograph (GC) rather than a fixed lab or (2) advanced field probing using equipment such as the Hydraulic Profiling Tool (HPT) and/or Membrane Interface Probe (MIP) rather than conventional geologic logging, if these choices benefit the investigation.

No significant changes will be made to the nature or scope of work without prior discussion with KDHE.

1.2 Pathways, Receptors, and Standards

The conceptual site model is presented in Dragun (2008). Based on previous investigations, impacts have been observed in soil, groundwater, sediment, surface water, soil vapor, and indoor air. The main objective of this investigation is to further delineate these impacts. At this time, all exposure pathways will be considered potentially applicable. Receptors may include both residential and non-residential property users. The data from this investigation will be compared to KDHE standards presented in *Risk-Based Standards for Kansas RSK Manual – 5th Version*, dated October 2010.

1.3 Sample and Location Designations

Samples and sampling locations will be named according to the following convention:

DXXyyyyA-zz

DXX
DAA = ambient air
DHP = hydraulic profile boring
DIA = indoor air
DMW = monitoring well
DPW = pumping well
DRW= residential well
DSB = soil boring
DSD = sediment
DSS = surface soil
DSV = soil vapor
DSW = surface water
DTP = test pit
DTW = temp well

yyyy
location number based on OU
four-digit number permits number of locations in an OU to exceed 100
1xxx = OU1
2xxx = OU2
3xxx = OU3

A
letter name of plume, if within a known plume [A-G]
use "X" for locations not currently associated with Plume A through G
duplicates: use same designation as sample location with Z in this position
equipment blank: use same designation as sample location with Y in this position

zz
bottom depth in feet below ground level (fbgl) of sample interval, screen, etc.

The first four numbers in a designation indicate a unique location. For example, "DTW1010D-30" is the 10th location in OU1, which is a 30-foot deep, temporary monitoring well in Plume D. Another example might be: "DMW2031X-50," which is the 31st location in OU2 and is a 50-foot deep permanent monitoring well not yet assigned to a plume.

1.4 QA/QC Samples

Field QC samples will be collected as follows:

- Trip blanks will be used for all samples. One trip blank will be included in each cooler.
- Equipment blanks will be obtained where appropriate.
- Matrix spike and matrix spike duplicate samples will be collected at a rate of one for every 20 environmental samples, or another frequency approved by the Project Manager.
- Quality control samples will be analyzed for the same chemical constituents as the environmental samples, except for the trip blank. The trip blank will be analyzed for volatile organic compounds (VOCs).
- If a field GC is used, one environmental sample for every 10 will be tested at a fixed lab. If less than ten samples are collected, one sample per day per matrix will be analyzed at a fixed lab.

The QA/QC sample frequency for soil, groundwater, surface water, sediment, and vapor are:

- One soil, groundwater, surface water, sediment, or vapor sample in every ten will be collected in duplicate for chemical analysis.
- Duplicate samples will be collected by filling two sets of sample containers.

- Field duplicates will not be identified as duplicates on the sample labels or chain-of-custody forms, but will be identified as such in the field notebook and the sample logs.

The QAPP (Dragun, 2013c) provides additional information regarding the collection of QA/QC samples.

1.5 Miscellaneous Notes and Assumptions

This work plan does not include all of the tasks listed in Consent Decree and CAFO, rather, this work plan focuses on site characterization field activities. Other tasks in the Consent Decree and CAFO not discussed here will be part of subsequent work plans.

1. All of the work in this work plan will be conducted under the supervision of a professional geologist and/or a professional engineer licensed by the Kansas Board of Technical Professions.
2. It should also be noted that the scope of this investigation was negotiated and agreed upon by the Public Entities, USACE, and KDHE, and is incorporated into the Consent Decree and CAFO.
    a. The proposed locations, orientations, spacings, and depths of soil borings and groundwater sampling points are not strictly defined. Rather, the proposed locations, orientations, spacings, and depths are starting points based on the existing knowledge and the need to define both the spatial extent of impact and the degree of impact within the defined scope of work.
    b. It is a central part of this work plan strategy to adjust field proposed locations, orientations, spacings, and depths in the field as necessary to reflect real-time advances in understanding of the distribution of target chemicals and the hydrogeology.
    c. Dragun will consult with KDHE prior to any changes in proposed locations and prior to deeming any source or plume delineated.
3. The depths of proposed soil borings and monitoring wells are estimated average depths. Regardless of the stated depth of soil or groundwater investigation, we will extend the depth of investigation to complete vertical delineation.
4. Initially, Dragun will delineate soil source areas primarily on the basis of trichloroethylene (TCE) concentration; however, if the soil data indicate other critical parameters, Dragun will discuss alternate delineation targets with KDHE. With respect to TCE, Dragun intends to delineate soil impact to 1,000 µg/kg TCE. This value represents the TCE soil concentration above which Dragun would likely consider physical removal to be feasible and cost effective. This value is also consistent with the USEPA's Regional Removal Management Levels at Superfund Sites.
5. For soil borings where continuous logging is indicated, Dragun will field screen each core section (direct push liner, hollow stem auger split spoon, sonic drilling core, etc.) for

organic vapors using a photoionization detector, stain, odor, and other indications of impact as soon as the core is extracted. Dragun will then collect the most impacted section of each core where impact is evident and store that sample in a cooler for consideration for laboratory testing. Once a soil boring is complete, Dragun will select the appropriate soil sample(s) for laboratory testing from that location based on the number of soil samples specified in the work plan for that boring.

6. Prior to any drilling or test pitting work on public property, either Dragun or the selected contractor will contact Kansas One Call / Dig Safe to determine the utility locations near the planned drilling or test pitting locations.
7. The number and/or nature of samples, tests, and methods may be adjusted based on the results of prior work within this scope of work.
8. The use of a mobile lab or expedited turn-around using a fixed lab will be decided based on the number of samples requiring expedited turn-around. This decision will likely vary during this scope of work.
9. Durations for surveys are given in each field task. In practice, surveying may be grouped across tasks.
10. Section 8.0, Appendix E, and the Plume D delineation work plan (Dragun, 2014) provide additional information on sample collection methods.

2.0 OU1 FIELD INVESTIGATIONS

Previous investigations have identified five main areas of TCE-impacted groundwater in Operable Unit 1 (OU1, Figures 2-4). There are three documented soil source areas of TCE:

- Building 606-626 for groundwater Plume A (AOIs 11 and 12),
- Near monitoring well 99M08 for groundwater Plume B (AOI 04), and
- Building 837 for groundwater Plume C (AOI 37).

In addition, there are two suspected soil source areas of TCE based on the observed TCE concentrations in groundwater: the LOX Plant area for groundwater Plume Area D and near monitoring well 99M54 for groundwater Plume Area E (see Figure 4). These source locations have not yet been found.

Issues requiring further Site characterization in OU1 include:

- More precise delineation of known soil sources for Plumes A through C.
- The presence/absence and extent of dense non-aqueous phase liquid (DNAPL) in source areas, especially the source areas for Plumes A and C.

- Identification and delineation of the TCE source(s) in soil at the LOX Plant and near monitoring well 99M54.
- Further delineation of groundwater impacts within the bedrock.
- The presence/absence of other potential chemicals of concern (COCs), including other VOCs and metals in soil and/or groundwater.
- The extent of surface water and sediment impacts.
- Aquifer flow and transport properties and connections between permeable zones.

This work plan addresses the above requirements in three tasks: Source Area Investigations, Surface Water and Sediment Sampling, and Aquifer Testing.

2.1 Delineation of Plume D

Dragun provided the work plan for the delineation of Plume D to KDHE in a separate document (Dragun, 2014).

2.2 Source Area Investigations

This section outlines the source area investigations for Plumes A through C and E (Figure 4).

2.2.a. Plume A

Plume A is located in the southwest corner of OU1 (Figures 4, 5, and 6). Plume A originates at the Building 606-626 area and extends approximately 1,500 feet (ft) to the northeast: north beyond Building 634 and northeast beyond the United School District (USD) #305 VO-Tech Building.

The overburden consists predominantly of clay and silt that extends to bedrock, which is shale. The overburden thickness in the source area is generally less than 20 ft and groundwater is expected to be at approximately 10 feet below ground level (fbgl). Groundwater flow is toward the northeast.

Evaluation of Existing Conditions: The known chemicals of concern in the Building 606-626 area are chlorinated VOCs, primarily TCE. Very high TCE concentrations have been reported at GP-D09 (see Figure 6) in the vadose zone soil (220,000 micrograms per kilogram [µg/kg]) and near the bedrock surface (530,000 µg/kg). These concentrations suggest the presence of DNAPL in soil and bedrock.

The highest TCE concentration in groundwater in Plume A, based on the long-term monitoring data, was 1,100 micrograms per liter (µg/L) at monitoring well 99M04 (see Figure 4) on October 6, 2008.

Objectives: The three main objectives of the Plume A investigation are to:

1. Refine horizontal and vertical delineation of impacted vadose zone soil,
2. Investigate the presence/absence of DNAPL, and
3. Delineate impacted groundwater in the bedrock.

Planned Work: The basic strategy for delineation of the Plume A source area is to: (1) first encompass historical soil exceedances with new soil borings spaced approximately every 20 ft (adding step-out soil borings as needed), and (2) then delineate impacted bedrock groundwater. The scope of work for Plume A is summarized in Tables 2.2.a.1 and 2.2.a.2 and the following bullet points. Figure 6 shows the proposed boring locations.

Section 8.0 of this document, "Details of Field Procedures," provides details of specific field procedures used in this task, as well as all the field tasks outlined in this document. Section 8.0 also contains reference to relevant standard operating procedures (SOPs) for these tasks. Appendix E contains the SOPs.

The Plume A scope of work will include the following:

- Negotiate access for drilling locations
- Delineate Plume A soil source (15 vertical profile borings to 15 fbgl).
    - Advance 11 direct-push soil borings to 15 fbgl at approximately 20 foot spacing.
    - Continuously log geology in each soil boring.
    - Sample worst-case (based on field observations and measurements) soil from each boring.
    - Test soil samples for VOCs.
    - Add four step-out borings as above as needed to complete delineation.
    - Log, sample, and test soil samples as above.
- Evaluate the presence/absence of DNAPL at up to six locations using visual observations and SUDAN IV test kits.
- Delineate groundwater impact in bedrock (one bedrock well to approximately 70 fbgl and 6 vertical profile borings to 40 fbgl).
    - Advance a line of four borings 40 fbgl (in bedrock) transverse to groundwater flow.
        - Start in area of greatest soil impact.
        - Space borings along transect at approximately 20-foot spacing.
        - Use double-casing, if warranted.
        - Log geology.
        - Sample groundwater through temporary monitoring wells at each location; test samples for VOCs.

- Advance a line of two borings 40 fbgl (in bedrock) in the direction of groundwater flow.
  - Start in area of greatest groundwater impact based on transverse locations.
  - Space borings along transect at approximately 30-foot spacing.
  - Use double-casing, if warranted.
  - Log geology.
  - Sample groundwater through temporary monitoring wells at each location, test samples for VOCs.
- Advance one boring into bedrock to approximately 70 fbgl.
  - In the area of greatest impact.
  - Use double-casing,if warranted.
  - Log geology.
  - Install bedrock monitoring well.
  - Sample groundwater, and test samples for VOCs.

- Survey soil boring and monitoring well locations and elevations. The survey will be performed by a licensed surveyor.

Table 2.2.a.1 Task 2.2.a Soil Boring and Monitoring Well Details – Plume A

Number of Borings	Soil Boring/ Drilling Method	Stratum	Borings Logged	Average Depth (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
15	Direct Push	Overburden	Yes	15	0	Delineate vadose zone impact	1	0
4	Sonic	Bedrock	Yes	40	4/TMW	Transverse to GW flow	0	1
2	Sonic	Bedrock	Yes	40	2/TMW	In GW flow direction	0	1
1	Sonic	Bedrock	Yes	70	1/MW	Location of greatest impact	0	1

GW = Groundwater
TMW = Temporary Monitoring Well
MW = Monitoring Well

Table 2.2.a.2 Task 2.2.a Samples and Analyses – Plume A

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
DNAPL	6	Highest PID readings, visual observation	Sudan IV test kit	NA	Field analysis
Soil	15	Highest PID readings, visual observation	VOCs	Fixed	Expedited
Groundwater-bedrock (40 fbgl)	6	Highest PID readings, visual observation	VOCs	Mobile	Expedited
Groundwater-bedrock (70 fbgl)	1	Based on prior analytical data	VOCs	Fixed	Standard
TAT = Turn Around Time PID = Photoionization Detector VOCs = Volatile Organic Compounds NA = Not Applicable					

Anticipated Schedule: Dragun anticipates that the field work for the Plume A investigation will begin in fall 2014 and the take approximately nine days.

Table 2.2.a.3 Task 2.2.a Schedule – Plume A

Activity	Duration (days)	Other
Overburden drilling and soil sampling (15 fbgl)	2	
Bedrock drilling (40 fbgl)	2	
Bedrock drilling (70 fbgl)	1	
Sampling of groundwater (40 fbgl)	1	
Sampling of groundwater (70 fbgl)	0.5	
Survey	1	
Standard TAT laboratory analysis	7-10	working days

2.2.b. 99M08 (Plume B)

Plume B is located in the southwest corner of OU1 (Figures 4, 5, and 6). Plume B originates just north of the Plume A source, and its core extends approximately 2,200 ft to the northeast.

The overburden consists predominantly of clay and silt that extend to bedrock, which is shale. The overburden in the source area is generally 10 to 30 ft thick, and groundwater is expected to be at approximately 10 fbgl. Groundwater flow is toward the northeast.

Evaluation of Existing Conditions: Impacted soil near GP-D06 (Figure 6) appears to be the source area of Plume B. Impacted soil in this area contains very high TCE concentrations (65,000 µg/kg at GP-D06). Because bedrock is expected to be at 10 to 20 fbgl near GP-D06, the high TCE concentration in soil at GP-D06 suggests DNAPL may have reached and/or entered the bedrock.

The highest TCE concentration in groundwater in Plume B, based on the long-term monitoring data, was 5,600 µg/L at monitoring well 99M13 (Figure 4) on June 6, 2007.

Objective: The main objective of the Plume B investigation is to refine the horizontal and vertical delineation of impacted vadose zone soil.

Planned Work: The basic strategy for delineation of the Plume B source area is to first encompass historical soil exceedances with new borings at approximately every 25 ft, then add step-out soil borings as needed.

The scope of work for Plume B is summarized in Tables 2.2.b.1 and 2.2.b.2 and in the following bullet points. Figure 6 shows the proposed boring locations. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The Plume B scope of work will include the following:

- Negotiate access for drilling locations.
- Delineate Plume B soil source (24 vertical profile borings to 20 fbgl)
    - Advance 15 direct-push soil borings at approximately 25-foot spacing to 20 fbgl.
    - Continuously log geology in each soil boring.
    - Sample worst-case (field observations and measurements) soil from each boring.
    - Test soil samples for VOCs.
    - Add nine step-out borings as above as needed to complete delineation.
    - Log, sample, and test soil samples as above.
- Survey soil boring locations and elevations. The survey will be performed by a licensed surveyor.

Table 2.2.b.1 Task 2.2.b Soil Boring Details – Plume B

Number of Borings	Soil Boring / Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
24	Direct Push	Overburden	Yes	20	0	Delineate vadose zone impact	1	0

Table 2.2.b.2 Task 2.2.b Samples & Analyses – Plume B

Type/Media	Number of samples	Depths/Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	24	Highest PID readings, visual observation	VOCs	Fixed	Expedited

Anticipated Schedule: Dragun anticipates that the field work for the Plume B investigation will begin in fall 2014 and the take approximately four days.

Table 2.2.b.3 Task 2.2.b Schedule – Plume B

Activity	Duration (days)	Other
Overburden drilling and soil sampling	3	
Survey	1	
Standard TAT laboratory analysis	7-10	working days

2.2.c. Building 837 Area (Plume C)

Plume C originates in the Building 837 area and extends approximately 1,250 ft to the northeast (Figures 4, 5, and 7). Severely impacted soil extends to at least 25 fbgl into the low permeability clayey soils in some areas (see sample location 1C01AG in the Building 837 area; Figure 7). TCE concentrations in soil at the Building 837 area suggest that DNAPL is present in the soil. Further remedial investigation is required to refine the limits of impacted soil requiring removal.

Evaluation of Existing Conditions: The overburden consists predominantly of clay and silt that extends to bedrock, which is shale. Sandy soil occurs in some locations just above the bedrock. The overburden thickness ranges from about 50 to 60 ft. The water table is at approximately 10 fbgl, and groundwater flow is to the north and northeast.

Historical data from the Building 837 area include 39 vadose zone soil samples. Impacted soils were predominantly north of Building 837. The maximum detected TCE concentration was 156,000 µg/kg at 1C01AG occurring at 23 to 23.5 fbgl (Figure 7).

Outside of the long-term monitoring data, the maximum detected TCE concentration in Plume C was 170,000 µg/L at MW-4A and MW-5A from a depth of 15 to 20 fbgl. MW-4A and MW-5A are located north of Building 837. In addition, TCE was detected at a concentration of 815,000 ug/L at 99M24 on August 24, 2006, during pilot testing conducted by USACE.

There have also been 154 groundwater samples collected from 19 monitoring wells as part of the long-term monitoring program in Plume C conducted between August 2006 and October 2009. The highest TCE concentration was 160,000 µg/L at monitoring well 99M24RA (at 11 fbgl) on August 8, 2007.

Objectives: The three main objectives of the Plume C investigation are to:

1. Refine the vertical and horizontal delineation of VOC vadose zone soil impact.
2. Determine if, and where, DNAPL is present.
3. Perform geotechnical testing on soil near buildings for use during remedial design.

Planned Work: The basic strategy for delineation of the Plume C source area is to (1) first encompass historical soil exceedances with new 20-foot borings spaced at approximately every 30 ft, (2) add step-out soil borings as needed, and (3) delineate the depth of soil impact and evaluate current conditions with 30-foot soil borings.

The scope of work for Plume C is summarized in Tables 2.2.c.1 and 2.2.c.2 and in the following bullet points. Figure 7 shows the proposed boring locations. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The Plume C scope of work includes:

- Negotiate access for drilling locations.
- Determine current groundwater flow directions.
    - Measure groundwater elevation at existing groundwater monitoring wells in Plume C.
- Delineate Plume C soil source (30 vertical profile borings: 10 to 30 fbgl and 20 to 20 fbgl).
    - Advance 11 direct-push soil borings at approximately 20-foot spacing to 20 fbgl.
        - Continuously log geology in each soil boring.
        - Sample worst-case (field observations and measurements) soil from each boring.
        - Test soil samples for VOCs.
    - Add nine step-out borings as above as needed to complete delineation.
    - Log, sample, and test samples as above.
    - Advance 10 direct-push soil borings distributed through source area to 30 fbgl.
        - Focus on locations with historically high VOCs in soil.
        - Continuously log geology in each soil boring.
        - Sample up to three worst-case (field observations and measurements) soils from each boring.
    - Test soil samples for VOCs.
    - Evaluate the presence/absence of DNAPL at up to 20 locations using visual observations and SUDAN IV test kits.
- Collect four soil samples near buildings and test for geotechnical properties.
    - grain size, Atterberg limits, hydraulic conductivity-triaxial compression test-consolidated drained and undrained.
- Perform laboratory analysis using a fixed base laboratory.

- Survey soil boring locations and elevations. The survey will be performed by a licensed surveyor.

Table 2.2.c.1 Task 2.2.c Soil Borings and Monitoring Well Details – Plume C

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
20	Direct Push	Overburden	Yes	20	0	Delineate vadose zone boundary (horizontal extent)	1	0
10	Direct Push	Overburden	Yes	30	0	Delineate vadose zone vertical extent	3	0

Table 2.2.c.2 Task 2.2.c Samples and Analyses – Plume C

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	20	Greatest PID, visual observation	VOCs	Fixed	Expedited
Soil	30	Greatest PID, visual observation	VOCs	Fixed	Standard
DNAPL	20	PID, visual observation	Sudan IV test kit	NA	Field analysis
Soil-Geotechnical	4	For excavation evaluation	Grain size, Atterberg limits, Hydraulic Conductivity-Triaxial Compression Test-Consolidated Drained and Undrained	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for the Plume C investigation will begin in fall 2014 and will take approximately five days.

Table 2.2.c.3 Task 2.2.c Schedule – Plume C

Activity	Duration (days)	Other
Overburden drilling and soil sampling (10 vertical profile and 20 lateral delineation borings)	4	
Survey	1	
Standard TAT Laboratory analysis	7-10	working days

2.2.d. LOX Plant (Plume D source area)

Plume D (Figures 4, 5, and 8) is a chlorinated hydrocarbon plume that extends approximately 2,500 ft from an undefined source area at/around the former Liquid Oxygen (LOX) Plant into the residential neighborhood east of I-135. Despite intensive soil and groundwater testing at, and around, the LOX plant, the source(s) of TCE have not been identified.

Evaluation of Existing Conditions: Historically, TCE concentrations in groundwater have been highest north of the LOX Plant, with the highest observed concentration 27,800 µg/L at 20 fbgl at 1D01BH (Figure 8), approximately 220 ft north of the LOX plant. The groundwater flow direction is generally to the northeast in this area. Immediately downgradient of this location, TCE concentrations in groundwater more than 40 fbgl at, or near, the bedrock subcrop exceed 1,000 µg/L.

The area with the second highest TCE concentration in groundwater is at 1D01AF (12,700 µg/L at about 40 fbgl), approximately 200 ft north of 1D01BH. The TCE concentrations at shallower depths at this location were lower.

Two other areas near the LOX plant have high TCE concentrations in groundwater: GP-N45 (>2,000 µg/L at about 30 fbgl north of Tony's Road Ditch) and 1D01BP (>1,000 µg/L from about 20 to 30 fbgl near the eastern extent of the former SAFB). The highest TCE concentration reported in the long-term monitoring wells occurred on August 16, 2007, at 99M53C, about 40 ft downgradient from 1D01BH (screen bottom at 41.4 fbgl, concentration of 4,400 µg/L).

However, since none of the 74 vadose zone soil samples collected from above the most impacted groundwater around the LOX Plant had detectable TCE, the source remains unknown.

Given (1) the absence of TCE in vadose zone soil above the highly impacted groundwater, (2) the considerable depth of TCE-impacted groundwater at, or around, the LOX plant, (3) the low TCE concentrations in groundwater at some of these locations, (4) northeastward flowing groundwater, and (5) the alignment of the TCE highs in groundwater tranverse to groundwater flow, the source area(s) may be in separate locations upgradient (west and southwest) of the highest TCE values observed in groundwater.

Objectives: The four main objectives of the former LOX Plant investigation are:

1. Identify the vadose soil source areas.
2. Delineate the vadose soil source areas (if identified).
3. Delineate the impacted groundwater.
4. Characterize soil fraction organic carbon (f_{oc}) for remedial method evaluation.

Planned Work:

The basic strategy for identification and delineation of the former LOX Plant source area(s) is to (1) first test soil and groundwater conditions immediately (approximately 100 ft) upgradient from historical groundwater TCE high concentrations and (2) move stepwise up-, down-, and/or side-gradient, as needed, to delineate the soil and groundwater source(s).

The scope of work for the LOX Plant is summarized in Tables 2.2.d.1, 2.2.d.2, and the following bullet points. Figure 8 shows "proposed potential" boring locations. The actual locations will be determined on a real-time basis, based on the results from preceding soil borings. Some of the proposed potential locations are located along a former drainage ditch that may be a historic source (shown in Figure 8). These locations will be preferred locations to be considered for investigation. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

Burns and McDonnell (2010, page 14) indicate that part(s) of the LOX Plant area is underlain by rubble that is difficult to investigate using conventional direct-push drilling. Burns and McDonnell (2010) do not indicate a specific area where rubble has been encountered. Figure 8 shows the suspected rubble area based on Dragun's examination of boring logs from Burns and McDonnell (2010).

The LOX Plant investigation includes:

- Negotiate access for drilling locations.
- Determine current groundwater flow directions.
    - Measure groundwater elevations at existing groundwater monitoring wells at, or near, former LOX plant.
- For each high TCE groundwater concentration, delineate soil source (12 vertical profile borings: 6 to 20 fbgl and 6 to 40 fbgl):
    - Step 1: Advance a 40-foot boring 100 ft directly upgradient of highest historic TCE concentration in groundwater (i.e. 1D01BH).
        - Continuously log the geology in the soil boring.
        - Sample two worst-case soil intervals in soil boring (based on field observations and measurements).
        - Sample uppermost groundwater using direct-push equipment.

        - Test soil and groundwater samples for VOCs.
        - If impacted soil (source material) is encountered, move to Step 3.
    - Step 2:
        - If neither groundwater nor soil is highly impacted at the Step 1 location, move approximately 50 ft downgradient and repeat Step 1, as needed, until soil impact encountered.
        - If groundwater is highly impacted and soil is not at the Step 1 location, move approximately 50 ft upgradient and repeat Step 1, as needed, until soil impact encountered.
    - Step 3: Once soil impact is located, delineate the width of impacted area with transect of borings through the first boring and perpendicular to groundwater flow; use 100-foot spacing along transect.
        - Advance 20 to 40-foot borings, as needed .
        - Continuously log geology in each soil boring.
        - Sample two worst-case soil intervals in soil boring (based on field observations and measurements).
        - Sample uppermost groundwater using direct-push equipment.
        - Test soil and groundwater samples for VOCs.
    - Step 4: Delineate the length of impacted soil area, as needed.
        - Move upgradient 100 ft from the centroid of the impact in Step 3.
        - Delineate width as above by moving out from the center of the previous line.
        - Move upgradient again, as needed, to delineate soil impact .
- Evaluate soil conditions where rubble is encountered.
    - Advance four 20-foot borings in rubble area using sonic drill or equivalent.
        - Continuously log geology in each soil boring.
        - Sample two worst-case soil intervals in soil boring (based on field observations and measurements).
        - Test soil for VOCs.
- Test three soil samples from saturated zone for f_{oc}.
- Survey soil boring locations and elevations. The survey will be performed by a licensed surveyor.

Table 2.2.d.1 Task 2.2.d Borings/Monitoring Wells – LOX Plant (Plume D)

Number of Borings	Soil Boring /Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Soil Samples per Location	# GW Samples per Location
6	Direct Push	Over-burden	Yes	20	0	Delineate soil and groundwater impact	2	1
6	Direct push	Over-burden	Yes	40	0	Delineate soil and groundwater impact	2 3 total for f_{oc}	1
4	Sonic	Rubble	Yes	20	0	Delineate soil impact	2	0

Table 2.2.d.2 Task 2.2.d Samples & Analyses – LOX Plant (Plume D)

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	3	Saturated zone	f_{oc}	Fixed	Standard
Soil	32	PID, visual, olfactory, and deepest extent of impact	VOCs	Fixed	Expedited
Groundwater	12	Based on soil PID	VOCs	Mobile	Expedited

Anticipated Schedule: Dragun anticipates that the field work for the LOX Plant investigation will begin in fall 2014 and will take approximately six days.

Table 2.2.d.3 Task 2.2.d Schedule – LOX Plant (Plume D)

Activity	Duration (days)	Other
Overburden drilling	3	
Drilling in rubble	1-2	
Survey	1	
Standard TAT laboratory analysis	1-10	working days

2.2.e. Plume E

Plume E originates south of the former sewage treatment plant and extends to the northeast into the agricultural land to the east of the Burlington Northern Railroad (Figures 4, 5, and 9). The current sewage lift station (Figure 9) is at the location of the former Sewage Treatment Plant.

The TCE concentrations in soil and groundwater are above the KDHE RSK levels, but compared to other OU1 plumes, concentrations are low.

Evaluation of Existing Conditions: The overburden consists predominantly of clay and silt that extends to bedrock. The water table is at depths from approximately 9 to 13 fbgl.

The soil source for Plume E has not been identified. Fifteen historical soil samples in Plume E have vadose zone soil data. Ten of these have TCE concentrations less than 10 µg/kg. The maximum reported TCE in soil near Plume E (437 µg/kg) was at sample point 1A01E, in the northeast corner of the former Sewage Treatment Plant (Figure 9). However, this soil sample is shallow (1-2 fbgl) and is outside the currently defined plume boundary. Furthermore, the observed concentration of TCE in this soil sample is less than the concentration of 1,000 µg/kg that would indicate delineation of a source (for the purposes of this investigation). The soil sample from 1A01J (near the railway) at 11-12 fbgl had 65 µg/kg TCE.

The highest TCE concentration in groundwater reported in long-term monitoring data was 106 µg/L (estimated) at 99M39 in the northeast part of Plume E on August 25, 2006. However, this value is suspect since there were no concentrations reported above 4 µg/L for this monitoring well between 1999 and 2009. Groundwater at monitoring well 99M60A/B (near the leading edge of the Plume E) had TCE in the 30-41 µg/L range during October 2007.

Objectives/Goals: The main objectives of the Plume E investigation are to identify and delineate the source of Plume E and to further characterize the extent of TCE impacted groundwater in the Plume E source area.

Planned Work: The basic strategy for identification and delineation of the Plume E source is to (1) test soil and groundwater conditions upgradient from historical groundwater TCE high and (2) move stepwise up- and side-gradient to delineate the soil source(s).

The scope of work for Plume E is summarized in Tables 2.2.e.1 and 2.2.e.2 and the following bullet points. Figure 9 shows the proposed boring locations. Refer to Section 8.0 for “Details of Field Procedures” and Appendix E for the SOPs.

The Plume E scope of work includes:

- Negotiate access for drilling locations.
- Determine current groundwater flow directions.
    - Measure groundwater elevation at 12 existing groundwater monitoring wells
- Delineate soil source and extent of impacted groundwater in the source area (12 vertical profile borings to 30 fbgl).
    - Advance a 30-foot boring at, or near, the former Sewage Treatment Plant.
        - Continuously log geology in each soil boring.
        - Sample two worst-case soil intervals in soil boring (based on field observations and measurements).
        - Sample uppermost groundwater in the source area using direct-push equipment (assume one groundwater sample collected per three soil borings).

        - Test soil and groundwater samples for VOCs.
    - Delineate width of impacted area with transect of borings starting, from first boring and perpendicular to groundwater flow, using approximately a 225-foot spacing.
        - Advance up to three 30-foot borings, as needed.
        - Log, sample, and test soil and groundwater samples as above.
    - Delineate the length/width of the impacted soil, as needed.
        - Move 150 to 225 ft upgradient.
        - Advance up to eight 30-foot borings, as needed.
            - Delineate the plume width as above moving out from the center of the previous line.
    - Limited delineation of soil impact around 1A01E.
        - At the request of KDHE, advance three borings within 20 feet of, and around, 1A01E to a depth of 8 feet.
        - Log, sample, and test soil samples as above.
        - If the soil is impacted based on field observations (organic vapors, staining, odor), Dragun will advance these soil borings deeper until there are no field indications of impact.
        - If the laboratory data indicate TCE concentrations in soil exceed 1,000 µg/kg, Dragun will consult with KDHE regarding further investigation.

- Perform laboratory analysis using a fixed-base laboratory.
- Survey the soil boring locations and elevations. The survey will be performed by a licensed surveyor.

Table 2.2.e.1 Task 2.2.e Soil Borings and Monitoring Well Details – Plume E

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
12	Direct Push	Overburden	Yes	30	0	Delineate vadose zone source area	1	One per three soil boring locations
3	Direct Push	Overburden	Yes	8	0	Evaluate soil around 1A01E	1	None

Table 2.2.e.2 Task 2.2.e Samples and Analyses – Plume E

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	15	Vertical profile	VOCs	Fixed	Expedited
Groundwater-overburden	4	Vertical profile or temporary monitoring wells	VOCs	Fixed	Expedited

Anticipated Schedule: Dragun anticipates that the field work for the Plume E investigation will begin in fall 2014 and will take approximately four days.

Table 2.2.e.3 Task 2.2.e Schedule – Plume E

Activity	Duration (days)	Other
Overburden drilling and soil sampling (30 vertical profile borings)	2-3	
Survey	1	
Standard TAT laboratory analysis	7-10	working days

2.3 Aquifer Testing

Dragun (2008) considers pump and treat to be a more reliable remedial approach to prevent impacted groundwater from moving towards the Salina municipal water supply wells than the *in situ* injections proposed by USACE. Dragun (2008) preferred pump and treat primarily because (1) the complexity of the hydrogeology west of Highway 135 would limit the likelihood of injected chemicals reaching the target contaminants and (2) TCE and other chemicals that diffused into the low hydraulic conductivity soils, which are predominant west of Highway 135, will gradually diffuse back into the "remediated" soil after the injectate is spent.

USACE (2007b) conducted an aquifer test east of Highway 135 outside the extent of Plume D during 2007. However, the hydrogeology east and west of Highway 135 is very different. Low hydraulic conductivity soils with minor permeable zones occur west of the Highway, while there is a thick, semi-confined aquifer east of the Highway. There has been no previous aquifer testing conducted west of Highway 135.

Evaluation of Existing Conditions: The known chemicals of concern are chlorinated VOCs. Groundwater is expected to be encountered near 10 fbgl. In the Plume C and D areas, about 75% of the overburden is low hydraulic conductivity soil; permeable zones appear discontinuous in the groundwater flow direction, and hydraulic connections between permeable zones are complicated. Bedrock is expected to be encountered deeper than 50 fbgl.

Objectives: The three main objectives of the aquifer testing are to:

- Determine the hydraulic parameters of the aquifer.
- Evaluate the potential for controlling/remediating TCE plumes west of Highway 135 using groundwater pump and treat.
- Evaluate hydraulic connections between permeable zones west of Highway 135.

Planned Work: The basic strategy of this task is to evaluate aquifer hydraulics near, but not within, Plume C or D. By testing a location outside the plume, disposal costs/effort associated with pumped, impacted groundwater can be minimized.

The scope of work is summarized in Tables 2.3.a and 2.3.b and the following bullet points. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work of aquifer testing includes:

- Negotiate access for drilling locations.
- The exact location(s) for aquifer testing will be selected after the OU1 soil and groundwater investigation.
    - Locate aquifer test pumping well outside, but adjacent to, a plume (either Plume C or D) to minimize water treatment or disposal costs.
        - Test groundwater at pumping and observation wells prior to aquifer test.
        - Test pumped groundwater for VOCs during the test with a 2-hour turn-around time with a mobile lab or field GC.
- Install wells.
    - Assume pumping well screened at approximately 50 fbgl.
    - Assume 4 piezometers, screened at the same depth as the pumping well (for aquifer parameter evaluation).
    - Assume 2 piezometers, screened in other permeable units (for connection evaluation).
- Aquifer test:
    - Determine the static groundwater elevations at wells and within 1,000 ft.
    - Set up and test equipment.
    - Perform step test (assume six hours).
        - Determine which observation wells respond.
        - Determine the aquifer test pumping rate. Use at least three different pumping rates. Change rates when stabilization occurs (less than 0.02 feet change in drawdown over 10 minutes) or two hours, whichever is less.
    - Perform 24 to 48-hour aquifer test (assess confined/unconfined conditions).
        - Use pumping rate determined from step test.
        - Observe drawdown in observation and pumping wells at least until stabilization (less than 0.02 feet change in drawdown over 10 minutes), using intervals noted in SOPs.
        - Observe drawdown in surrounding monitoring wells periodically.
        - Monitor field chemistry during the test. Monitor VOCs at beginning, middle, and end of test.
        - If necessary (depending on the location of the test and the distribution of chemicals of concern in the groundwater in the pumping well area prior to the test), temporarily store water in frac tanks for subsequent testing (one sample per frac tank, tested for VOCs and metals) to determine whether the water requires treatment. Dragun will evaluate treatment and disposal options. If acceptable to the City of Salina, the stored water will be released into the sewer system. If not acceptable to the City, Dragun may pre-treat the water and release or have the water removed by a licensed hauler for appropriate disposal.

- Perform recovery test (assume six hours).
- Remove equipment.

Table 2.3.a Task 2.3 Borings/Monitoring Wells – Aquifer Test

Number of Borings	Soil Boring /Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Soil Samples per Location	# GW Samples per Location
6	Direct Push	Overburden	Yes	50	6/piezometers	Aquifer test	0	1
1	Sonic	Overburden	Yes	50	1/pumping well 4-6" diameter	Aquifer test	0	5

Table 2.3.b Task 2.3 Samples & Analyses – Aquifer Test

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Groundwater	11	Evaluate groundwater to be pumped and water pumped during test	VOC	10 mobile, 1 fixed	2 hour mobile, standard fixed

Anticipated Schedule: Dragun anticipates that the field work for the aquifer test will begin after the plume delineation work, in late 2014 or early 2015, and will take approximately nine days.

Table 2.3.c Task 2.3 Schedule – Aquifer Test

Activity	Duration (days)	Other
Pumping well and piezometer installation	3	
Aquifer test	4-5	
Survey	0.5	
Mobile Lab TAT	-	2 hours
Standard TAT laboratory analysis	7-10	working days

2.4 Surface Water and Sediment Sampling

The most recent surface water or sediment data were obtained in 2000. Additional sediment and surface water sampling are needed to determine current conditions.

Potential chemical impacts to surface water and sediment are primarily associated with three surface waters that traverse areas with TCE-impacted groundwater: (1) Centennial Ditch and Derussy Ditch near the Sewage Treatment Plant, (2) Centennial Ditch, Tony's Road Ditch, and Dry Creek near the LOX Plant, and (3) Scanlan Ditch near 99M08 (Figure 10).

Historical sediment and surface water sampling near the LOX Plant detected low levels of TCE in Tony's Road Ditch (1.66 ug/kg at SED-005 and 1.9 µg/L at SW-05) and Dry Creek (2 µg/L at

02S50). TCE has not been detected in surface water or sediment at Derussy Ditch, Centennial Ditch (Sewage Treatment Plant area), or Scanlan Ditch (99M08 area).

Evaluation of Existing Conditions: The known chemicals of concern are chlorinated VOCs. The ditches have estimated depths of approximately 4-10 fbgl. Except for Tony's Road Ditch, flow in the ditches is intermittent. Centennial Ditch, Tony's Road Ditch, and Derussy Ditch discharge to Dry Creek. Scanlan Ditch discharges to Centennial Ditch.

Objectives: The main objective of the surface water and sediment sampling is to investigate current conditions in surface water and sediment impacts.

Planned Work: The basic strategy for this task is to re-sample surface water and sediment at locations where there are historical data. Six of the sample locations are 100-300 ft upstream of the confluence with another surface water body; two locations are at/near the source of the surface water body; one location is on Centennial Ditch at the southern end of OU1; and the last location is on Dry Creek about 400 ft downgradient from the Site. Dragun will evaluate potential sediment sampling locations and avoid sampling in areas where scour or recent deposition is observed.

The scope of work for the surface water and sediment sampling is summarized in Tables 2.4.a and 2.4.b and the following bullet points. The proposed sampling points are shown in Figure 10. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for surface water and sediment sampling includes:

- Negotiate access.
- Select and mark locations with stake for potential future monitoring.
- Evaluate surface water and sediment.
    - Sample surface water and sediment at 10 sample pair locations.
    - Test water and sediment samples for VOCs.
- Survey elevation and location of surface water and sediment sampling points.

Table 2.4.a Task 2.4 Sampling Locations – Surface Water and Sediment

Number of Samples	Method	Stratum	Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Sediment Samples per Location	# Surface Water Samples per Location
10	Dipper	Surface water	NA	0.5-1 (if possible >0.5 ft deep).	0	Prior sampling data, at the confluence of creeks, at source areas	0	1
10	Slide Hammer	Sediment	NA	0-1	0	Prior sampling data, at the confluence of creeks, at source areas	1	0

Table 2.4.b Task 2.4 Samples & Analyses – Surface Water and Sediment

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Surface water	10	Top of water/sediment column	VOCs	Fixed	Standard
Sediment	10				

Anticipated Schedule: Dragun anticipates that the field work for the surface water and sampling will begin after the plume delineation work, in late 2014, and will take approximately three days.

Table 2.4.c Task 2.4 Schedule – Surface Water and Sediment

Activity	Duration (days)	Other
Surface water and sediment sampling	1-2	
Survey	1	
Standard TAT Laboratory analysis	7-10	working days

2.5 Investigation of Vapor Intrusion to Indoor Air

Dragun previously provided KDHE with a vapor intrusion work plan that focuses on 12 of the most impacted areas in OU1 (Dragun, 2013e). This work was conducted in May 2014 and the data is currently being evaluated. Once the sources and plumes in OU1 are fully delineated and the data from the initial 12 locations have been analyzed, Dragun will select the remaining 18 test locations. Dragun will use the methods outlined in Dragun (2013e) to evaluate vapor conditions at the remaining locations.

2.6 Investigation/Documentation of Water Use

Dragun will conduct the investigation/documentation of water use in OU1 following completion of the Plume D delineation work. Dragun will provide a separate work plan for this Task.

2.7 Data Validation/QCSR

The data quality objectives for this project are detailed in the Draft Final Quality Assurance Project Plan (QAPP, Dragun, 2013c). Upon receipt of each laboratory data report, Dragun will review the data and the associated quality assurance/quality control to verify that the data quality objectives have been met. A Quality Control Summary Report (QCSR) will be prepared at the completion of the OU1 investigation to summarize the results of the comparison to the data quality objectives.

3.0 OU2 FIELD INVESTIGATIONS

3.1 North Zone

The North Zone is located in the northern part of OU2 (Figures 3, 4, and 11). This area contains the former Hobby Auto and Photographic Shops, Maintenance Area, and Base Engineering Area.

Evaluation of Existing Conditions: The hydrogeology of OU2 has not yet been fully characterized. The overburden consists predominantly of clay and silt that extends to bedrock, which is shale. Sandy soil occurs in some locations. The overburden thickness ranges from about 2 ft in the west to at least 51 ft in the east. The water table is at approximately 10 fbgl in the west to at least 23 fbgl in the east (Burns and McDonnell, 2007c).

Minimal TCE has been detected in surface soil or sediment in the North Zone. Historical data from the North Zone include 38 vadose zone soil samples; four of these have reported detections (maximum of 4 µg/kg [estimated] at 06b13/S01 at 1-4 fbgl, near General Jim Road).

According to Burns and McDonnell (2007c), approximately 5,500 pounds of soil and sediment were removed from a box culvert about 200 ft west of monitoring well 06M31 (at 06B12 on Figure 11). The soil and sediment there had elevated lead and TCE concentrations.

Historical data from the North Zone plume also include 13 groundwater samples, of which six contained detectable concentrations of TCE. The maximum detected concentration was 130 µg/L detected at GPW-H28-042 (located approximately 915 ft east and 35 ft north of the southeast corner of the Maintenance Area shown in Figure 11) from a depth of 42 fbgl. GPW-H28-042 is located east of Centennial Road and appears to be in a plume that originates from the Central Zone of OU2. The second highest TCE concentration in groundwater (15.6 µg/L) is at 22-27 fbgl at GPW-100, which is located near the center of the Maintenance Area (Figure 11).

There are two long-term monitoring wells in the northwest part of the North Zone, 06M30 and 06M31 (Figure 11). TCE concentrations have historically been <1 µg/L at the former and up to 8.9 µg/L at the latter.

Although there is impacted groundwater in the North Zone, historically, no reports have depicted a defined groundwater plume.

Objectives: The two main objectives of the North Zone investigation are to (1) delineate the plume downgradient of the former Hobby Auto and Photographic Shops and Maintenance Area and (2) evaluate groundwater chemistry versus time.

Planned Work: The basic strategy for delineation of the North Zone Plume is to test groundwater quality along selected transects downgradient of the former Hobby Auto and Photographic Shops and Maintenance Area.

The scope of work in the North Zone is summarized in Tables 3.1.a and 3.2.b and the following bullet points. Figure 11 shows the proposed boring locations. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for the North Zone Plume includes:

- Negotiate access for drilling locations.
- Determine current groundwater flow direction.
    - Measure groundwater elevations at North Zone and surrounding monitoring wells.
- Delineate the plume (total of 20 vertical profile borings up to 25 ft deep).
    - Advance two 25-foot borings at approximately 150-foot spacing downgradient (north) and four 25-foot borings at approximately 100-foot spacing downgradient (east) of former Hobby Auto and Photographic Shops.
    - Log soil borings continuously.
    - Sample uppermost groundwater using direct-push equipment.
    - Test groundwater samples for VOCs and semivolatile organic compounds (SVOCs).

    - Advance four 25-foot borings upgradient (west) and three 25-foot borings downgradient (east) of former Maintenance Area.
    - Log, sample, and test samples as above.

    - Advance seven 25-foot borings down- and sidegradient, as needed, to complete plume delineation.
    - Log, sample and test samples as above.

    - Test two soil samples from these 20 locations for f_{oc}.

- Evaluate temporal trends in groundwater quality.
    - Establish permanent monitoring well nests; install seven monitoring wells in three well nests (three 2-well clusters and one single well) at locations determined from plume delineation.
        - Screens at 25 and 50 fbgl for well pairs, 25 fbgl for single well.
    - Collect one groundwater sample from each monitoring well.
    - Test samples for VOCs and SVOCs.
    - Collect two groundwater samples for natural attenuation (NA) parameters.
        - NA parameters include methane, ethane, ethane, iron (total), chloride, nitrate, nitrite, sulfate, sulfide, and total organic carbon.
- Install one bedrock monitoring well to 30 fbgl if prior plume evaluation identifies the need.
    - Use double-casing, if warranted.
    - Collect groundwater sample.
    - Test sample for VOCs and SVOCs.
- Perform laboratory analysis using a fixed-base laboratory.
- Survey soil boring and monitoring well locations and elevations. The survey will be performed by a licensed surveyor.

Table 3.1.a Task 3.1 Soil Borings and Monitoring Well Details – North Zone Plume

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
20	Direct Push	Overburden	Yes	25	0	Groundwater plume definition	0	1
4	HSA or sonic	Overburden	Yes	25	4/MW	Groundwater plume definition	0	1
3	HSA or sonic	Overburden	Yes	50	3/MW	Groundwater plume definition	0	1
1	Sonic	Bedrock	Yes	30	1/MW	Groundwater plume definition	0	1

Table 3.1.b Task 3.1 Samples and Analyses – North Zone Plume

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	2	Vertical profile	f_{OC}	Fixed	Standard
Groundwater-overburden	20	Vertical profile	VOCs, SVOCs	Mobile	Expedited
Groundwater-overburden	7	Permanent wells	VOCs, SVOCs	Fixed	Standard
Groundwater-overburden	2	Permanent wells	NA parameters	Fixed	Standard
Groundwater-bedrock	1	Permanent wells	VOCs, SVOCs	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for the North Zone will begin during fall 2014 and will take approximately 15 days.

Table 3.1.c Task 3.1 Schedule – North Zone Plume

Activity	Duration (days)	Other
Overburden drilling and soil sampling (20 vertical profile borings)	4	
Overburden drilling (install 3 monitoring well nests (7 wells total)	2	
Bedrock drilling (1 monitoring well)	1	
Sampling of 8 permanent (7 overburden and 1 bedrock) groundwater monitoring wells	2	
Survey	2	
Standard TAT laboratory analysis	7-10	working days

3.2 Central Zone

The Central Zone groundwater plumes are located in the central part of OU2 (Figures 4, 5, and 12). The plumes, which include both TCE and carbon tetrachloride (CCl_4) plumes, originate near Hangar 1 and the former Auto Wash and extend at least 3,600 ft to the northeast. The plumes reach the residential subdivision to the east of Foxboro Drive; however, the full downgradient extents have not been delineated.

Evaluation of Existing Conditions: The overburden in the Central Zone is typically dominated by clay with variable amounts of silt and sand that increase with depth. Sand is a locally significant component of the alluvial materials. The weathered bedrock residuum is predominantly clay with silt/sand and some shale fragments near the contact. The combined thickness of the overburden ranges from 24 ft near the former Auto Wash Area to more than 70 ft in the residential area east of Foxboro Drive and north of Schilling Road. The bedrock subcrop is shale.

Historical data include 105 vadose zone soil samples from outside areas near Hangar 1 and the Auto Wash. However, only one sample, GPS-H14-012, contained TCE or CCl_4, and it contained both. The soil source may be in unsampled areas, such as inside Hangar 1 and/or the Auto Wash and two sumps.

Historical data also include 83 groundwater samples, of which 39 contained detectable concentrations of TCE and 21 contained detectable concentrations of CCl_4. The maximum detected TCE concentration was 130 µg/L, detected at 29-33 fbgl at GP-H29 (Figure 12). Boring GP-H29 is located along Foxboro Drive at the west end of a subdivision. The maximum detected CCl_4 concentration was 893 µg/L, detected at 33-37 fbgl at GPW-084 (Figure 12). Boring GPW-084 is located in the northeast corner of the first parking lot, on the west side of Arnold Ave., south of Schilling Road.

Only one monitoring well in the Central Zone (31M09) was included in the long-term monitoring program. This well was abandoned in 2012 by the Salina Airport Authority as part of a construction project. None of the six groundwater samples from this monitoring well had TCE or CCl4 concentrations that exceeded 2 µg/L.

Objectives: The three main objectives of the Central Zone investigation are:

1. Delineate the vadose zone soil source at, and around, Hangar 1 and the Auto Wash areas.
2. Delineate the groundwater plumes.
3. Investigate bedrock groundwater impact.

Planned Work: The basic strategies for the Central Zone are:

1. For delineation of the Central Zone source area, evaluate soil and groundwater quality immediately downgradient from Hangar 1, then move step-wise up- and sidegradient from the centroid of the plume, as needed.
2. For delineation of the Central Zone plume, evaluate soil and groundwater quality immediately downgradient from Hangar 1, then move step-wise down- and sidegradient from the centroid of the plume along selected transects, as needed.
3. For the bedrock groundwater investigation, install a monitoring well in the bedrock within 100 ft downgradient of most impacted groundwater observed just above the bedrock surface.

The scope of work for the Central Zone is summarized in Tables 3.2.a and 3.2.b and the following bullet points. Figure 12 shows the proposed boring locations. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The Central Zone scope of work includes:

- Negotiate access for drilling locations.
- Determine groundwater flow direction.
    - Measure groundwater elevations at existing groundwater monitoring wells.
- Delineate source areas (10 vertical profile borings to 25 fbgl; 20 to 15 fbgl).
    - Advance 12 soil borings at approximate 100-foot spacing along a north-south transect along Arnold Ave., immediately downgradient (east) of Hangar 1, the former Auto Wash Area, and former Pumphouse No. 1.
    - Continuously log geology in each soil boring.
    - Sample two worst-case soil intervals (based on field observations and measurements) from each boring.
    - Test 24 soil samples for VOCs.
    - Test eight soil samples for SVOCs and metals.
    - Collect groundwater samples from five worst-case soil locations.
        - Test samples for VOCs.
    - Move stepwise further up- and side-gradient, as needed, centered on centroid of impact from the first transect.
        - Advance remaining 18 borings, as needed, to complete source area delineation.
        - Log and sample soil as above.
        - Test 36 soil samples for VOCs.
        - Test twelve soil samples for SVOCs and metals.
        - Collect groundwater samples from five worst-case soil locations.
            - Test samples for VOCs.
- Delineate groundwater plume (35 vertical profile borings to 60 fbgl).
    - Advance six direct-push borings at approximately 200- to 300-foot spacing in transects approximately 400 ft downgradient (east), centered on the centroid of impact indicated along Arnold Ave.
    - Continuously log geology in each soil boring.
    - Sample groundwater in each boring at three depths depending on permeable zones.
    - Test groundwater samples for VOCs
    - Add direct-push borings and groundwater samples, as needed, to complete delineation of plume width.
    - Advance direct-push borings at approximately 200-foot spacing in transects oriented perpendicular to the groundwater flow direction; centered on the centroid of impact; and located approximately 1,600 ft (five borings), 2,800 ft (four borings), and 3,300 ft (three borings) downgradient (northeast) of first transect (see Figure 12).
    - Continuously log geology in each soil boring.
    - Sample groundwater in each boring at three depths, depending on permeable zones.
    - Test groundwater samples for VOCs.

- Add direct-push borings and groundwater samples down- and side-gradient, as needed, to complete and/or refine delineation of plume length and width.
    - Log, sample, and test groundwater as above.
- Collect ten soil samples from the saturated zone
    - Test for f_{oc}.

- Permanent groundwater monitoring wells:
    - Install 35 monitoring wells in 14 well nests for long-term groundwater monitoring based on data from plume delineation.
        - seven 3-well clusters: 30, 50, and 70 fbgl
        - seven 2-well clusters: 30 and 50 fbgl
    - Collect 35 groundwater samples.
        - Test all groundwater samples for VOCs.
        - Test 20% of groundwater samples for NA parameters.

- Investigate bedrock groundwater quality.
    - Install one bedrock monitoring well if groundwater impact extends to bedrock.
    - Use double-casing, if warranted.
    - Move approximately100 ft downgradient of most impacted overburden groundwater.
    - Assume a boring to 40 fbgl.
    - Log boring.
    - Collect and test one groundwater sample for VOCs.

- Perform laboratory analysis using a fixed-base laboratory.

- Evaluate groundwater quality at two building sumps. The sump in the Schwan's Welcome Center is labeled "Sump B" in Figure 12 and is just southwest of Jumper and Centennial. The sump in the Kansas State University Gymnasium building (Sump A) is shown on Figure 12 (about 1,000 ft east and 100 ft south of former Pumphouse No. 1).
    - Collect and test two sump samples for VOCs.

- Survey soil boring and monitoring well locations and elevations. The survey will be performed by a licensed surveyor.

Table 3.2.a Task 3.2 Borings/Monitoring Well Details – Central Zone

Number of Borings	Soil Boring /Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
10	Direct push	Overburden	Yes	25	0	Hangar 1 and Auto Wash	2	1
20	Direct push	Overburden	Yes	15	0	Hangar 1 and Auto Wash	2	0
35	Direct push	Overburden	Yes	60	0	Groundwater plume	10 total for f_{oc}	3
14	HSA or sonic	Overburden	No	30	14/MW	Groundwater plume	0	1
14	HSA or sonic	Overburden	No	50	14/MW	Groundwater plume	0	1
7	HSA or sonic	Overburden	No	70	7/MW	Groundwater plume	0	1
1	Sonic	Bedrock	Yes	40	1/MW	Groundwater plume	0	1

Table 3.2.b Task 3.2 Samples and Analyses – Central Zone

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	60	Greatest PID, visual observation	VOCs	Fixed	Expedited
	20		SVOCs, metals		
	10	Saturated zone	f_{OC}		
Groundwater-overburden	105	Vertical profile	VOCs	Mobile	Expedited
Groundwater-overburden	35	Permanent wells	VOCs	Fixed	Standard
	7		NA parameters		
Groundwater-bedrock	1	Screened in bedrock	VOCs	Fixed	Standard
Sumps	2	Grab	VOCs	Fixed	Standard
Metals = Target Analyte List metals, 23 metals including: Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Tl, V, Zn.					

Anticipated Schedule: Dragun anticipates that the field work for the Central Zone will begin during the fall 2014 and will take approximately 59 days.

Table 3.2.c Task 3.2 Schedule – Central Zone

Activity	Duration (days)	Other
Overburden drilling and soil sampling (Hangar 1 and Auto Wash)	4-5	
Overburden drilling and groundwater sampling (Groundwater Plume):	25-35	
Bedrock drilling (Groundwater Plume)	1-2	
Monitoring well installation (Groundwater Plume)	6	
Sampling of groundwater monitoring wells (Groundwater plume)	8	
Sampling of sumps	1	
Survey	2	
Standard TAT laboratory analysis	7-10	working days

3.3 South Zone

The South Zone groundwater plumes are located in the southern part of OU2 (Figures 4, 5, and 13). The plume, which originates from the former Fire Training Burn Area, contains TCE, carbon tetrachloride, and associated degradation products and is migrating toward the northeast. The plume extends at least 3,000 ft to the northeast of the source; however, the full extent of the plume has not yet been delineated.

Evaluation of Existing Conditions: The overburden consists predominantly of clay and silt that extends to bedrock, which is shale. Sandy soil occurs in some locations just above the bedrock. The overburden thickness ranges between about 19 to 35 ft. The water table is at depths from approximately 17 to 27 fbgl.

Historical data from the fire training burn area include 208 vadose zone soil samples, of which 52 contained TCE (maximum of 540 µg/kg at S-263 at 9 – 11 fbgl). The impacted soils are predominantly at the south and east sides of the former Fire Training Burn Area.

Historical data from the South Zone plume also include 15 groundwater samples, of which six contained detectable concentrations of TCE. The maximum detected concentration was 453 µg/L detected at GPW-087 (Figure 13) from a depth of 17 - 22 fbgl. GPW-087 is located near the center of the former Fire Training Burn Area

Between April 2004 and October 2009, 46 groundwater samples were collected from seven monitoring wells in the long-term monitoring well network. The highest TCE concentration observed in groundwater in the long-term monitoring network was 170 µg/L at WSMW04 (approximately 750 ft west of Centennial Road along the southern perimeter of the former SAFB) on October 6, 2008. The highest CCl_4 concentration observed in groundwater in the long-term monitoring network was 190 µg/L at 07M01 (near the west end of Wall Street, west of Scanlon Avenue) on April 8, 2008.

During 2011, Geoprobe obtained soil and groundwater data on the west side of their building on Wall Street to calibrate MIP/HPT logging. Geoprobe reported TCE and CCl_4 in soil as high as 5,480 µg/kg and 13,000 µg/kg, respectively, at 36 fbgl at WS07, about midway north and south on the west side of the Geoprobe building (Figure 13). Geoprobe also reported TCE and CCl_4 concentrations of 19,500 and 48,700 µg/L between 34 and 36 fbgl in groundwater at this location. The soil and groundwater concentrations reported by Geoprobe are much higher than those reported previously in the OU2 south zone.

Objectives: The three main objectives of the South Zone investigation are:

1. Delineate the VOC plume(s).
2. Determine hydraulic conductivity of the overburden water bearing zones using single well tests (slug tests).
3. Evaluate groundwater chemistry versus time.

Planned Work: The basic strategies for the South Zone are:

1. For delineation of the South Zone plume, evaluate groundwater quality immediately downgradient from the former Fire Training Burn Area, then move step-wise down- and side-gradient from the centroid of the plume along selected transects, as needed.

2. For the bedrock groundwater investigation, install two monitoring wells in the bedrock within 100 ft downgradient of most impacted groundwater observed just above the bedrock surface.

The scope of work in the South Zone is summarized in Tables 3.3.a and 3.3.b and the following bullet points. Figure 13 shows the proposed boring locations. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The South Zone scope of work includes:

- Negotiate access for drilling locations
- Determine groundwater flow direction
    - Measure groundwater elevations at existing groundwater monitoring wells.
- Delineate the groundwater plume (30 vertical profile borings to 60 fbgl)
    - Advance five soil borings at approximately 200-foot spacing along transect immediately downgradient (east) of the former Fire Training Burn Area.
    - Continuously log geology in each soil boring.
    - Sample groundwater in each boring at up to three depths, depending on permeable zones.
    - Test groundwater samples for VOCs.

- Add side-gradient direct-push borings and groundwater samples, as needed, to complete delineation of plume width.
- Move approximately 800 ft downgradient (northeast) of the centroid of impact observed on the first transect.
- Advance six direct-push borings at approximately 200 foot spacing in transect oriented perpendicular to groundwater flow direction and centered on centroid of impact from the previous transect.
- Continuously log geology in each soil boring.
- Sample groundwater in each boring at three depths, depending on permeable zones.
- Test groundwater samples for VOCs.
- Add direct-push borings and groundwater samples, as needed, to complete and/or refine delineation of plume width.
    - Log, sample, and test groundwater samples as above.
- Move approximately 1,400 ft downgradient of the centroid of impact observed on the first transect.
- Advance five direct-push borings at approximately 200-foot spacing in transect along Scanlon Road and centered on centroid of impact from the previous transect.
- Continuously log geology in each soil boring.
- Sample groundwater in each boring at three depths, depending on permeable zones.
- Test groundwater samples for VOCs.
- Add direct-push borings and groundwater samples, as needed, to complete and/or refine delineation of plume width.
    - Log, sample, and test groundwater samples as above.
- Move approximately 2,800 ft downgradient of the centroid of impact observed on the first transect.
- Advance six direct-push borings at approximately 300-foot spacing in transect along Centennial Road and centered on centroid of impact from the previous transect.
- Continuously log geology in each soil boring.
- Sample groundwater in each boring at three depths, depending on permeable zones.
- Test groundwater samples for VOCs.
- Add direct-push borings and groundwater samples, as needed, to complete and/or refine delineation of plume length and width.
    - Log, sample, and test groundwater samples as above.
- Collect three soil samples from saturated zone
    - Test for f_{oc}.

- Permanent groundwater monitoring wells:
    - Install 18 monitoring wells in seven well nests for long-term groundwater monitoring based on data from above.
        - Four 3-well clusters: approximately 30, 50, and 70 fbgl.
        - Three 2-well clusters: approximately 30 and 50 fbgl.
    - Collect 18 groundwater samples.
        - Test all groundwater samples for VOCs.
        - Test 20% of groundwater samples for NA parameters.

- Investigate bedrock groundwater quality.
  - Install two bedrock monitoring wells if groundwater impact extends to bedrock.
  - Use double-casing, if warranted.
  - Move approximately100 ft downgradient of most impacted overburden groundwater.
  - Assume borings to 50 fbgl.
  - Log borings.
  - Collect and test two groundwater samples for VOCs.
- Perform laboratory analysis using a fixed-base laboratory.
- Determine hydraulic conductivity of the overburden water bearing zones using single well (slug) tests.
  - Test three locations along centerline of plume.
- Survey soil boring and monitoring well locations and elevations. The survey will be performed by a licensed surveyor

Table 3.3.a Task 3.3 Soil Borings and Monitoring Well Details – South Zone

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
30	Direct Push	Overburden	Yes	60	0	Groundwater plume definition	3 total	3
7	HSA or sonic	Overburden	No	30	7/MW	Groundwater plume definition	0	1
7	HSA or sonic	Overburden	No	50	7/MW	Groundwater plume definition	0	1
4	HSA or sonic	Overburden	No	70	4/MW	Groundwater plume definition	0	1
2	Sonic	Bedrock	Yes	50	2/MW	Groundwater plume definition	0	1

Table 3.3.b Task 3.3 Samples and Analyses – South Zone

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	3	Vertical profile	f_{OC}	Fixed	Standard
Groundwater-overburden	90	Vertical profile	VOCs	Mobile	Expedited
Groundwater-overburden	18	Permanent wells	VOCs	Fixed	Standard
Groundwater-overburden	4	Permanent wells	NA parameters	Fixed	Standard
Groundwater-bedrock	2	Permanent wells	VOCs	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for the South Zone will begin during the late 2014 and will take approximately 45 days.

Table 3.3.c Task 3.3 Schedule – South Zone

Activity	Duration (days)	Other
Overburden drilling and groundwater and soil sampling (30 vertical profile borings)	30	
Overburden drilling (install 7 monitoring well nests (18 wells total)	4-5	
Bedrock drilling (2 monitoring wells)	2-3	
Sampling of 20 permanent (18 overburden and 2 bedrock) groundwater monitoring wells	3-4	
Single well tests	1	
Survey	2	
Standard TAT laboratory analysis	7-10	working days

3.4 OU 2-wide Previously Investigated Area Borings

The most recent soil chemistry data are from 1997 in the North Zone, 2003 in the Central Zone, and 2011 in the South Zone. The main purpose of this task is to determine current soil quality conditions at previously investigated locations in OU2 that were adequately characterized, according to Burns and McDonnell (2007c).

Evaluation of Existing Conditions: Little is known about the subsurface conditions in OU2, other than: groundwater flow in the overburden is generally to the east and northeast; the overburden consists predominantly of clay and silt that extend to bedrock; the bedrock is shale; and the overburden becomes thicker to the east.

Objectives: The main objective of this task is to evaluate current soil quality conditions at the worst-case locations of previously investigated areas in OU2.

Planned Work: The basic strategy for Task 3.4 is to re-evaluate soil quality at areas that were not previously considered to be source areas. Table 3.4.a summarizes the proposed soil sampling and the rationale.

The scope of work for this task is summarized in Tables 3.4.b and 3.4.c and the following bullet points. Figures 11-13 show the areas considered for this task. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

Table 3.4.a Task 3.4 Proposed Sampling Locations and Rationale – OU2 Wide

Zone	Proposed Soil Boring Location	Rationale
North	Two locations between southeast corner of base Engineering Area and Centennial Ditch	• Elevated TCE concentration in groundwater at GPW-H28 at 42 fbgl (130 J µg/L) • Approximate groundwater flow is west to east in this area • Only surface soil samples for approximately 1,500 ft upgradient of GPW-H28 • Closest upgradient groundwater sample approximately 800 ft
North	25-50 ft southwest of GPW-95 in Hobby Auto & Photographic Shops Area	• Elevated TCE concentration at GPW-095 at 17-21 fbgl (14 µg/L) • Groundwater flow to northeast • Low level TCE in soil upgradient • Determine source
North	~100 ft southwest of 06M31near 06B30	• Elevated TCE concentration at 06M31 (up to 28 µg/L, screen bottom at 21 fbgl) • Groundwater flow to northeast • Resample 06B30 location
Central	At former location of 31M09	• 144 µg/L TCE in 2006, screen bottom at 19 fbgl • Only one other sample at 1 µg/L • Determine current conditions
Central	Southwest corner of former Base Photographic Laboratory	• Upgradient side of CCl_4 plume • Groundwater flow to east-northeast • Determine current conditions
Central	~100 ft west –southwest of 24B03 in Solvent Detect Area	• Elevated TCE in groundwater (30 µg/L) at 24B03 at 15-19 fbgl • Groundwater flow to east-northeast • Determine current conditions, source
South	At S-270 near Fire Training Burn Area	• Elevated TCE in soil: 47 µg/kg at 1-3 fbgl;180 µg/kg at 9-11 fbgl • Groundwater flow to north-northeast • Outside mapped source area • Determine current conditions, delineate source
South	At S-263 near Fire Training Burn Area	• Elevated TCE in soil: 55 µg/kg at 1-3 fbgl; 540 µg/kg at 9-11 fbgl • Groundwater flow to north-northeast • Outside mapped source area • Determine current conditions, delineate source
South	At S-220 in Fire Training Burn Area	• Elevated TCE in soil: 27.1 µg/kg at 1-3 fbgl; 445 µg/kg at 9-11 fbgl • Groundwater flow to north-northeast • Inside mapped source area • Determine current conditions

The OU2 Wide scope of work will include:

- Advance 10 direct-push soil borings to 30 fbgl at locations discussed above.
  - Continuously log geology in each soil boring.
  - Sample worst-case soil (based on field observations and measurements) from each boring.
  - Test soil samples for VOCs.
- Perform laboratory analysis using a fixed-base laboratory.
- Survey the soil boring locations and elevations. The survey will be performed by a licensed surveyor.

Table 3.4.b Task 3.4 Borings/Monitoring Wells – OU2 Wide

Number of Borings	Soil Boring /Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Soil Samples per Location	# GW Samples per Location
10	Direct Push	Soil	Yes	30	0	Current conditions at previously investigated location	1	0

Table 3.4.c Task 3.4 Samples & Analyses – OU2 Wide

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	10	Worst-case depth	VOCs	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for this task will begin during the late 2014 and will take approximately four days.

Table 3.4.d Task 3.4 Schedule – OU2 Wide

Activity	Duration (days)	Other
Overburden drilling (10 soil borings)	2-3	
Survey	0.5	
Standard TAT laboratory analysis	7-10	working days

3.5 Aquifer Testing

There has been no previous aquifer testing conducted in OU2.

Evaluation of Existing Conditions: The known chemicals of concern are chlorinated VOCs. The hydrogeology and the distributions of VOCs in soil and groundwater in OU2 are largely unknown; however, historical data indicate that VOC plumes in the Central and South Zones are extensive.

Objectives: The three main objectives of the aquifer testing are to:

- Determine the hydraulic parameters of the aquifer.
- Evaluate the potential for controlling/remediating VOC plumes in OU2 using groundwater pump and treat.
- Evaluate hydraulic connections between permeable zones.

Planned Work: The scope of work is summarized in Tables 3.5.a and 3.5.b and the following bullet points. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for OU2 Aquifer Testing includes:

- Negotiate access for drilling locations
- The exact location(s) for aquifer testing will be selected after plume delineation in the Central Zone is completed.
    - Locate aquifer test pumping well outside, but adjacent to, a plume to minimize water treatment or disposal costs.
        - Test groundwater at pumping and observation wells prior to aquifer test.
        - Also test pumped groundwater for VOCs during test with 2 hour turnaround time.
- Install wells.
    - Assume pumping well screen at approximately 70 fbgl.
    - Assume 4 piezometers, at least two screened same depth as pumping well (for aquifer parameter evaluation).
- Aquifer test:
    - Determine static groundwater elevations at wells and within 1,000 ft.
    - Set up equipment and testing.
    - Perform step test (assume six hours).
        - Determine which observation wells respond.
        - Determine the aquifer test pumping rate. Use at least three different pumping rates. Change rates when stabilization occurs (less than 0.02 feet change in drawdown over 10 minutes) or two hours, whichever is less.
    - Perform 24 to 48-hour aquifer test (assess confined/unconfined conditions).
        - Use pumping rate determined from step test.
        - Observe drawdown in observation and pumping wells, at least until stabilization (less than 0.02 feet change in drawdown over 10 minutes), using intervals noted in SOPs.
        - Observe drawdown in surrounding monitoring wells periodically.
        - Monitor field chemistry during the test. Monitor VOCs at beginning, middle, and end of test.

- If necessary, temporarily store water for treatment. Discharge or dispose of pumped water.
- Perform recovery test (assume six hours).
- Remove equipment.

Table 3.5.a Task 3.5 Borings/Monitoring Wells – OU2 Aquifer Test

Number of Borings	Soil Boring /Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Soil Samples per Location	# GW Samples per Location
4	HSA or sonic	Overburden	Yes	70	4/piezometers	Aquifer test	0	1
1	Sonic	Overburden	Yes	70	1/pumping well 4-6”	Aquifer test	0	5

Table 3.5.b Task 3.5 Samples & Analyses – OU2 Aquifer Test

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Groundwater	9	Evaluate groundwater to be pumped and water pumped during test	VOC	10 mobile, 1 fixed	2 hour mobile, standard fixed.

Anticipated Schedule: Dragun anticipates that the field work for the aquifer test will begin after the plume delineation work, in late 2014 or early 2015, and will take approximately nine days.

Table 3.5.c Task 3.5 Schedule – OU2 Aquifer Test

Activity	Duration (days)	Other
Pumping well and piezometer installation	2-3	
Aquifer test	4-5	
Survey	0.5	
Mobile Lab TAT	-	2 hours
Standard TAT laboratory analysis	7-10	working days

3.6 Surface Water and Sediment Sampling

Surface water run-off in OU2 is primarily through swales toward Juniper Ditch and Ordinance Ditch. Juniper Ditch is located along the south side of Juniper Road. Ordinance Ditch is an east flowing ditch located between Bailey Road and Wall Street. Both Juniper and Ordinance Ditch discharge to Centennial Ditch, which flows northward adjacent to the eastern boundary of OU2.

Historical surface water and sediment sampling has been performed in the North, Central, and South Zones. Seven surface water and 21 sediment samples have been obtained from the ditches; however, none contained detectable concentrations of TCE.

Ten surface water and ten sediment samples are proposed. Specific locations for sampling will be selected in consultation with KDHE following completion of the soil and groundwater investigations in OU2.

Evaluation of Existing Conditions: Flow in the ditches is intermittent.

Objectives: The main objective of the surface water and sediment sampling is to investigate current conditions of surface water and sediment impacts.

Planned Work: The basic strategy for this task is to sample surface water and sediment upgradient and downgradient of locations where surface water bodies are above groundwater plumes. Dragun will evaluate potential sediment sampling locations and avoid sampling in areas where scour or recent deposition is observed.

- Negotiate access.
- Select locations, and mark with stake for potential future monitoring
- Evaluate surface water and sediment.
    - Sample surface water and sediment at 10 sample pair locations.
    - Test water and sediment for VOCs, SVOCs, and metals.
- Survey elevation and location of surface water and sediment sampling points.

Table 3.6.a Task 3.6 Sampling Locations – OU2 Surface Water and Sediment Sampling

Number of Samples	Method	Stratum	Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Sediment Samples per Location	# Surface Water Samples per Location
10	Dipper	Surface water	NA	0.5-1	0	Prior sampling data, at the confluence of creeks, plume areas	0	1
10	Slide Hammer	Sediment	NA	0-1	0	Prior sampling data, at the confluence of creeks, plume areas	1	0

Table 3.6.b Task 3.6 Samples & Analyses – OU2 Surface Water and Sediment Sampling

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Surface water	10	Top of water/sediment column	VOCs, SVOCs, metals	Fixed	Standard
Sediment	10				

Anticipated Schedule: Dragun anticipates that the field work for the surface water and sampling will begin after the plume delineation work, in late 2014, and will take approximately three days.

Table 3.6.c Task 3.6 Schedule – OU2 Surface Water and Sediment Sampling

Activity	Duration (days)	Other
Surface water and sediment sampling	1-2	
Survey	1	
Standard TAT laboratory analysis	7-10	working days

3.7 Investigation of Vapor Intrusion to Indoor Air

Dragun previously provided KDHE with a final work plan for investigation of vapor intrusion to indoor air at 12 building locations in OU1 (Dragun, 2013e). Dragun will use the same investigation approach in OU2; however, we will not select test locations until the OU2 source and plume delineations are complete.

3.8 Data Validation/QCSR

The data quality objectives for the OU2 investigation of this project are detailed in the Final QAPP (Dragun, 2013c). Upon receipt of each laboratory data report, Dragun will review the data and the associated quality assurance/quality control to verify that the data quality objectives have been met. A Quality Control Summary Report (QCSR) will be prepared at the completion of the OU2 investigation to summarize the results of the comparison to the data quality objectives.

4.0 OU3 FIELD INVESTIGATIONS

4.1 Landfill #1

Landfill #1 is located in the southeastern part of OU3 (Figures 4, 5, and 14). Figure 14 shows the approximate boundaries of the landfill based on historic air photographs. Previous reports (SEC Donahue Environment and Infrastructure, 1993 and Burns and McDonnell, 2007b) indicate that Landfill #1 was used between about 1946 and 1961.

Little is known about the soil and groundwater quality in OU3. VOCs, SVOCs, and metals have been detected in groundwater around Landfill #1 during previous investigations. Details of these

investigations can be found in Burns and McDonnell (2007b). At Landfill #1, the only groundwater quality data collected since 2006 were part of the USACE long-term monitoring program.

Evaluation of Existing Conditions: The overburden consists predominantly of clay and silt that extends to bedrock, which is shale. The overburden thickness ranges from 1 to 30 ft, and the depth to the water table ranges from 3 to 16 fbgl. The groundwater flow in this area is generally to the northeast.

Data from historic investigations in the Landfill #1 area include ten vadose zone soil samples, ten surface soil samples, 18 groundwater samples, seven sediment samples, and five surface water samples. In addition, groundwater samples were collected from the four existing monitoring wells around Landfill #1 between 2006 to 2010 as part of the USACE long-term monitoring program. These samples were tested for the following chemicals:

- Soil: VOCs, SVOCs, metals, pesticides, herbicides, polychlorinated biphenyl (PCBs), and dioxins.
- Sediment: VOCs, SVOCs, metals, pesticides, herbicides, PCBs, dioxins, and explosives.
- Surface water: SVOCs, metals, pesticides, and herbicides.
- Groundwater: VOCs, SVOCs, metals, pesticides, and herbicides.

Based on these historic investigations, the contaminants of concern in groundwater are TCE and 1,2-dichloroethane (1,2-DCA). The maximum concentration of TCE was 50 µg/L, detected at GPW-062, which is near the northern end of the landfill (Figure 14) from a depth of 28 - 32 fbgl. The maximum concentration of 1,2-DCA was 32 µg/L, detected at monitoring well 01M17, which is at the northern end of the landfill (Figure 14).

Objectives: The three main objectives of Task 4.1 are to:

- Evaluate groundwater quality around the landfill.
- Investigate landfill cap characteristics.
- Evaluate groundwater chemistry versus time.

Planned Work: The basic strategies for Landfill #1 are:

1. For delineation of impacted groundwater around Landfill #1, collect groundwater samples using direct-push equipment to: (a) evaluate groundwater quality immediately downgradient (assumed east and northeast) from Landfill #1; (b) evaluate groundwater quality immediately downgradient (east side) of former Special Weapons Area (upgradient of Landfill #1), then (c) move step-wise down- and side-gradient from the centroid of the impacted groundwater, as needed, to delineate the impacted groundwater.

2. For evaluation of the Landfill #1 cap characteristics, evaluate cap extent, soil composition, and hydraulic conductivity via shallow direct-push soil borings distributed across, and around, the landfill.
3. For the long-term groundwater quality investigation, install monitoring wells based on the results from the temporary monitoring wells.

The scope of work in Task 4.1 is summarized in Tables 4.1.a and 4.1.b and in the following bullet points. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for OU3 Landfill #1 includes:

- Negotiate access for drilling locations.
- Determine groundwater flow direction.
    - Measure groundwater elevations at four existing groundwater monitoring wells.
- Delineate groundwater impact northeast of landfill (25 vertical profile borings to 20 fbgl).
    - Advance 17 soil borings at approximately 200-foot spacing along downgradient side of landfill.
    - Continuously log geology in each soil boring.
    - Collect two saturated soil samples for f_{oc} test.
    - Collect groundwater from each boring.
        - Assume approximately 20% groundwater samples by direct-push equipment and approximately 80% requiring temporary wells (piezometers).
    - Test all groundwater samples for VOCs, SVOCs, and metals.
    - Add eight direct-push borings and collect groundwater samples, as needed, to complete delineation of impacted groundwater downgradient from Landfill #1.
        - One of these locations may be used between GPW-062 and 01M17, where groundwater impact has historically been identified, if these data indicate this is the most problematic area.
- Evaluate groundwater impact south and west of landfill (20 vertical profile borings to 30 fbgl).
    - Advance 11 soil borings at approximately 200-foot spacing along the downgradient side of the former Special Weapons Storage Area.
    - Continuously log geology in each soil boring.
    - Collect groundwater from each boring.
        - Assume approximately 20% groundwater samples by direct-push equipment and approximately 80% requiring temporary wells.
    - Test all groundwater samples for VOCs, SVOCs, and metals.
    - Add nine direct-push borings and collect groundwater samples, as needed, to complete delineation of impacted groundwater downgradient from the former Special Weapons Storage Area.

- Investigate landfill cap (20 shallow soil borings).
    - Advance 14 soil borings distributed over the landfill surface to the top of refuse or 4 fbgl maximum (whichever is less).
    - Continuously log geology in each soil boring.
    - Collect eight cap soil samples for hydraulic conductivity testing.
    - Advance 6 soil borings to maximum 8 fbgl to confirm lateral extent of landfill.
    - Continuously log geology in each soil boring.
- Permanent groundwater monitoring wells located for evaluating groundwater flow direction and representative groundwater quality:
    - Install four permanent monitoring wells northeast of landfill to 30 fbgl.
    - Install three permanent monitoring wells south and west of landfill to 30 fbgl.
        - Install one permanent bedrock monitoring well to 50 fbgl if groundwater impact extends to bedrock; Double case, if necessary.
    - Collect eight groundwater samples.
        - Test all groundwater samples for VOCs, SVOCs, and metals.
- Perform laboratory analysis using a fixed-base laboratory.
- Survey soil boring and monitoring well locations and elevations. The survey will be performed by a licensed surveyor.

Table 4.1.a Task 4.1 Soil Borings and Monitoring Well Details – OU3 Landfill #1

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples	Number of GW Samples per Location
25	Direct Push	Overburden	Yes	20	TW in 20 locations	Groundwater plume definition	2 total	1
20	Direct Push	Overburden	Yes	30	TW in 16 locations	Groundwater plume definition	0	1
14	Direct Push	Landfill cap	Yes	4	0	Cap investigation	8 total	0
6	Direct Push	Landfill cap	Yes	8	0	Cap investigation	0	0
7	HSA or sonic	Overburden	Yes	30	7/MW	Groundwater plume definition	0	1
1	Sonic	Bedrock	Yes	50	1/MW	Groundwater plume definition	0	1

Table 4.1.b Task 4.1 Samples and Analyses – OU3 Landfill #1

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil-overburden	2	Saturated zone	f_{oc}	Fixed	Standard
Soil-landfill cap	8	Within cap	hydraulic conductivity	Fixed	Standard
Groundwater-overburden	45	Vertical profile	VOCs, SVOCs, and metals,	Mobile or Fixed	Expedited
Groundwater-overburden	7	Permanent wells	VOCs, SVOCs, and metals	Fixed	Standard
Groundwater-bedrock	1	Permanent wells	VOCs, SVOCs, and metals	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for Task 4.1 will begin in late 2014 and will take approximately 23 days.

Table 4.1.c Task 4.1 Schedule – OU3 Landfill #1

Activity	Duration (days)	Other
Overburden drilling, soil sampling, and groundwater sampling (45 borings)	10-12	
Overburden drilling (install 7 monitoring wells)	3-4	
Bedrock drilling (1 monitoring well)	1	
Cap investigation and soil sampling	2	
Sampling of 8 permanent (7 overburden and 1 bedrock) groundwater monitoring wells	1-2	
Survey	2	
Standard TAT laboratory analysis	7-10	working days

4.2 Landfill #3

Landfill #3 is located in the western part of OU3 (Figures 4, 5 and 15). Figure 15 shows the approximate boundaries of the landfill based on historic air photographs. Previous reports (Rust Environment and Infrastructure, 1996 and Burns and McDonnell, 2007b) indicate that Landfill #3 was used between approximately 1961 and 1966.

Little is known about the soil and groundwater quality in OU3. VOCs, SVOCs, and metals have been detected in groundwater around Landfill #3 during previous investigations. Details of these investigations can be found in Burns and McDonnell (2007b). In addition, the Public Entities conducted an investigation on the west side of Landfill #3 in 2010 (Dragun, 2010b). Furthermore, groundwater quality data have been collected during the USACE long-term monitoring program from 2006 to 2010.

Evaluation of Existing Conditions: The overburden consists predominantly of clay and silt with some sand that extends to bedrock, which is shale. The overburden thickness ranges from

7 to 35 ft and the depth to the water table ranges from 5 to 20 fbgl. The groundwater flow in this area is generally to the north and northwest.

Surface water drains northward on both the east and west sides of Landfill #3. A pond on the west side of Landfill #3 (evident in historic air photographs) was drained by Salina Airport Authority in 2011.

Data from historic investigations in the Landfill #3 area include two vadose zone soil samples, 26 surface soil samples, 49 groundwater samples, 16 sediment samples, and 12 surface water samples. In addition, groundwater samples were collected from eight monitoring wells around Landfill #3 as part of the USACE long-term monitoring program from 2006 to 2010. Samples were tested for the following chemicals:

- Soil: VOCs, SVOCs, metals, pesticides, herbicides, PCBs, and dioxins.
- Sediment: VOCs, SVOCs, metals, pesticides, and herbicides.
- Surface water: VOCs, SVOCs, metals, pesticides, and herbicides.
- Groundwater: VOCs, SVOCs, metals, pesticides, and herbicides.

Based on these historic investigations, the contaminants of concern in groundwater are: perchloroethene (PCE), TCE, carbon tetrachloride, 1,1,2,2-tetrachloroethane, chloroform, bis(2-ethylhexyl)phthalate, antimony, and arsenic.

Objectives: The three main objectives of Task 4.2 are to:

- Delineate the groundwater plume.
- Investigate landfill cap characteristics.
- Evaluate groundwater chemistry versus time.

Planned Work: The basic strategies for Landfill #3 are:

1. For delineation of impacted groundwater around Landfill #3, collect groundwater samples using direct-push equipment to: (a) evaluate groundwater north and northeast from Landfill #3 (b) evaluate groundwater quality west of Landfill #3, and (c) then move step-wise down- and side-gradient from the centroid of the impacted groundwater, as needed, to complete delineation.
2. For evaluation of the Landfill #3 cap characteristics, evaluate cap extent, soil composition, and hydraulic conductivity via shallow direct-push soil borings distributed across, and around, the landfill.
3. For the long-term groundwater quality investigation, install monitoring wells based on the results from the temporary monitoring wells.

The scope of work in Task 4.2 is summarized in Tables 4.2.a and 4.2.b and in the following bullet points. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The OU3 Landfill #3 scope of work includes:

- Determine groundwater flow direction.
    - Measure groundwater elevations at existing groundwater monitoring wells.
- Delineate groundwater impact northeast of landfill (30 vertical profile borings to 25 fbgl).
    - Advance 12 soil borings at approximately 200-foot spacing north and northeast side of landfill.
    - Continuously log geology in each soil boring.
    - Collect two saturated soil samples for f_{oc} test.
    - Collect groundwater from each boring.
        - Assume all require temporary wells.
    - Test all groundwater samples for VOCs, SVOCs, and metals.
    - Add 18 direct-push borings and collect groundwater samples, as needed, to complete delineation of impacted groundwater north and northeast from Landfill #3.
- Evaluate groundwater impact west of landfill (five vertical profile borings to 20 fbgl).
    - Advance three soil borings at approximately 200-foot spacing along west side of the landfill (includes one existing monitoring well in spacing determination).
    - Continuously log geology in each soil boring.
    - Collect groundwater from each boring.
        - Assume all require temporary wells.
    - Test all groundwater samples for VOCs, SVOCs, and metals.
    - Add two direct-push borings and collect groundwater samples, as needed, to complete delineation of impacted groundwater west of landfill.
- Investigate landfill cap (15 shallow soil borings).
    - Advance nine soil borings distributed over the landfill surface to the top of refuse or 4 fbgl maximum (whichever is less).
    - Continuously log geology in each soil boring.
    - Collect four cap soil samples for hydraulic conductivity testing.
    - Advance six soil borings to maximum 8 fbgl to confirm lateral extent of landfill.
    - Continuously log geology in each soil boring.
- Permanent groundwater monitoring wells located for evaluating groundwater flow direction and representative groundwater quality:
    - Install five permanent monitoring wells north and northeast of landfill to 25 fbgl.
    - Install one permanent monitoring well west of landfill to 20 fbgl.
    - Install one permanent bedrock monitoring well to 45 fbgl if groundwater impact extends to bedrock; double case, if necessary.

- Collect seven groundwater samples.
  - Test all groundwater samples for VOCs, SVOCs, and metals.

- Perform a single well test at one groundwater monitoring well along centerline of plume.
- Perform laboratory analysis using a fixed-base laboratory.
- Survey soil boring and monitoring well locations and elevations. The survey will be performed by a licensed surveyor.

Table 4.2.a Task 4.2 Soil Borings and Monitoring Well Details – OU3 Landfill #3

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples	Number of GW Samples per Location
30	Direct Push	Overburden	Yes	25	Temp PZ	Groundwater plume definition	2 total	1
5	Direct Push	Overburden	Yes	20	Temp PZ	Groundwater plume definition	0	1
9	Direct Push	Landfill cap	Yes	4	0	Cap investigation	4 total	0
6	Direct Push	Landfill cap	Yes	8	0	Cap investigation	0	0
5	HSA or sonic	Overburden	No	25	5/MW	Groundwater plume definition	0	1
1	HSA or sonic	Overburden	No	20	1/MW	Upgradient Groundwater	0	1
1	Sonic	Bedrock	No	45	1/MW	Groundwater plume definition	0	1

Table 4.2.b Task 4.2 Samples and Analyses –OU3 Landfill #3

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil-overburden	2	Saturated zone	f_{oc}	Fixed	Standard
Soil-landfill cap	4	Within cap	Hydraulic conductivity	Fixed	Standard
Groundwater-overburden	35	Vertical profile	VOCs, SVOCs, and metals	Mobile or Fixed	Expedited
Groundwater-overburden	6	Permanent wells	VOCs, SVOCs, and metals	Fixed	Standard
Groundwater-bedrock	1	Permanent wells	VOCs, SVOCs, and metals	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for Task 4.2 will begin in late 2014 and will take approximately 15 days.

Table 4.2.c Task 4.2 Schedule – OU3 Landfill #3

Activity	Duration (days)	Other
Overburden drilling, soil sampling, and groundwater sampling (35 borings)	7-9	
Overburden drilling (install 6 monitoring wells)	3	
Bedrock drilling (1 monitoring well)	1	
Cap investigation and soil sampling	1-2	
Single well test (1 monitoring well)	1	
Sampling of 7 permanent (6 overburden and 1 bedrock) groundwater monitoring wells	1	
Sampling of surface water and sediment (7 locations)	1	
Survey	2	
Standard TAT laboratory analysis	7-10	working days

4.3 Debris Landfill

The Debris Landfill is located in the northern part of OU3 (Figures 4, 5, and 16). Figure 16 shows the approximate boundaries of the landfill based on historical air photographs. Previous reports (USEPA, 1999 and Burns and McDonnell, 1996) indicate that the Debris Landfill was used between approximately 1957 and 1965.

Little is known about the soil and groundwater quality in OU3. VOCs and metals have been detected in groundwater around the Debris Landfill during previous investigations. Details of these investigations can be found in Burns and McDonnell (2007b). Groundwater quality data have been collected during the USACE long-term monitoring program from 2006 to 2010.

Evaluation of Existing Conditions: The overburden consists predominantly of silty and sandy clays to bedrock, which is shale. The overburden thickness ranges from 11 to 28 ft and the depth to the water table ranges from 3 to 10 fbgl. The groundwater flow in this area is generally to the north-northeast.

Data from historic investigations in the Debris Landfill area include 12 groundwater samples and two sediment samples. In addition, groundwater samples were collected from four monitoring wells around the Debris Landfill as part of the USACE long-term monitoring program from 2006 to 2010. Samples were tested for the following chemicals:

- Sediment: VOCs, SVOCs, and metals
- Groundwater: VOCs, SVOCs, metals, pesticides, and herbicides

Based on these historic investigations, there are no contaminants of concern in groundwater. Although 1,2-dichloroethane was detected at a concentration of 23 µg/L in monitoring well 10M12 in 1997, the only VOCs detected during subsequent sampling events were low level

detections (listed as estimated values) of 1,2,3-trichlorobenzene and hexachlorobutadiene in 2009.

Objectives: The main objective of Task 4.3 is to evaluate groundwater chemistry versus time at existing monitoring wells in the Debris Landfill area.

Planned Work: The basic strategy for the Debris Landfill is to test groundwater from existing monitoring wells to determine current groundwater quality conditions.

The scope of work in Task 4.3 is summarized in Tables 4.3.1 and 4.3.2 and in the following bullet points. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for the Debris Landfill includes:

- Determine groundwater flow direction.
    - Measure groundwater elevations at four existing groundwater monitoring wells.
- Collect four groundwater samples.
    - Test all groundwater samples for VOCs, SVOCs, and metals.
- Perform laboratory analysis using a fixed-base laboratory.
- Survey of monitoring well locations and elevations by a licensed surveyor.

Table 4.3.a Task 4.3 Soil Borings and Monitoring Well Details – Debris Landfill

Number of Borings	Soil Boring Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples	Number of GW Samples per Location
none	NA	NA	NA	NA	NA	NA	NA	NA

Table 4.3.b Task 4.3 Samples and Analyses – Debris Landfill

Type/Media	Number of Samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Groundwater-overburden	4	Permanent/Existing wells	VOCs, SVOCs, and metals	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for Task 4.3 will begin in late 2014 and will take approximately 1 day.

Table 4.3.c Task 4.3 Schedule – Debris Landfill

Activity	Duration (days)	Other
Sampling of 4 permanent groundwater monitoring wells	1	
Standard TAT laboratory analysis	7-10	working days

4.4 OU3-wide Previously Investigated Area Borings

Most of the historical data for OU3 are from investigations completed between 1996 and 2004. The main purpose of this task is to determine current conditions at previously investigated locations in OU3 for which no further investigations were required, according to Burns and McDonnell (2007b).

Evaluation of Existing Conditions: Little is known about the subsurface conditions in OU3 other than: groundwater flow in the overburden is generally to the east and northeast, the groundwater flow velocity is low, the overburden consists predominantly of clay and silt that extend to bedrock, and the bedrock is shale.

Historical soil and groundwater quality data have been collected in OU3 from the following areas, which are indicated in Figure 17:

- Landfill #1
- Buildings 1103/1104
- Radar Tube Disposal Vault and Tool Trench
- Special Weapons Storage Area
- Skeet Range #1
- Skeet Range #3
- Jet Engine Test Stand
- Landfill #3
- Debris Landfill
- Transformer Vault

Of these areas, additional investigation is planned only at Landfill #1, Landfill #3, and the Debris Landfill. The planned investigation activities at Landfill #1 will also verify previous characterization at Buildings 1103/1104, the South Radar Tube Disposal Vault area, and the Special Weapons Storage Area, which are adjacent to Landfill #1 (Figure 14).

In the remaining four areas, three soil borings will be advanced in “worst-case” locations based on historical data and soil samples tested to verify the previous characterization. Locations of the three proposed borings are shown on Figure 17. Two soil borings will be used to further delineate impacted soil, if necessary.

Objectives: The main objective of this task is to evaluate current soil quality conditions at the worst-case locations of previously investigated areas where no additional investigation is currently planned (see Figure 17).

Planned Work: The basic strategy for Task 4.4 is to re-evaluate soil quality at areas that were not previously considered to be source areas.

The scope of work for this task is summarized in Tables 4.4.a and 4.4.b and the following bullet points. Figure 17 shows the proposed boring locations. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.
The scope of work for the OU3 Wide investigation includes:

- Negotiate access for drilling locations.
- At each of the three locations:
  - Advance direct-push soil borings to 20 fbgl.
  - Continuously log geology in each soil boring.
  - Sample worst-case soil (based on field observations and measurements) from each boring.
  - Test soil samples for COCs in each AOC.
  - Advance two additional direct-push soil borings to 20 fbgl, if required, to delineate impacted soil
  - Log, sample, and test as above.
- Perform laboratory analysis using a fixed-base laboratory.
- Survey of sample locations and elevations by a licensed surveyor.

Table 4.4.a Task 4.4 Borings/Monitoring Wells – OU3 Wide

Number of Borings	Soil Boring /Drilling Method	Stratum	Borings Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Soil Samples per Location	# GW Samples per Location
5	Direct push	Soil	Yes	20	0	Current conditions at previously investigated location	1	0

Table 4.4.b Task 4.4 Samples & Analyses – OU3 Wide

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Soil	5	Worst-case depth	COCs based on previous investigations	Fixed	Standard

Anticipated Schedule: Dragun anticipates that the field work for this task will begin in late 2014 and will take approximately three days.

Table 4.4.c Task 4.4 Schedule – OU3 Wide

Activity	Duration (days)	Other
Overburden drilling (3-5 soil borings)	1-2	
Survey	0.5	
Standard TAT Laboratory analysis	7-10	working days

4.5 Surface Water and Sediment Sampling

Surface water in OU3 generally flows northward toward Deer Run Ditch, which flows northeast along the northern portion of OU3. During previous investigations, surface water and sediment samples were collected from the ditches around Landfill #1, Landfill #3, the Debris Landfill, the Special Weapons Storage Area, and the Transformer Vault for chemical testing.

The only area where surface water and sediment are concerns is near Landfill #3. Historical sediment and surface water sampling near Landfill #3 indicate VOCs (TCE and chloroform), SVOCs (bis[2-ethylhexyl]phthalate), and metals are COCs.

Evaluation of Existing Conditions: The known COCs are chlorinated VOCs. Surface water flows northward in a ditch along the west side of Landfill #3 until it meets Pheasant Ditch, which flows northwest along the east side of Landfill #3. From the confluence, Pheasant Ditch flows northward to Runway 12/30 Ditch.

Objectives: The main objective of the surface water and sediment sampling is to evaluate current conditions in surface water and sediment.

Planned Work: The basic strategy for this task is to re-sample surface water and sediment at locations where there are historical data. Six of the locations are near Landfill #3: two locations are downgradient from the landfill; two are about 300 ft upstream of the confluence of surface water bodies around the landfill; one is downstream from the confluence of the previously-mentioned surface water bodies; and one is a seep. The remaining locations will be selected following the groundwater characterization in OU3.

The scope of work for the surface water and sediment sampling is summarized in Tables 4.5.a and 4.5.b and the following bullet points. The proposed sampling points are shown in Figure 15. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for the OU3 Surface Water and Sediment Sampling includes:

- Select locations and mark with stakes for potential future monitoring. Dragun will evaluate potential sediment sampling locations and avoid sampling in areas where scour or recent deposition is observed.
- Evaluate surface water and sediment.
    - Sample surface water and sediment at 10 sample pair locations.
    - Test water and sediment for VOCs, SVOCs, and metals.
- Survey elevation and location of surface water and sediment sampling points. The survey will be performed by a licensed surveyor.

Table 4.5.a Task 4.5 Sampling Locations – OU3 Surface Water and Sediment Sampling

Number of Samples	Method	Stratum	Logged	Average Depths (fbgl)	Number and Type of Wells Installed	Location Rationale	# Sediment Samples per Location	# Surface Water Samples per Location
10	Dipper	Surface water	Yes	0.5-1	0	-	0	1
10	Slide Hammer	Sediment	Yes	0-1	0	-	1	0

Table 4.5.b Task 4.5 Samples & Analyses - OU3 Surface Water and Sediment Sampling

Type/Media	Number of samples	Depths/ Selection Rationale	Analyses	Lab (mobile or fixed)	TAT
Surface water	10	Downgradient of Landfill #3 and based on OU3 groundwater data	VOCs, SVOCs, metals	Fixed	Standard
Sediment	10				

Anticipated Schedule : Dragun anticipates that the field work for the surface water and sampling will begin after the plume delineation work, in early 2015, and will take approximately three days.

Table 4.5.c Task 4.5 Schedule - OU3 Surface Water and Sediment Sampling

Activity	Duration (days)	Other
Surface water and sediment sampling	2	
Survey	1	
Standard TAT laboratory analysis	7-10	working days

4.6 Data Validation/QCSR

The data quality objectives for this project are detailed in the Final QAPP (Dragun, 2013c). Upon receipt of each laboratory data report, Dragun will review the data and the associated quality assurance/quality control to verify that the data quality objectives have been met. At the completion of the OU3 investigation, a QCSR will be prepared to summarize the results of the comparison to the data quality objectives.

5.0 GROUNDWATER MONITORING

The long term groundwater monitoring program at the former SAFB began in July/August 2006 when 79 groundwater monitoring wells were sampled. Sampling continued through fall of 2009 with a maximum of 149 monitoring wells sampled during the spring and fall of each year and three private wells sampled during the winter and summer sampling events.

However, starting in the winter of 2010, only 23 monitoring wells were included in the sampling program. Most of these wells are near the leading edge of Plume D. Not all wells were sampled each quarter: the three private wells were sampled quarterly during the first three quarters of each year, and the remaining 20 wells were sampled each fall. This sampling continued through 2013.

5.1 1st Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR)

Dragun conducted the first quarterly monitoring event in June and July 2014 (approval from KDHE received on March 24, 2014, by email from Bob Jurgens). At the time of drafting this Work Plan, results from the groundwater monitoring event have not yet been received.

Evaluation of Existing Conditions: Figure 4 shows the 2009 groundwater flow map and the highest TCE concentrations observed in groundwater, regardless of date.

Objectives: The two main objectives of the groundwater monitoring are to (1) update groundwater flow and quality conditions in OU1, OU2, and OU3 and (2) develop base-line data to be used to evaluate the effectiveness of future remediation.

Completed Work: The basic strategy of this task is to determine current Site-wide groundwater quality conditions at existing long-term monitoring well locations prior to conducting further Site characterization.

The scope of work for this task is summarized in Tables 5.1a and 5.1.b and the following bullet points. Figure 18 shows the locations of monitoring wells currently in the long-term monitoring well network. Refer to Section 8.0 for “Details of Field Procedures” and Appendix E for the SOPs.

The scope of work for groundwater monitoring included:

- Determine current groundwater flow directions.
  - Inspect the condition of each well (approximately 123 in OU1 [120 monitoring wells and 3 private wells], 10 in OU2, and 26 in OU3).
  - Install data loggers in 10 selected monitoring wells distributed throughout the Site to obtain continuous water level data. These locations will be selected based on the results of the investigations in Sections 2.0 through 4.0. Dragun will consult with KDHE prior to implementing this work.
- Evaluate groundwater quality in OU1.
  - Collect one groundwater sample from each monitoring well.
  - Test all samples for VOCs.
  - Test 20 selected sample locations for metals.
  - Test 20% of the samples for NA parameters.
- Evaluate groundwater quality in OU2.
  - Collect one groundwater sample from each monitoring well.
  - Test all samples for VOCs.
  - Test 2 selected sample locations for metals and NA parameter.
- Evaluate groundwater quality in OU3.
  - Collect one groundwater sample from each monitoring well.
    - 23 long-term monitoring wells
    - 3 monitoring wells west of Landfill #3 (installed by Dragun in 2010)
  - Test all samples for VOCs and metals.
  - Test 20% of the samples for NA parameters.
- Perform laboratory analysis using a fixed-base laboratory.

A total of 159 wells (156 monitoring wells and 3 private wells) were planned to be sampled during the 1st Quarter Groundwater Monitoring. Eleven monitoring wells were not sampled due to access restrictions, previous well abandonment, or lack of water. Details are included in Tables 5.1.a and 5.1.b.

Table 5.1.a Task 5.1 Planned Samples and Analyses – Groundwater Monitoring

Operable Unit	Number of Samples	Analyses	Lab (mobile or fixed)	TAT
1	123	VOC	Fixed	Standard
	24	NA parameters	Field &Fixed	Standard
	20	Metals	Fixed	Standard
2	10	VOC	Fixed	Standard
	2	NA parameters	Field & Fixed	Standard
	2	Metals	Fixed	Standard
3	26	VOC	Fixed	Standard
	5	NA parameters	Field & Fixed	Standard
	26	Metals	Fixed	Standard

Table 5.1.b Task 5.1 Groundwater Samples Collected

OU1				
VOCs			Metals	Natural Attenuation
99M46A	99M26	99M50A	02W06	99M51B
02M45	99M26B	99M50B	99M08	02W06
02M46	99M26C	99M50C	99M10	99M08
02M46C	99M28	99M51A	99M13	99M10
02W05	99M28A	99M51B	99M13A	99M13
02W06	99M28C	99M51C	99M14	99M13A
02W06B	99M31	99M52A	99M23	99M14
02W06C	99M32	99M52B	99M23C	99M23
02W07	99M33	99M52C	99M26B	99M23C
02W07B	99M34	99M53A	99M26C	99M26B
02W08	99M35	99M53C	99M31	99M26C
22M12	99M37	99M53D	99M46A	99M31
99M02	99M38	99M54A	99M46C	99M46A
99M03	99M39	99M54C	99M50A	99M46C
99M04	99M40	99M55D	99M50B	99M50A
99M07	99M41A	99M56D	99M60A	99M50B
99M08	99M41B	99M57A	99M60B	99M60A
99M09	99M41C	99M57C	99M62A	99M60B
99M10	99M42A	99M58A	99M62B	99M62A
99M11	99M42B	99M58B	99M62C	99M62B
99M12	99M42C	99M58C	99M51B	99M62C
99M13	99M43A	99M59A		
99M13A	99M43B	99M59B		
99M14	99M43C	99M60A		
99M15	99M44A	99M60B		
99M15C	99M44C	99M61A		
99M17	99M45A	99M62A		
99M18	99M45B	99M62B		
99M19	99M45C	99M62C		
99M20	99M46B	99M63A		
99M21	99M46C	99M63C		
99M22	99M47A	KW-01		
99M22A	99M47B	NW02		
99M23	99M47C	NW04		
99M23C	99M48A	SAW04		
99M24RA	99M48C	SAW05		
99M24RB	99M49A	SAW07		
99M24RC	99M49C	SAW08		
99M25				

OU2				
VOCs			Metals	Natural Attenuation
WSM03	WSM05	06M30	WSM04	WSM04
WSM04	WSM06	06M31	WSM06	WSM06
		07M01		
OU3				
VOCs		Metals		Natural Attenuation
03W09	03W12	03W09	03W12	03W11
03W10	10M09	03W10	10M09	01M17
03W11	10M10	03W11	10M10	01M18
03W12	10M11	03W12	10M11	03M41
03M40	10M12	03M40	10M12	03M43
03M41	00M01	03M41	00M01	
03M42	00M03	03M42	00M03	
03M43	00M05	03M43	00M05	
03M52	00M07	03M52	00M07	
03M53	00M10	03M53	00M10	
03W09	DMW-1	03W09	DMW-1	
03W10	DMW-2	03W10	DMW-2	
03W11	DMW-3	03W11	DMW-3	

Wells Not Sampled	Rationale
31M09 (OU2)	Abandoned in 2012
99M29 (OU1)	Access not granted by property owner
99M29C (OU1)	Access not granted by property owner
99M30 (OU1)	Access not granted by property owner
PZ-01 (OU1)	Access not granted by property owner
PZ-02 (OU1)	Presumed abandoned
PZ-03 (OU1)	Presumed abandoned
PZ-04 (OU1)	Presumed abandoned
SAW02 (OU1)	No water in well
WSMW01 (OU2)	No water in well
WSMW02 (OU2)	No water in well

5.2 2nd Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR)

The next three quarterly groundwater monitoring events will commence once Tasks 2 through 4 are completed. Dragun anticipates this event in spring 2014.

Dragun will submit a separate work plan that includes this and subsequent quarterly groundwater monitoring events once the long term monitoring well network is updated.

5.3 3rd Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR)

See Task 5.2.

5.4 4th Quarter (Initial) Groundwater Monitoring (including Data Validation/QCSR)

See Task 5.2.

6.0 INVESTIGATION AND MONITORING OF GROUNDWATER/SURFACE WATER INTERACTION

TCE may impact surface water at the Site via groundwater discharge. These impacts may occur where (1) the groundwater is impacted by TCE, (2) there is an upward vertical hydraulic gradient, and (3) the water table elevation is higher than the surface water elevation. This condition may be permanent, seasonal, or episodic.

Evaluation of Existing Conditions: The locations where the above conditions may occur include where:

- Plumes A and B cross Scanlon Ditch
- Plumes C and D cross Tony's Road Ditch
- Plume D crosses Dry Creek
- Plume E crosses Dry Creek
- Plume F crosses Centennial Ditch
- Impact from Landfill #3 is adjacent to the unnamed ditch west of Landfill #3

Objective: The main objectives of this task are to determine if, where, and when TCE-impacted groundwater discharges to surface water.

Planned Work: In this scope of work, we will evaluate whether groundwater discharges to surface water at five locations. We will determine whether TCE-impacted groundwater discharges to surface water by continuously monitoring the vertical hydraulic gradient at five surface water locations for a year. If the groundwater elevation in a shallow well in a stream bed exceeds the surface water elevation, groundwater discharges.

Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

This scope of work is summarized in Table 6.1 and the following bullet points. The scope of work for determining Groundwater/Surface Water Interaction includes:

- Negotiate property access at five locations.
    - Tony's Road Ditch immediately east of Centennial Road
    - Dry Creek northeast of the former LOX plant
    - Dry Creek near 99M60

  - Centennial Road Ditch between Schilling and Summers Road
  - Unnamed ditch near Landfill #3 in OU3

- Install piezometers and staff gauges:
  - Advance a drive point piezometer into the stream bed such that the top of the screened section is at least three ft below the streambed. This piezometer will provide for measurement of the shallow groundwater elevation.
  - Drive a metal pipe into the stream bed next to the piezometer. The metal pipe will have a "screened" section just above the stream bed. This pipe will provide the surface water elevation data.
  - Survey the locations and top-of casing elevations of the piezometer and stream pipe.

- Monitor surface water and groundwater elevations:
  - Install data loggers in both the piezometer and stream pipe. Add a staff gauge to the stream pipe for visual observations of surface water elevation.
  - Continuously monitor surface water and groundwater water elevations using the data loggers.
  - Download data quarterly (minimum) for 1 year.
  - Calculate continuous vertical hydraulic gradients.
  - Manually check vertical hydraulic gradient quarterly.

- Evaluate surface water and groundwater elevation data.
  - Perform data evaluation after 1 year of quarterly data collection.

Anticipated Schedule: Dragun anticipates that the field work for the surface water / groundwater interaction investigation will begin in late 2014. Installation and surveying should take approximately two days. Subsequent monitoring of the installations will occur, at minimum, during quarterly groundwater sampling events.

Table 6.1 Task 6.0 Schedule – Groundwater/Surface Water Interaction

Activity	Duration (days)	Other
Piezometer and staff gage installation	1	
Survey	1	

7.0 MONITORING WELL MAINTENANCE, ABANDONMENT, REPLACEMENT

Since the majority of the monitoring wells at SAFB have not been inspected since the summer of 2009 (only 20 of 156 monitoring wells used for LTM have been sampled), some monitoring wells may require repair, replacement, or abandonment.

Evaluation of Existing Conditions: Dragun evaluated the condition of the monitoring well network in June 2014 to determine whether the existing wells are usable. The results of this evaluation will be included in the reporting to KDHE and the assumptions regarding scope of work and schedule below adjusted for the conditions observed in the field.

Objectives: The main objectives of Task 7.0 are to:

1. Repair damaged long term monitoring wells, when possible, and
2. Abandon, and potentially replace, damaged monitoring wells that cannot be repaired.

Planned Work: The scope of work is summarized in Tables 7.1 and 7.2 and the following bullet points. Refer to Section 8.0 for "Details of Field Procedures" and Appendix E for the SOPs.

The scope of work for Monitoring Well Maintenance, Abandonment, and Replacement includes:

- Inspect all monitoring wells during first quarterly groundwater monitoring event (see Task 5.1).
- Negotiate access for well repair and drilling locations.
- Address damaged monitoring wells.
    - Repair damaged monitoring wells, when possible, which may include replacement of:
        - Protective casings (requires driller)
        - Well casing (requires driller)
        - Well plugs
        - Locks
        - Concrete pads
    - Abandon, and potentially replace, irreparably damaged wells (assume 16 locations).
        - Replace damaged monitoring wells which Dragun and KDHE consider critical.
        - Advance replacement soil borings.
        - Install replacement monitoring wells screened at same depth intervals as originals.
- Survey repaired and/or replaced monitoring well locations and elevations. The survey will be performed by a licensed surveyor.

Table 7.1 Task 7.0 Soil Boring and Monitoring Well Details – Monitoring Wells

# of Borings	Soil Boring/ Drilling Method	Stratum	Borings Logged	Average Depth (fbgl)	Number and Type of Wells Installed	Location Rationale	Number of Soil Samples per Location	Number of GW Samples per Location
16	Direct Push	Overburden	No	30-35 (assumed)	0	Abandon damaged monitoring well	0	0
16	Direct Push	Overburden	Yes	35	16/MW	Replacement of abandoned well	0	0

Schedule: Dragun completed the inspection during June 2014. We anticipate that the field work for the monitoring well maintenance, abandonment, and replacement will begin in fall 2014 and will take approximately nine days.

Table 7.2 Task 7.0 Schedule – Monitoring Wells

Activity	Duration (days)	Other
Well repair	1	
Well Abandonment	2	
Drilling and installing replacement well	6	
Survey	0.5	Shared with other tasks

8.0 FIELD SAMPLING PLAN

As required by the state, prior to commencement of field activities, KDHE will be notified of the planned field work using the designated online KDHE Bureau of Environmental Remediation (BER) Remedial Section Field Activities Notification Form located at http://www.kdheks.gov/remedial/fieldactivities_notification.html.

This section of the work plan discusses the main field activities required to conduct this work plan and directs the reader to the appropriate SOPs for details on the methods. In general, we plan to use:

1. A KDHE SOP, if available, for a given activity.
2. If there is no appropriate KDHE SOP for a given activity, we will use a Dragun SOP.

Table 8.0 SOP Summary

Activity	KDHE SOP #	Similar Dragun SOP #	Comment
Safety	BER-18, -20, -21	1.01 to 1.06	Minimum standard KDHE SOP.
Decontamination	BER-05	2.01 to 2.04	Minimum standard KDHE SOP.
Drum sampling	BER-08	2.05 and 2.06	Minimum standard KDHE SOP.
Documentation	None	3.01 and 3.02	No KDHE SOP, use Dragun SOP.
	BER-01, -03	3.03	Minimum standard KDHE SOP.
	BER-19	3.04	Minimum standard KDHE SOP.
	BER-03	3.05	Minimum standard KDHE SOP.
	None	3.06 and 3.07	No KDHE SOP, use Dragun SOP.
Drilling hollow stem augers	None	4.01	No KDHE SOP, use Dragun SOP.
Drilling multiple casings	None	4.05	No KDHE SOP, use Dragun SOP.
Drilling arrangement	None	4.07	No KDHE SOP, use Dragun SOP.
Drilling sonic	None	4.08	No KDHE SOP, use Dragun SOP.

Activity	KDHE SOP #	Similar Dragun SOP #	Comment
Dissolved oxygen meter use (YSI Model 95)	None	5.01	No KDHE SOP, use Dragun SOP.
High density polyethylene dipper use	None	5.02	No KDHE SOP, use Dragun SOP.
Multimeter use (Myron L Ultrameter Model 6P)	None	5.03	No KDHE SOP, use Dragun SOP.
Water level meter use	None	5.07	No KDHE SOP, use Dragun SOP.
Peristaltic pump use	None	5.08	No KDHE SOP, use Dragun SOP.
Photoionization detector use (MiniRAE 2000)	BER-30	5.10	Minimum standard KDHE SOP.
Bladder pump use (Geocontrol Pro)	None	5.12	No KDHE SOP, use Dragun SOP.
GPS use	BER-32	5.16	Minimum standard KDHE SOP.
Oilscreensoil (Sudan IV) Test Kit	None	5.19	No KDHE SOP, use Dragun SOP.
Sample types-definitions	None	6.01	No KDHE SOP, use Dragun SOP.
Lab parameter choice	None	6.02	No KDHE SOP, use Dragun SOP.
QA/QC samples	BER-12	6.03	Minimum standard KDHE SOP.
Sample equipment selection	BER-01, -03	6.04	Minimum standard KDHE SOP.
Forms and checklists	None	6.05	No KDHE SOP, use Dragun SOP.
Geoprobe – Groundwater sampling	BER-01	7.01	Minimum standard KDHE SOP.
Geoprobe –VAS	None	7.02	No KDHE SOP, use Dragun SOP.
Geoprobe – soil sampling	None	7.03	No KDHE SOP, use Dragun SOP.
Well installation	BER-06, -29	8.01	Minimum standard KDHE SOP.
Temp wells	None	8.02	No KDHE SOP, use Dragun SOP.
Well development methods	None	8.03, 8.04, and 8.05	No KDHE SOP, use Dragun SOP.
Aquifer test	BER-09	8.08	Minimum standard KDHE SOP.
Monitoring well decommissioning & abandonment	None	8.09	No KDHE SOP, use Dragun SOP.
Low-flow	BER-01	9.01	Minimum standard KDHE SOP except for: (1) use Waterra pump in temporary one-inch diameters wells, (2) use bladder pump in two-inch diameter wells, and if necessary, (3) use peristaltic pump using KDHE approved method or (4) bailer for low yield formations.
VOC-SVOC sampling in Groundwater	BER-01	9.02	
Metals sampling in Groundwater	BER-01	9.03	
General chemistry readings	BER-01, -26	9.04	
Groundwater sampling from a residential well	None	9.05	No KDHE SOP, use Dragun SOP.
VAS in groundwater	None	9.07	No KDHE SOP, use Dragun SOP.
Soil sampling using hand auger	BER-03,- 04	10.02	Minimum standard KDHE SOP.
Soil sampling VOCs	BER-03, -06, -07	10.05	Minimum standard KDHE SOP.
Soil sampling non-VOCs	BER-03, -06, -07	10.06	Minimum standard KDHE SOP.
VOC sampling from surface water	BER-02	11.01	Minimum standard KDHE SOP.
Soil classification	None	13.01	No KDHE SOP, use Dragun SOP.
Rock classification	None	13.02	No KDHE SOP, use Dragun SOP.
Evaluation and validation of data	BER-11	6.06 and 15.01	Minimum standard KDHE SOP.
Conducting on-site Reviews of field sampling activities	BER-24	None	Minimum standard KDHE SOP.

Activity	KDHE SOP #	Similar Dragun SOP #	Comment
Mobile laboratory use	BER-25	None	Minimum standard KDHE SOP.
Acquisition of location data using GPS general practice	BER-32	3.06 and 5.16	Minimum standard KDHE SOP.
Water level, product, and well depth measurements	BER-36	8.06	Minimum standard KDHE SOP.
Geoprobe Hydraulic Profiling Tool	None	None	GEOPROBE® - Hydraulic Profiling Tool (HPT) System, Standard Operating Procedure, Technical Bulletin No. MK3137, Prepared February 6, 2013

This section is arranged in the order we anticipate these activities will be conducted.

8.1 Drilling Methods and Subsurface Investigation Accessories

We anticipate using several drilling methods to: (1) characterize the nature of the geologic and hydraulic properties of subsurface soil, bedrock, and landfill caps; (2) obtain soil samples to determine the distribution of impacted soil; (3) access groundwater by installing monitoring wells to determine the distribution of impacted groundwater and for characterizing groundwater flow and transport; and (4) characterize groundwater-surface water interaction.

The anticipated drilling methods in this scope of work include: direct push, sonic, hollow-stem auger, and hand auger. In addition, we will use the Geoprobe® Hydraulic Profiling Tool (HPT) in selected situations where knowing the hydraulic properties of the soil is more important than the geologic description.

Pertinent field observations will typically be recorded electronically using an iPad® and proprietary software. Examples of the output form from the proprietary software are provided in Appendix G. Alternatively, documentation will be recorded by hand on the output forms.

8.1.a Direct-Push Drilling

Direct-push drilling collects soil and groundwater samples through a small-diameter drill rod that is hydraulically hammered into the ground. The drill rod can contain a liner for collecting a soil sample or be open and allow groundwater sampling through a screened tip or insertion of a small-diameter well.

Direct-push drilling can be used in unconsolidated soil that does not contain boulders. Traditionally, direct-push drilling has been limited to shallow depths; however, larger direct-push rigs can reach significant depths in certain geological environments. The main advantages of direct-push techniques include access flexibility and quick setup, they produce little waste soil, and they can be used with accessories such as MIP, Laser Induced Fluorescence (LIF), and HPT to characterize the hydrogeology and vertical contaminant distribution in real-time.

We anticipate using direct-push methods for most shallow drilling (< 50 fbgl) in overburden to: characterize the overburden geology, collect soil samples for soil quality testing, collect groundwater samples from temporary monitoring wells for groundwater quality testing, and characterize landfill cap materials.

Dragun will conduct direct-push drilling using methods that are consistent with KDHE SOP BER-07 and Dragun SOPs 7.01 to 7.03.

8.1.b Sonic Drilling

The sonic drilling uses high frequency vibrations in the drill rod to fluidize geologic materials adjacent to the rods as the rods are advanced. Sonic rigs can be used for unconsolidated soil and some rock, such as the shale that subcrops at the Site. Sonic rigs are fast, can reach significant depths, and yield long undisturbed cores.

We anticipate using sonic drilling for most of the deeper drilling (>50 fbgl) in the overburden for: characterizing the deeper overburden geology, all drilling in bedrock, and installing most permanent monitoring wells.

Dragun will conduct sonic drilling using methods that are consistent with Dragun SOP 4.08. KDHE does not have an SOP for sonic drilling.

8.1.c Hollow-stem Auger Drilling

Hollow-stem auger (HSA) drilling involves rotation of hollow, continuous-flight augers into the ground. Soil samples can be collected (using a split spoon or Shelby tube), and monitoring wells can be installed through the hollow augers. HSA rigs are used mainly for unconsolidated soil without boulders. HSA rigs can reach significant depths; however, they become slower with depth as the number of augers and drill rods increase.

We anticipate using HSA drilling for some shallow and deep drilling in overburden for: characterizing the deeper overburden geology, installing some permanent monitoring wells, and installing outer casings in multiple-cased wells.

Dragun will conduct HSA drilling using methods that are consistent with Dragun SOP 4.01, 4.05, 10.03, and 10.04. KDHE does not have an SOP for HSA drilling.

8.1.d Hand Auguring

Dragun will use a hand auger for collecting shallow (< 5 fbgl) soil and sediment samples. Dragun will use methods that are consistent with Dragun SOP 10.02. KDHE does not have an SOP for hand auguring, but it is mentioned in KDHE BER-03.

8.1.e Geoprobe Hydraulic Profiling Tool (HPT):

Dragun anticipates using HPT for rapid assessment of the vertical distribution of permeable zones. HPT will be used in the Plume D delineation work and may be used in other areas, if required. Dragun will use the HPT output in selecting depth intervals for installing temporary monitoring wells for vertical aquifer sampling. The temporary monitoring wells will be installed in separate soil borings adjacent to the HPT hole.

As the HPT probe is advanced into the soil using a Geoprobe drilling rig, the HPT system injects a small volume of water into the surrounding soil. The HPT system records the relative ease of injecting the water; that is, the pressure needed to inject is inversely related to the hydraulic conductivity of the soil opposite the probe. Dragun will "ground truth" the HPT by testing the system at locations where the geology was previously logged.

Neither KDHE nor Dragun has an SOP for HPT. Geoprobe's SOP is attached.

8.2 Soil Sampling Methods

One of the most common activities in this work plan is collecting subsurface soil samples. We will collect subsurface soils samples to: (1) interpret the geology, especially the distribution of permeable and less permeable zones, (2) test for the distribution of VOCs and other COCs in the soil, (3) test for *foc* for estimating transport rates, (4) test for engineering properties where remedial excavations are close to buildings, (5) test hydraulic properties of existing landfill caps, and (6) evaluate sediment quality.

Soil samples for chemical testing will typically be collected from above the water table; however, we may collect some soil samples for chemical testing from below the water table. We will not compare these latter samples to KDHE criteria; rather, they will be used for estimating chemical mass in low hydraulic conductivity soils below the water table. Soil samples for (1) f_{oc} testing will be collected from below the water table in areas where VOC impact is not significant and (2) engineering property testing may be collected both from above and below the water table.

The first step after collecting each soil sample, regardless of the drilling or sampling method, is to characterize geology and field screen for signs of impact (organic vapors, odors, and staining). These steps are discussed generally in KDHE SOPs BER-03 and -04 and Dragun SOP 7.03 and 10.05.

Pertinent field observations will typically be recorded electronically using an iPad® and proprietary software. Examples of the output form from the proprietary software are provided in Appendix G. Alternatively, documentation will be recorded by hand on the output forms.

8.2.a Soil Sampling for VOCs and COCs

Dragun will use EPA SW-846 Method 5035 to collect soil samples for VOC testing. This method involves using laboratory supplied specialized samplers (TerraCore® or EnCore®) to obtain a sub-sample "core" from the drill core, containers, and preservatives.

Next, for the remaining COCs, Dragun will collect a sample from the same interval of the soil core. Samples will be immediately transferred to the appropriate sample container and placed on ice.

Dragun will conduct soil sampling using methods consistent with KDHE SOP BER-03 and -04 and Dragun SOPs 10.02 through 10.06.

8.2.b Soil Sampling for Fraction Organic Carbon

Soil organic matter is the total organic portion of the soil that is derived from decomposed plant matter, microorganisms, and animal residues. Fraction organic carbon is the portion of the organic matter that is available to adsorb organic chemicals. The mobility of an organic chemical in groundwater is directly related to the f_{oc} of the soil.

When sampling for f_{oc}, there should be no extraneous organic matter in the sample, e.g., roots, sticks, wood, or biota. The samples will be collected and placed in appropriate containers and shipped to a laboratory for analysis.

Dragun will conduct soil sampling using methods consistent with Dragun SOP 10.06 (Soil Sampling – non VOCs). KDHE does not have an SOP for collection of samples for f_{oc} analysis.

8.2.c Soil Sampling for Engineering Properties

Soil samples for testing for engineering properties may be disturbed samples (from split spoons or liners from direct push or sonic) or undisturbed from Shelby tubes, as required for a particular test. The samples will be collected and placed in appropriate containers and shipped to a geotechnical laboratory for analysis.

Dragun will conduct soil sampling using methods consistent with Dragun SOP 10.06 (Soil Sampling – non VOCs). KDHE does not have an SOP for collection of geotechnical samples.

8.2.d Sediment Sampling

Sediment will be collected from below the channel of surface water features using a clean, hand-held device, such as a slide hammer coring device. Following collection, the sediment will be transferred from the sampling device to an appropriate sample container for laboratory analyses.

Dragun will conduct sediment sampling using methods consistent with KDHE SOP BER-04 and Dragun SOP 10.01 and 10.02 (Soil/Sediment Sampling).

8.2.e Suspected Separate Phase

Where soil PID readings are very high, Dragun will test soil and groundwater samples using a Sudan IV test kit to evaluate whether separate phase (LNAPL or DNAPL) is present.

Dragun will adhere to the methods consistent with Dragun SOP 5.19. KDHE does not have an SOP for Sudan IV testing.

8.3 Monitoring Wells

Dragun will use monitoring wells to: (1) determine water table and piezometric elevations, (2) collect groundwater samples for field and laboratory testing, (3) evaluate hydraulic conductivity by single well and aquifer tests, (4) evaluate aquifer connections during aquifer tests, and (5) evaluate groundwater - surface water interaction.

The intention of all monitoring wells is to obtain groundwater information on groundwater quality and/or hydraulic head from discrete depth intervals in the saturated zone.

8.3.a Types of Monitoring Wells

Several types of monitoring wells will be used during this scope of work, including: permanent monitoring wells, temporary monitoring wells, double-cased monitoring wells, hand-driven monitoring wells, and direct-push groundwater samplers.

Pertinent field observations will typically be recorded electronically using an iPad® and proprietary software. Examples of the output form from the proprietary software are provided in Appendix G. Alternatively, documentation will be recorded by hand on the output forms.

8.3.b Permanent Monitoring Wells

Table 8.1 outlines the various the components of typical permanent monitoring wells to be used during this investigation. Where modifications are required due to location-specific conditions, Dragun will contact KDHE in advance, if possible, and document any special conditions. Temporary monitoring wells, double-cased monitoring wells, and hand-driven monitoring wells will be modifications of the permanent monitoring well.

Table 8.1 is generally consistent with KDHE Standard Operating Procedure BER-06 and Dragun SOP 8.01.

Table 8.1 Typical Monitoring Well Construction

Well Component	Sub-component	Details and Description
Pipe	Riser (casing)	• 2-inch inside diameter, Schedule 40 PVC plastic, flush joint threaded • factory sealed • centralizers used for wells greater than 30 feet deep if not installed through HSA or temporary casing
	Screen	• 5-foot long, 2-inch inside diameter, Schedule 40 PVC plastic, 10-slot screen, flush joint threaded • factory sealed
Annular Fill/Seal	Annular fill	• bentonite grout or cement-bentonite grout tremied from lower bentonite seal to surface • minimum 20 feet where possible
	Lower bentonite seal	• minimum 24-inch thick above sand pack • either bentonite chips or pellets, hydrated according to the manufacturers specifications, but not less than 30 minutes
	Sand/gravel pack	• minimum 2-inch thick, filled to 24 inches above top of screen • clean silica sand appropriate for 10-slot screen (1020 or 2040, depending on the formation and discussions with the driller)
Protection	Lock	• lockable J-plug • all new wells keyed alike, locked on well completion
	Protective casing	• lockable 4-inch steel standup protective casing or flush mount casing • standup casings to extend 3 feet above grade • protective casings firmly set into concrete apron
	Concrete apron	• 2-3-foot square, minimum 5-inch thick • raised above normal ground level and sloped to shed precipitation
	Bollards	• as needed to protect standup casings • extend one-foot above protective casing and painted for visibility
Other	Drainage	• location selected or modified to avoid ponding of runoff at well
	North mark	• the north side of the inner casing of the monitoring well will be notched for subsequent water level measurements
	Documentation	• well details and hydrogeologic information logged by onsite geologist

No sooner than 24 hours following installation, the drilling contractor will develop the wells using either over-pumping, by alternately using pumping and a surge block, or equivalent. After each development cycle, the field geologist will check turbidity using a turbidity meter. Well development will continue until the turbidity value is less than 50 NTU or 90 minutes of development, whichever comes first. A minimum of five borehole volumes, casing plus annulus (assumed 30% porosity), and three times any water added during construction will be removed during development. Well development details are provided in Dragun SOP 8.01.

Table 8.2 lists other monitoring well considerations for specific monitoring well use.

Table 8.2 Other Monitoring Well Considerations

Situation	Procedures
Water table well	• Screen straddles water table
Suspected LNAPL	• Screen straddles water table
Suspected DNAPL	• Screened at interface between hydraulic conductivity types
Monitoring well nest	• Screens at various depths, all in separate boreholes
Aquifer test – pumping well	• Longer screen • Fully penetrating aquifer if possible
Aquifer test – observation well	• Screened opposite middle of pumping well screen for aquifer parameter estimation • Screened in separate hydrostratigraphic units to evaluate connection
Stream piezometer	• Driven well point • Screen must be entirely below stream bed
Well Abandonment	• All monitoring wells will be abandoned according to procedures described elsewhere in this document.

8.3.c Temporary Monitoring Wells

Temporary monitoring wells are installed for a limited time to obtain a one-time groundwater sample, and then they are removed. Temporary monitoring wells are similar to permanent monitoring wells, but may lack some attributes of a permanent monitoring well, such as annular fill, a protective casing, or a concrete apron.

We anticipate using two types of temporary monitoring wells during this scope of work: (1) PVC plastic pipe wells installed in soil borings where the hydraulic conductivity is low and groundwater accumulation is expected to be slow and (2) a direct-push tool, such as a Geoprobe® SP-16, which is pushed into higher hydraulic conductivity soil where groundwater collection is expected to be relatively fast.

Temporary monitoring wells using a PVC plastic well will be similar to the details outlined Table 8.1; however, we anticipate using a one-inch diameter, PVC pipe without (1) an annular seal above the lower bentonite seal, (2) significant development, and (3) any of the surface finishing details.

Dragun will install temporary wells using methods consistent with KDHE SOP BER-29 and Dragun SOPs 7.01 and 8.02.

8.3.d Double-cased Monitoring Wells

Double-cased monitoring wells are used to prevent leakage of impacted groundwater from a shallow permeable zone into a well screen completed in a deeper permeable zone. For example,

a double-cased well would be used for a monitoring well completed in bedrock that underlies impacted groundwater in the overburden.

In general, a double-cased well starts by sealing an outer casing into a competent unit that separates the impacted groundwater in the upper permeable zone and the deeper permeable zone. The outer casing is advanced at least five feet into the competent unit and cemented into place by tremiing cement grout through the outer casing. Once the cement grout sets, the soil boring or core is continued through the center of the outer casing to the desired depth in the deeper permeable zone, and the monitoring well is installed as in Table 8.1.

Dragun will install the bedrock monitoring wells using methods that are consistent Dragun SOP 4.05. KDHE does not have an SOP for the installation of double-cased monitoring wells.

8.4 Groundwater and Separate-Phase Level Measurements

Groundwater level measurements are critical to many aspects of this scope of work including: (1) determining which soil samples represent the vadose and saturated zones, (2) determining the direction of groundwater flow laterally and vertically, (3) determining whether drawdown is acceptable during low-flow-sampling, (4) evaluating hydraulic conductivity by single well and aquifer tests, and (5) evaluating capture zones and hydraulic connections during aquifer tests.

Dragun will measure the depth to groundwater in monitoring wells using an electric contact gauge that can be read to the nearest 0.01 feet. Measurements will be made from the notch on the north side of the inner casing or, if no notch is present, from the north side of the casing.

There are some preliminary considerations:

- Water-level measurements should proceed from the least to the most contaminated well to minimize the potential for cross-contamination.
- All of the wells in the area of investigation should be measured within a period of 24 hours to minimize the potential for atmospheric pressure-change effects on wells.
- Immediately after removing the well cap, field personnel should measure the concentration of organic vapors at the well head using a PID meter.
- The well cap should be off for several minutes prior to measuring the water level to allow the water level in the well to equilibrate to atmospheric pressure. Measurements should be repeated after five minutes until stabilized.

After determining the depth to groundwater, the bottom depth of the well should be determined with the electric contact gauge to evaluate sedimentation and to confirm the well identification.

If separate phase is observed during decontamination, determine the depth and thickness of the separate phase with an interface probe.

For some tasks, such as single well and aquifer tests, data loggers will be used to monitor temporal trends in groundwater elevation.

Dragun will measure groundwater and product levels using methods that are consistent with KDHE SOP BER-36 and Dragun SOP 8.06.

8.5 Groundwater Sampling

The objective of groundwater sampling is to obtain a representative groundwater sample by minimizing chemical and biological changes after the groundwater enters the well.

Dragun will use low-flow sampling procedures (discussed below) and will proceed from least to most contaminated areas, where possible. Dragun will collect groundwater samples using methods that are consistent with KDHE SOP BER-01 and Dragun SOP 9.01, 9.02, 9.03, 9.04.

8.5.a Preparation for Sampling

In preparation for sampling, Dragun will adhere to the methods and procedures consistent with KDHE SOP BER-01 and Dragun SOP 6.0 Field Activity Preparation, specifically 6.01 (Sample Type), 6.02 (Laboratory Parameters), and 6.03 (Quality Assurance Quality Control Samples).

8.5.b Groundwater Purging and Sampling

Dragun anticipates using a peristaltic pump, a variable speed bladder pump, or a direct displacement pump (Waterra) for low-flow sampling, depending on the depth to groundwater and the diameter of the monitoring well. Regardless of the pump, the intake will be placed at, or slightly above, the middle of the well screen.

Prior to collecting a groundwater sample, Dragun will (1) purge standing water from the monitoring well by pumping at a low rate that does not cause excessive drawdown in the well and (2) periodically monitor field parameters in the groundwater (temperature, electrical conductivity, Eh, pH, dissolved oxygen, and turbidity) for stability. Dragun may use a flow-cell for monitoring the field parameters during well purging.

When duplicate samples are collected, both samples will be collected at the same time. When sampling for other COCs, the sample may require filtration if turbidity cannot be reduced to representative ambient levels.

Dragun will use methods consistent with KDHE SOP BER-01 and Dragun SOPs 5.08, 5.12, 9.01, 9.02, 9.03, and 9.04.

8.5.c Low Recovery Monitoring Wells

For low hydraulic conductivity areas, which are common on the west side of the Site, low-flow sampling may not be possible. Dragun will sample groundwater in one of the following ways (see SOPs in Appendix E):

1. Remove stagnant water from above the well screen, and then sample groundwater from the screened using low flow.
2. Purge the well dry, and sample low-flow sample again when the well has recovered at least 90%. Sampling should occur between 2 and 24 hours after dewatering.
3. Use a no-purge groundwater sampling method such as HydraSleeve®.

8.5.d Natural Attenuation Parameters

The primary objective of the natural attenuation sampling is to determine whether natural processes will be capable of attaining site-specific remediation objectives in a time period that is reasonable compared to other alternatives.

Dragun will adhere to the methods consistent with Dragun SOP 9.01 through 9.04. KDHE does not have a specific SOP for sampling natural attenuation parameters.

8.5.e Suspected Separate Phase

Where soil PID readings are very high, Dragun will test soil and groundwater samples using a Sudan IV test kit to evaluate whether separate phase (LNAPL or DNAPL) is present.

Dragun will adhere to the methods consistent with Dragun SOP 5.19. KDHE does not have an SOP for Sudan IV testing.

8.6 Groundwater - Surface Water Interaction

Many of the surface water features at the Site are ephemeral (may not flow everywhere in the channel all the time) or intermittent (only flow after rainfall or snowmelt). The surface water features at the Site may interact with groundwater either by receiving groundwater discharge or by supplying groundwater recharge. Since impacted groundwater flows beneath parts of some of the surface water features, there is potential for the surface water to become impacted.

The direction of groundwater movement relative to surface water can be determined by pairing streambed piezometers and stream staff gauges. There are three possible relationships between the groundwater and the surface water bodies:

1. If the groundwater elevation is higher than the streambed elevation and the stream is "dry," groundwater discharges into the stream (even though it may not be apparent due to evapotranspiration).
2. If the groundwater elevation is greater than the stream elevation, groundwater discharges into the stream.
3. If the stream elevation is greater than the groundwater elevation, the stream recharges the groundwater.

Neither KDHE nor Dragun has an SOP for this type of work.

The easiest way to evaluate groundwater/surface water interactions is to first drive a short-screened drive point piezometer into the streambed to monitor the groundwater elevation. The screen must be driven completely below the elevation of the streambed. Immediately adjacent to the piezometer, drive a pipe (with a hole about two feet from the bottom to allow stream water in) into the streambed such that the hole is just above the streambed. The elevations of the tops of both pipes and the streambed are surveyed.

The water level in each pipe is continuously logged with a data logger. The water levels are compared to determine when the groundwater is discharging (groundwater elevation > streambed elevation if dry or stream elevation if not) or being recharged (stream elevation > groundwater elevation). The data logger in the stream pipe will also record periods when the stream is flowing.

8.7 Surface Water Sampling

Dragun will conduct surface water sampling in all three operating units. During normal flow conditions, the surface water bodies are small enough that a person on the bank can use a dipper on a handle/pole to collect surface water.

Dragun will adhere to the methods consistent with KDHE SOP BER-02 and Dragun SOPs 11.01 and 11.02.

8.8 Single-Well Tests

Dragun will conduct single-well testing in selected monitoring wells to determine the hydraulic conductivity at that location and depth. In general, a single-well test consists of two parts: (1) "instantaneously" changing the water level in a monitoring well from static conditions and (2) monitoring the return to static conditions with time. The rate at which the water level returns to static conditions is directly related to the hydraulic conductivity of the formation opposite the screen.

Dragun will use either the Hvorslev or Bouwer-Rice method for data analysis.

Dragun will adhere to the methods consistent with Dragun SOP 8.07. There is no KDHE SOP for single-well tests.

8.9 Aquifer Tests

Dragun will conduct aquifer tests in OU1 and OU2 mainly to evaluate how well pump-and-treat remediation can work for controlling plume movement and to evaluate connections between permeable zones. Dragun will use a standard approach to aquifer tests consistent with KDHE SOPs BER-09 and BER-10 and Dragun SOP 8.08.

It is not clear whether the aquifers will be confined or not, bounded or not, and/or leaky or not. The budget assumes worst-case scenario for duration and the work plan is general enough to accommodate the most likely scenarios.

8.10 Well Abandonment

Dragun will abandon monitoring wells that are superfluous or severely damaged. The intent of proper well abandonment is to minimize the potential for impacted surface water or groundwater to move into an uncontaminated zone.

Dragun will follow procedures outlined by KDHE (Procedure WWP-10, dated May 23, 2011). This procedure generally involves plugging of the entire screen and casing with a KDHE-approved grout tremied from the bottom of the well and removing the last three feet of well casing below grade.

Following abandonment, form WWC-5P (Appendix G) will be completed and submitted to KDHE and the landowner.

8.11 Summary of Analytical Requirements

Appendix H provides a summary of the analytical requirements for this scope of work. Appendix H will include several entries, including: types of analyses, analytical methods, sample containers, etc.

8.12 Professional Supervision

All of the work in this work plan will be conducted under the supervision of a professional geologist and/or a professional engineer licensed by the Kansas Board of Technical Professions.

9.0 REMEDIAL INVESTIGATION SCHEDULE

9.1 Field Investigations

The estimated schedule for the field investigations included in this work plan is shown on Table 9.1 below. Assuming that the field work can begin on or before April 1, 2014, the field investigations are estimated to be completed by September 2015. However, the majority of the investigation is concentrated between April and November 2014.

Table 9.1 Remedial Investigation Schedule

TASK ITEM SUMMARY	2014					2015												2016		
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
2.0 OU1 Field Investigation	■	■	■	■																
3.0 OU2 Field Investigation		■	■	■	■															
4.0 OU3 Field Investigation			■	■	■	■														
5.0 Groundwater Monitoring (Includes data validation/QCSR)	■	■							■	■			■	■			■	■		
6.0 Investigation/monitoring of Surface Water -Groundwater Interaction					■				■				■				■			
7.0 Monitoring Well Maintenance, Abandonment, Replacement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
RI Report (includes Baseline Risk Assessment, if necessary)							■	■	■	■	■	■	■	■	■	■	■	■	■	■

Notes: RI = remedial investigation, OU = Operating Unit, QCSR = Quality Control Summary Report, Assumes RI approval such that work can begin during August 2014.

9.2 Deliverables

A Remedial Investigation Report will be prepared to summarize and present the findings of the remedial investigation. We anticipate the Remedial Investigation Report to be submitted in a Draft Final form to KDHE by April 30, 2016.

Additional deliverables to be submitted to KDHE during the conduct of this work include Quarterly Progress Reports, Data Transmittals, Monitoring Reports, and QCSRs. These reports will be provided according to the following schedule:

- Quarterly Progress Report will be provided within 45 days of the end of each quarter. The Quarterly Progress Reports will include:
  - Actions, progress, and status of tasks undertaken to comply with the CAFO.
  - Actions scheduled for the following quarter.
  - Requirements under the CAFO that were not completed.

  - Results of sampling, tests, data, field notes, and conclusions drawn from data generated pursuant to the Work Plan.
  - Schedule updates.

- Data Transmittals (separate from those included in the Quarterly Progress Reports) will be provided at the request of KDHE.

- Monitoring Reports will be provided within 45 days of each quarterly monitoring event.

QCSRs will be provided at the completion of the investigations for each OU.

10.0 REFERENCES

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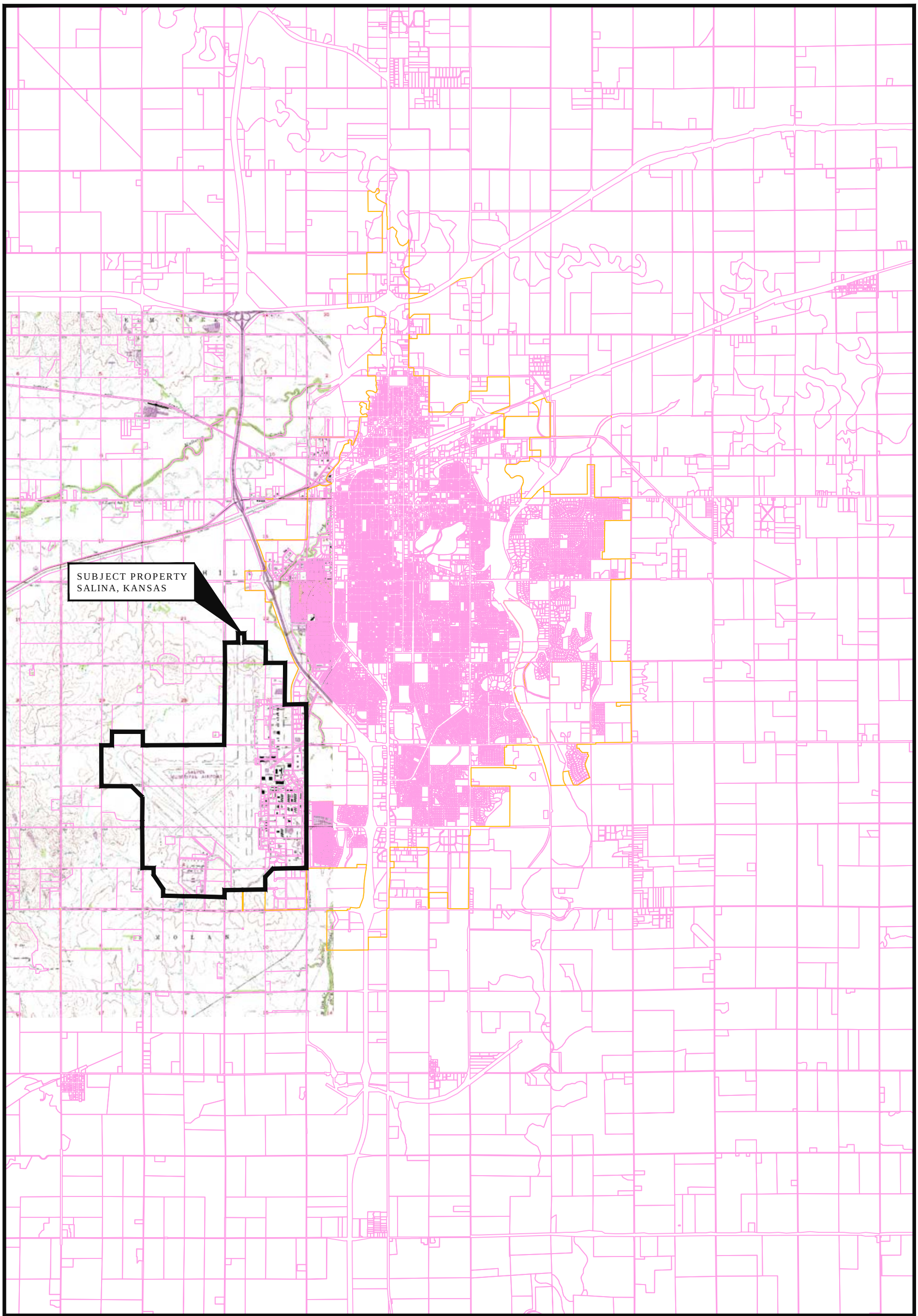
FIGURES

Final Remedial Investigation Work Plan
Former Schilling Air Force Base
Salina, Kansas



SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 1
SITE LOCATION MAP

SCALE
0 FEET 6000

KANSAS
QUADRANGLE LOCATION

References: Salina SW, Kansas Quadrangle (U.S. Geological Survey, 1978); and Parcels provided by City of Salina.

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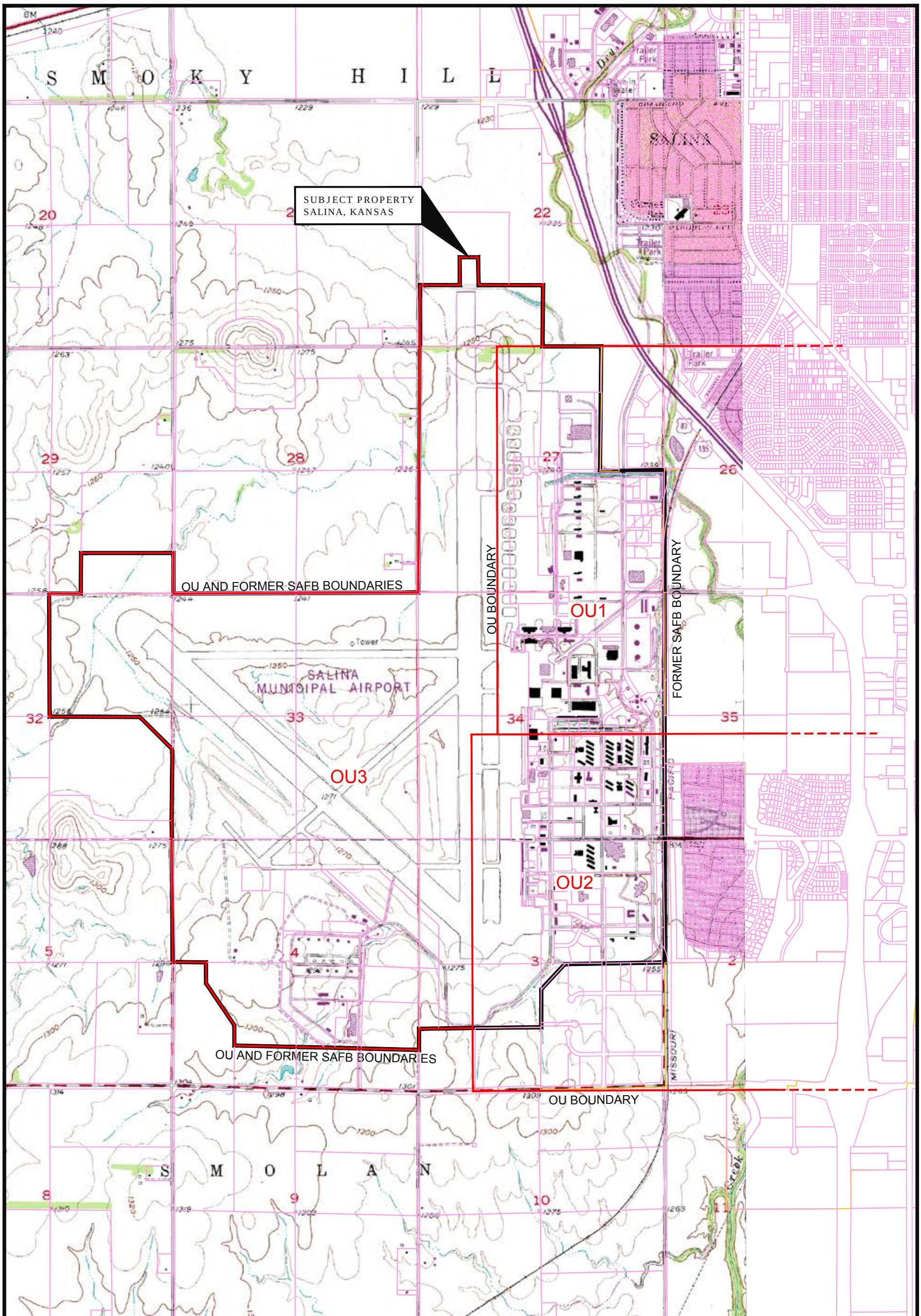
Date: 7.9.2014



SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 2
SITE PLAN

SCALE

0 FEET 2000

KANSAS
QUADRANGLE LOCATION

Reference: Salina SW, Kansas Quadrangle (U.S. Geological Survey, 1978)

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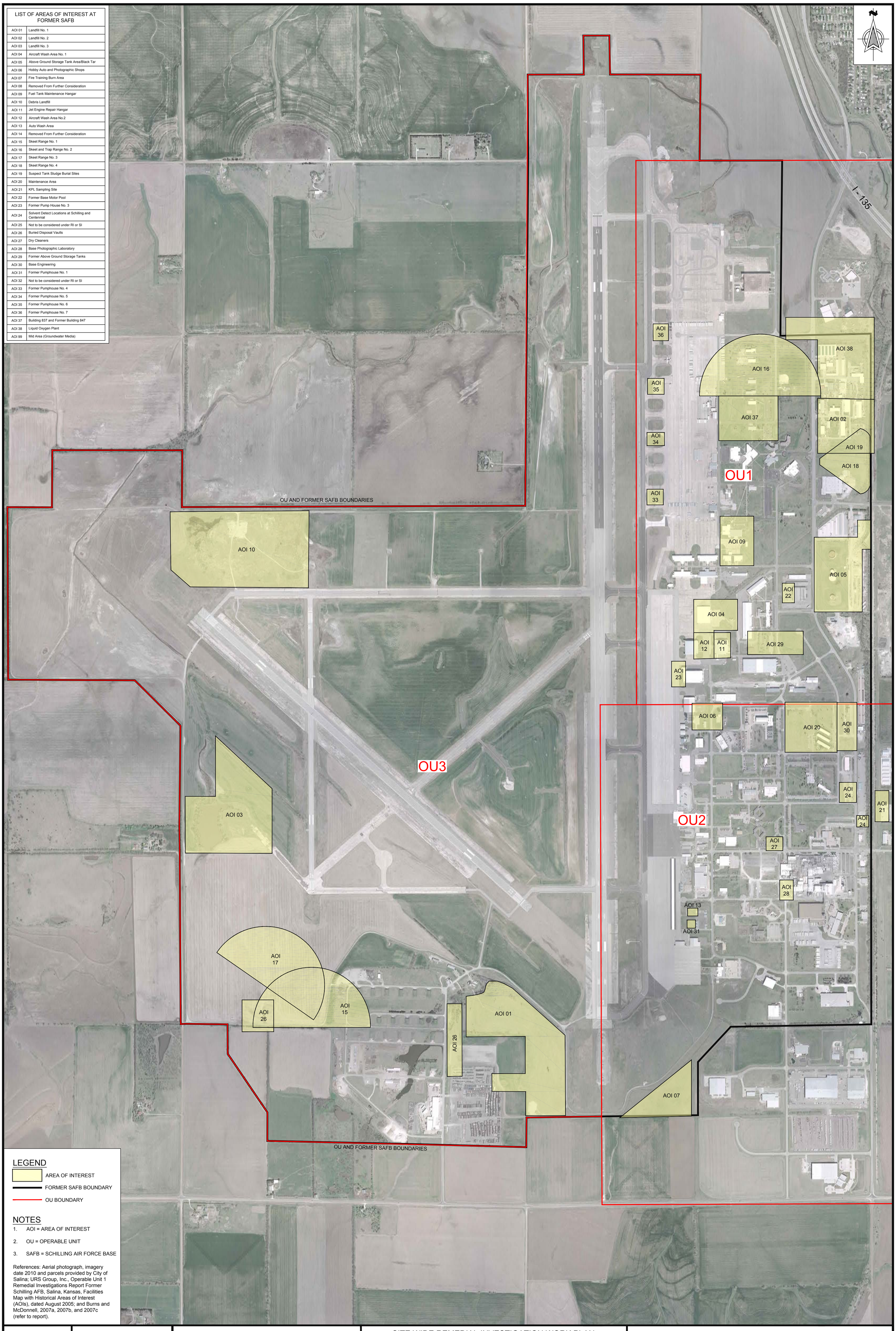
Date: 7.9.2014



LIST OF AREAS OF INTEREST AT FORMER SAFB	
AOI 01	Landfill No. 1
AOI 02	Landfill No. 2
AOI 03	Landfill No. 3
AOI 04	Aircraft Wash Area No. 1
AOI 05	Above Ground Storage Tank Area/Black Tar
AOI 06	Hobby Auto and Photographic Shops
AOI 07	Fire Training Burn Area
AOI 08	Removed From Further Consideration
AOI 09	Fuel Tank Maintenance Hangar
AOI 10	Debris Landfill
AOI 11	Jet Engine Repair Hangar
AOI 12	Aircraft Wash Area No.2
AOI 13	Auto Wash Area
AOI 14	Removed From Further Consideration
AOI 15	Skeet Range No. 1
AOI 16	Skeet and Trap Range No. 2
AOI 17	Skeet Range No. 3
AOI 18	Skeet Range No. 4
AOI 19	Suspect Tank Sludge Burial Sites
AOI 20	Maintenance Area
AOI 21	KPL Sampling Site
AOI 22	Former Base Motor Pool
AOI 23	Former Pump House No. 3
AOI 24	Solvent Detect Locations at Schilling and Centennial
AOI 25	Not to be considered under RI or SI
AOI 26	Buried Disposal Vaults
AOI 27	Dry Cleaners
AOI 28	Base Photographic Laboratory
AOI 29	Former Above Ground Storage Tanks
AOI 30	Base Engineering
AOI 31	Former Pumphouse No. 1
AOI 32	Not to be considered under RI or SI
AOI 33	Former Pumphouse No. 4
AOI 34	Former Pumphouse No. 5
AOI 35	Former Pumphouse No. 6
AOI 36	Former Pumphouse No. 7
AOI 37	Building 837 and Former Building 847
AOI 38	Liquid Oxygen Plant
AOI 99	Mid Area (Groundwater Media)

SCALE
0 FEET 600

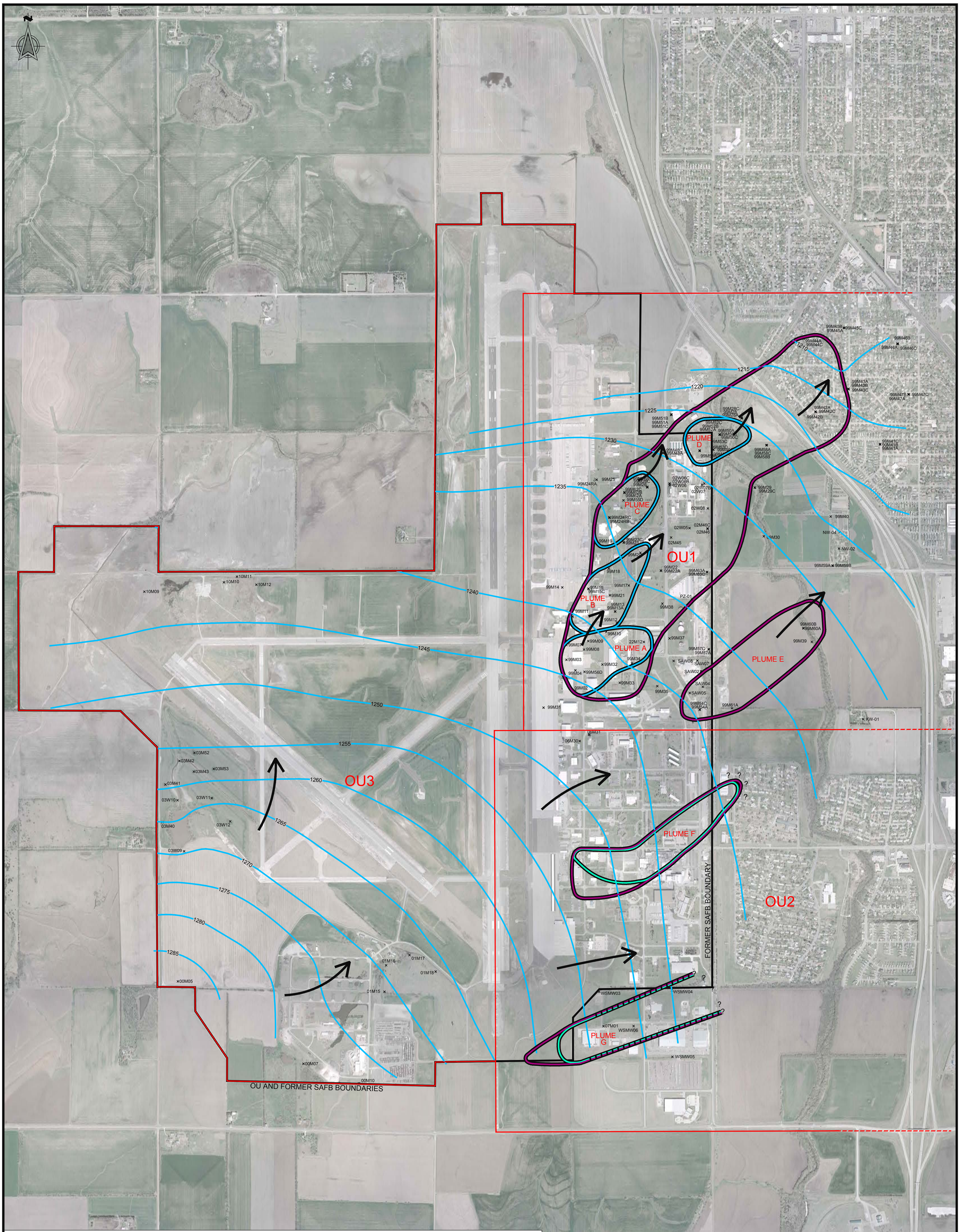
File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Fig 3.dwg

Date: 7.9.2014

Dragun Corporation
Environmental Advisors

SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 3
HISTORICAL AREAS OF INTEREST



LEGEND

- × 99M20 — LONG TERM MONITORING WELL
- FORMER SAFB BOUNDARY
- OU BOUNDARY
- OU BOUNDARY LIMIT UNDETERMINED
- TCE GROUNDWATER PLUME >100 µg/L, >5 µg/L
- CCl_4 GROUNDWATER PLUME >5 µg/L
- 1255 — APPROXIMATE GROUNDWATER CONTOUR (fasl) FALL 2009
- ILLUSTRATIVE GROUNDWATER FLOW DIRECTION

NOTES

1. OU = OPERABLE UNIT
2. SAFB = SCHILLING AIR FORCE BASE
3. USACE = UNITED STATES ARMY CORPS OF ENGINEERS
4. CCl_4 = CARBON TETRACHLORIDE
5. TCE = TRICHLOROETHENE
6. µg/L = MICROGRAMS PER LITER
7. fasl = FEET ABOVE SEA LEVEL
8. DASHED PLUME BOUNDARY IS INFERRED BASED ON GROUNDWATER FLOW DIRECTION
9. CHEMICAL DATA BASED ON INFORMATION PROVIDED BY USACE
10. POSTED CHEMICAL DATA AND PLUMES REPRESENT THE HIGHEST DETECTED AT THE LOCATION REGARDLESS OF DEPTH AND DATE
11. WATER LEVELS MEASURED ON SEPTEMBER 8th - 10th, 2009

References:
Aerial photograph provided by City of Salina, imagery date 2010; data are those provided in the electronic format by USACE prior to February 4, 2008; and Burns and McDonnell, 2007a, 2007b, and 2007c (refer to report).

SCALE
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Date: 7.14.2014

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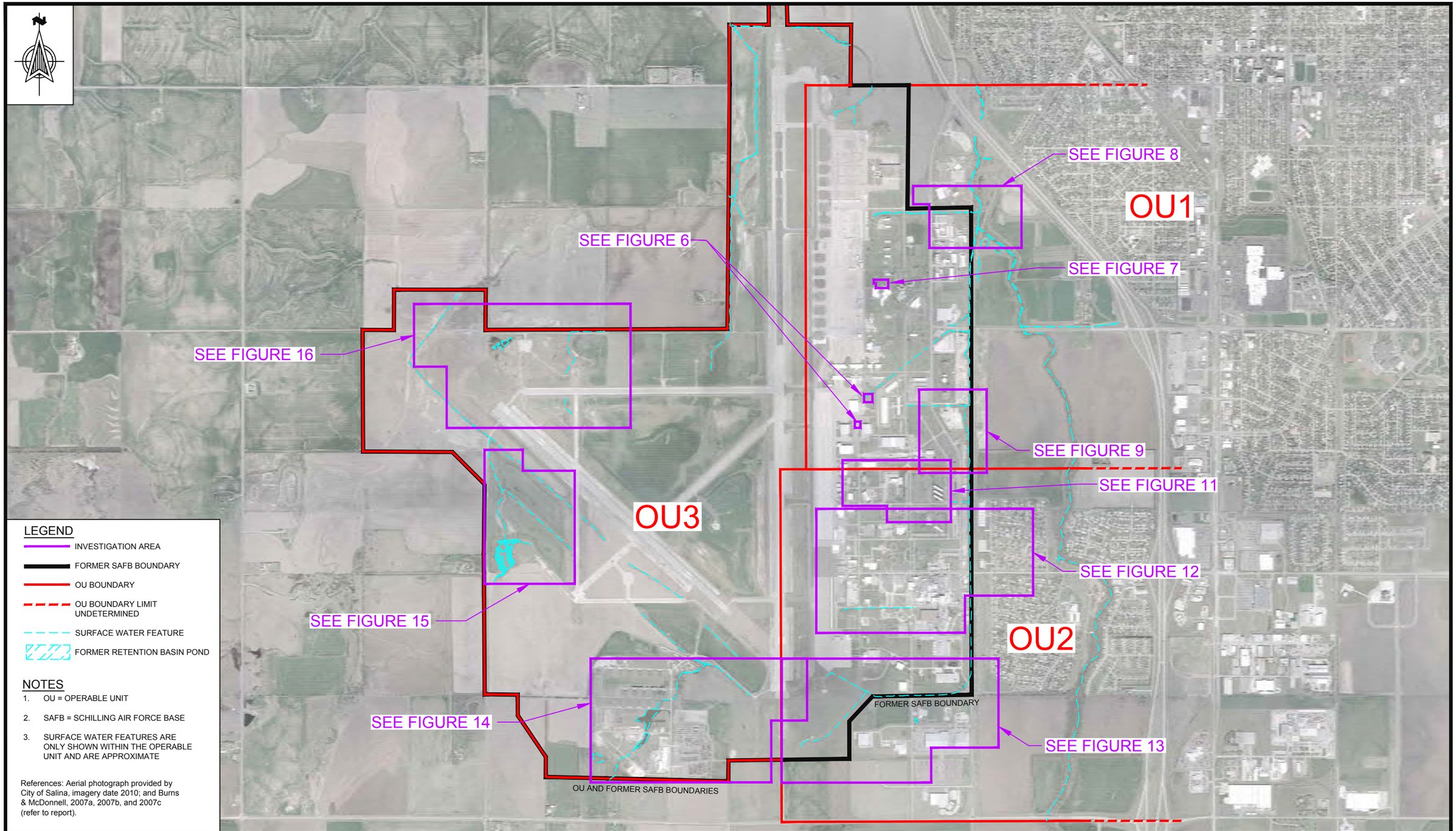
SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 4
GROUNDWATER PLUME MAP



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Date: 7.9.2014

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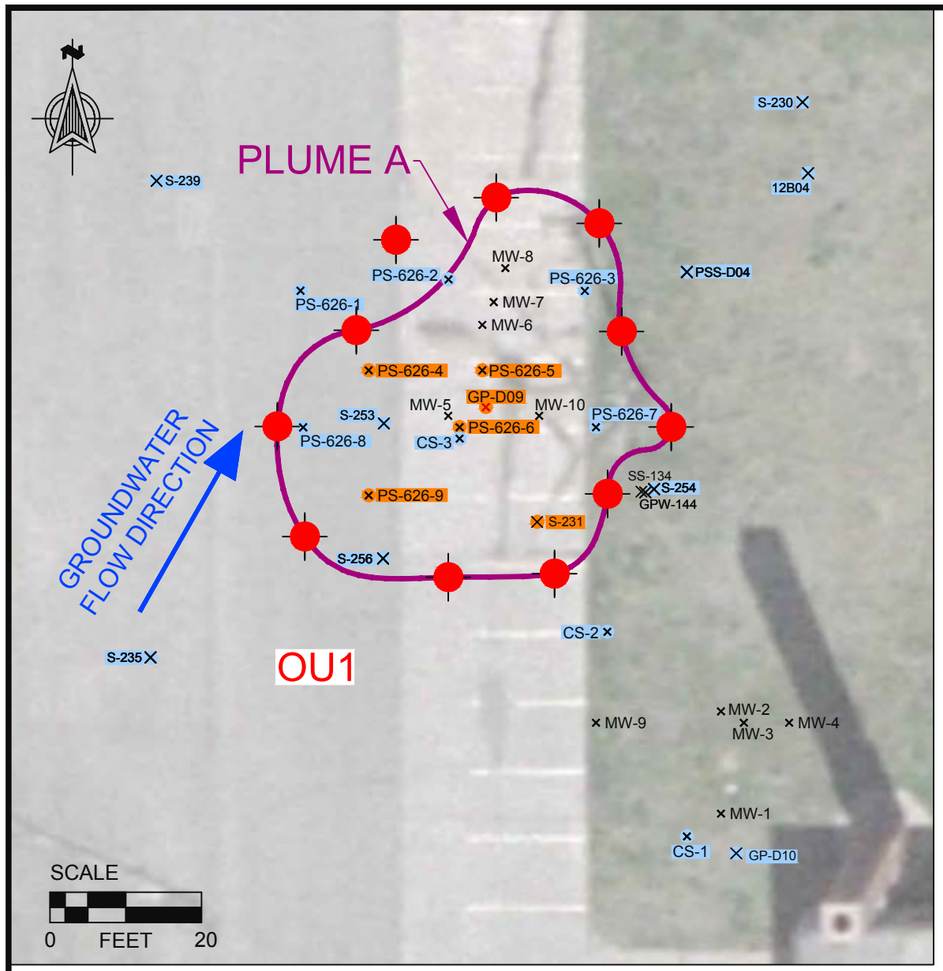
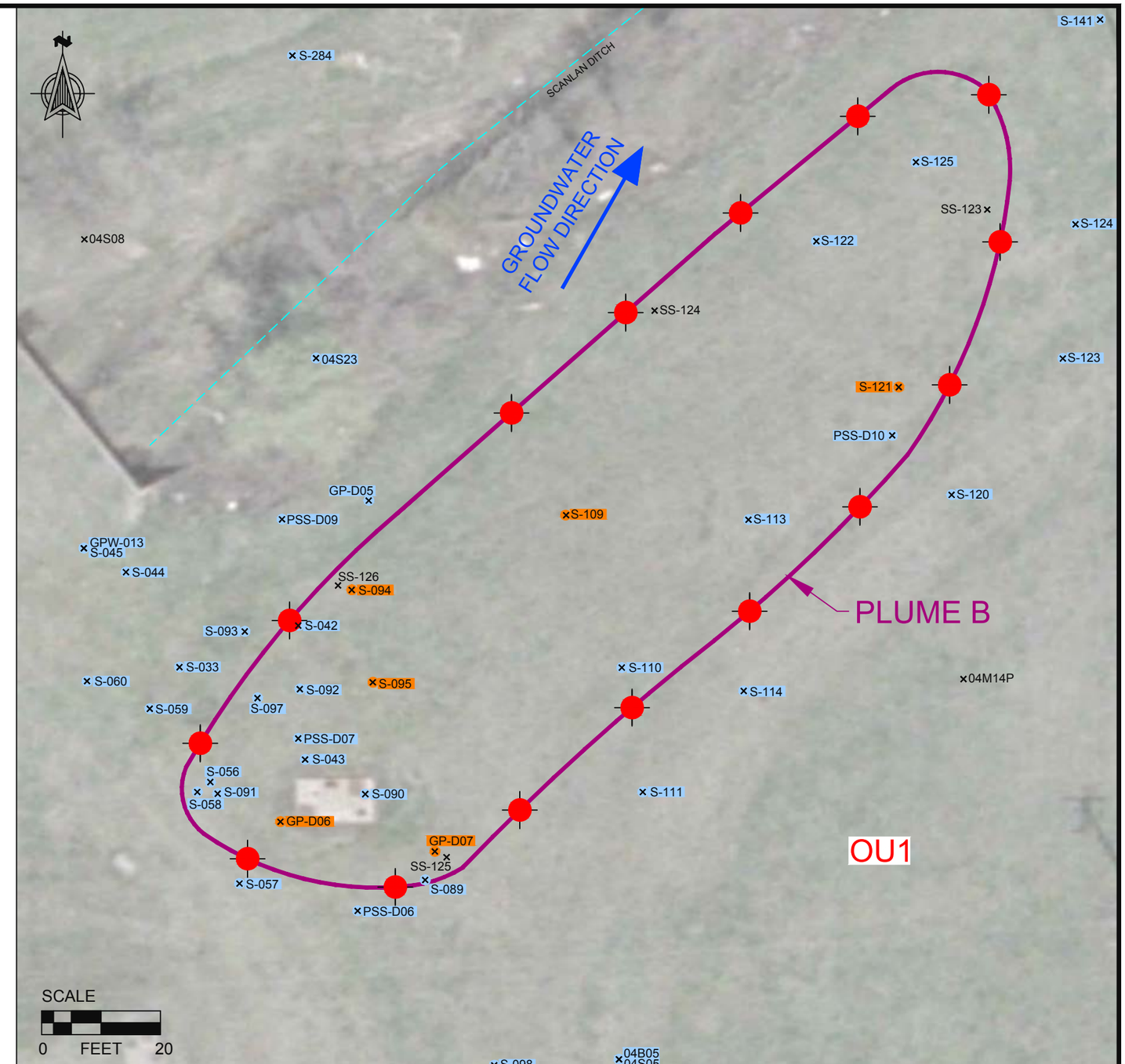
Environmental Advisors

SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 5
INVESTIGATION AREAS





LEGEND

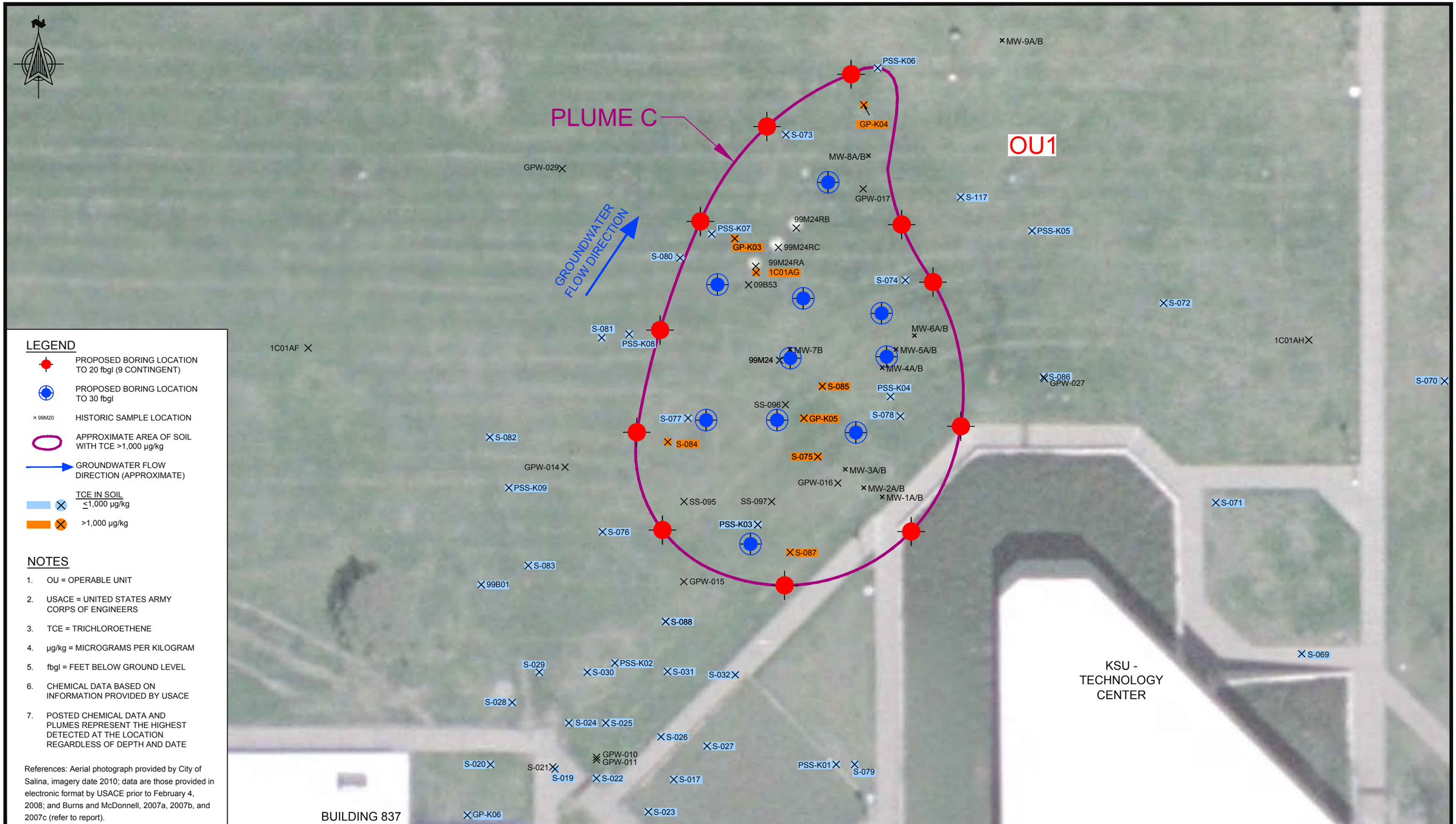
- PROPOSED BORING LOCATION (4 CONTINGENT AT PLUME A SOURCE AND 8 CONTINGENT AT PLUME B SOURCE)
- × 99M20 HISTORIC SAMPLE LOCATION
- SURFACE WATER FEATURE
- APPROXIMATE AREA OF SOIL WITH TCE >1,000 µg/kg
- GROUNDWATER FLOW DIRECTION (APPROXIMATE)
- TCE IN SOIL
  - ≤1,000 µg/kg
  - >1,000 µg/kg

NOTES

1. OU = OPERABLE UNIT
2. USACE = UNITED STATES ARMY CORPS OF ENGINEERS
3. TCE = TRICHLOROETHENE
4. µg/kg = MICROGRAMS PER KILOGRAM
5. SURFACE WATER FEATURES ARE APPROXIMATE
6. CHEMICAL DATA BASED ON INFORMATION PROVIDED BY USACE
7. POSTED CHEMICAL DATA AND PLUMES REPRESENT THE HIGHEST DETECTED AT THE LOCATION REGARDLESS OF DEPTH AND DATE

References: Aerial photograph provided by City of Salina, imagery date 2010; data are those provided in electronic format by USACE prior to February 4, 2008; and Burns and McDonnell, 2007a, 2007b, and 2007c (refer to report).

SCALE AS NOTED	File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Fig 6&7.dwg Date: 7.9.2014	Dragun Corporation Environmental Advisors	SITE WIDE REMEDIAL INVESTIGATION WORK PLAN FORMER SCHILLING AIR FORCE BASE SALINA, KANSAS	FIGURE 6 PROPOSED BORING LOCATIONS, PLUME A AND PLUME B



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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Fig 6&7.dwg
Date: 7.9.2014

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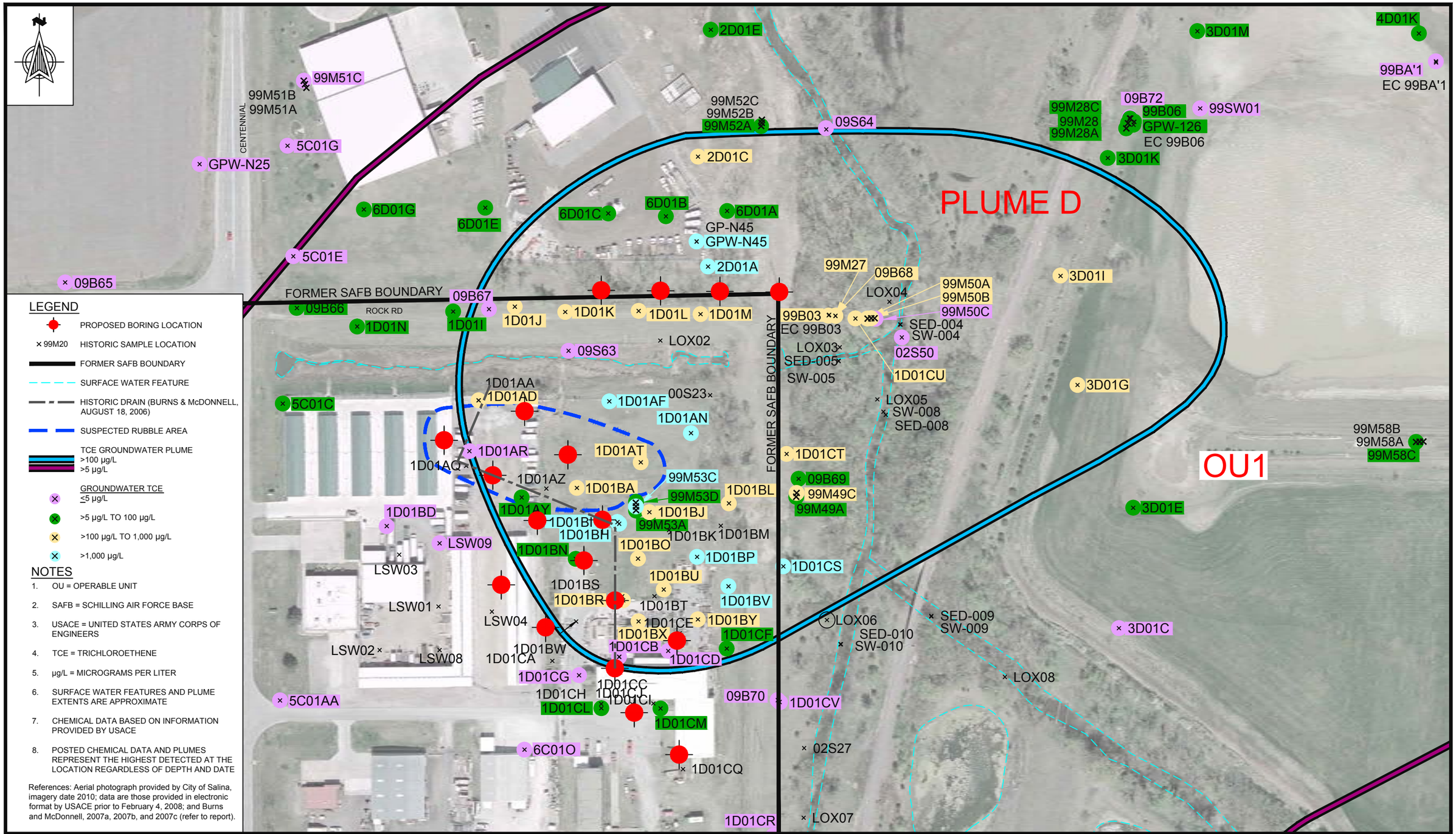
SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 7
PROPOSED BORING LOCATIONS, PLUME C



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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Figs 8,9,11.dwg

Date: 7.9.2014

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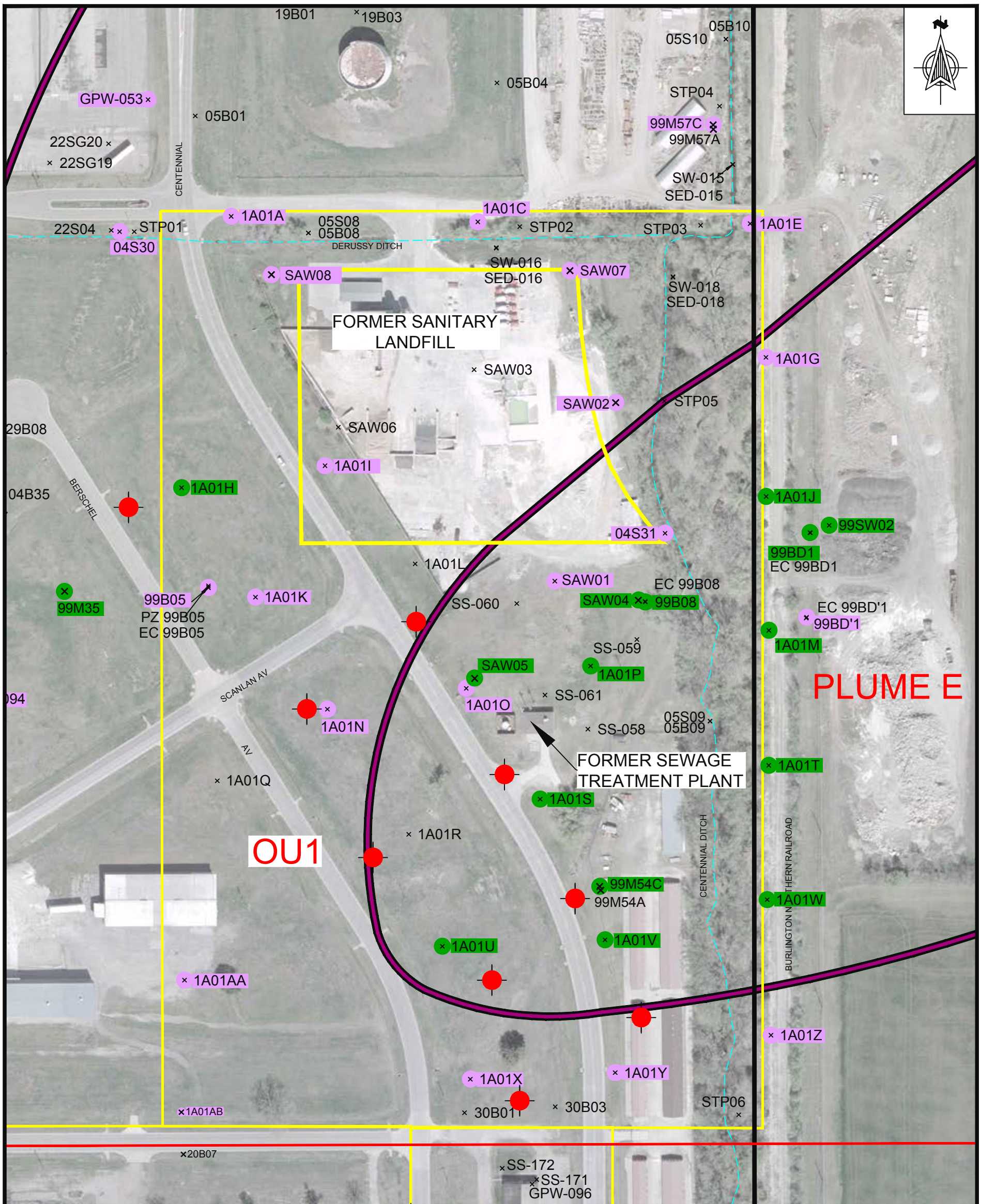
SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 8
PROPOSED BORING LOCATIONS,
FORMER LOX PLANT



LEGEND

- PROPOSED BORING LOCATION (4 CONTINGENT)
- × 99M20 HISTORIC SAMPLE LOCATION
- FORMER SAFB BOUNDARY
- OU BOUNDARY
- POTENTIAL SOURCE LOCATION (USACE)
- SURFACE WATER FEATURE
- TCE GROUNDWATER PLUME >5 µg/L

GROUNDWATER TCE
- ≤5 µg/L
- >5 µg/L TO 100 µg/L

NOTES

1. OU = OPERABLE UNIT
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3. USACE = UNITED STATES ARMY CORPS OF ENGINEERS
4. TCE = TRICHLOROETHENE
5. µg/L = MICROGRAMS PER LITER
6. SURFACE WATER FEATURES AND PLUME EXTENTS ARE APPROXIMATE
7. CHEMICAL DATA BASED ON INFORMATION PROVIDED BY USACE
8. POSTED CHEMICAL DATA AND PLUMES REPRESENT THE HIGHEST DETECTED AT THE LOCATION REGARDLESS OF DEPTH AND DATE

References: Aerial photograph provided by City of Salina, imagery date 2010; data are those provided in electronic format by USACE prior to February 4, 2008; and Burns and McDonnell, 2007a, 2007b, and 2007c (refer to report).

SCALE

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SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 9
PROPOSED BORING LOCATIONS, PLUME E

File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Figs 8,9,11.dwg
Date: 7.9.2014

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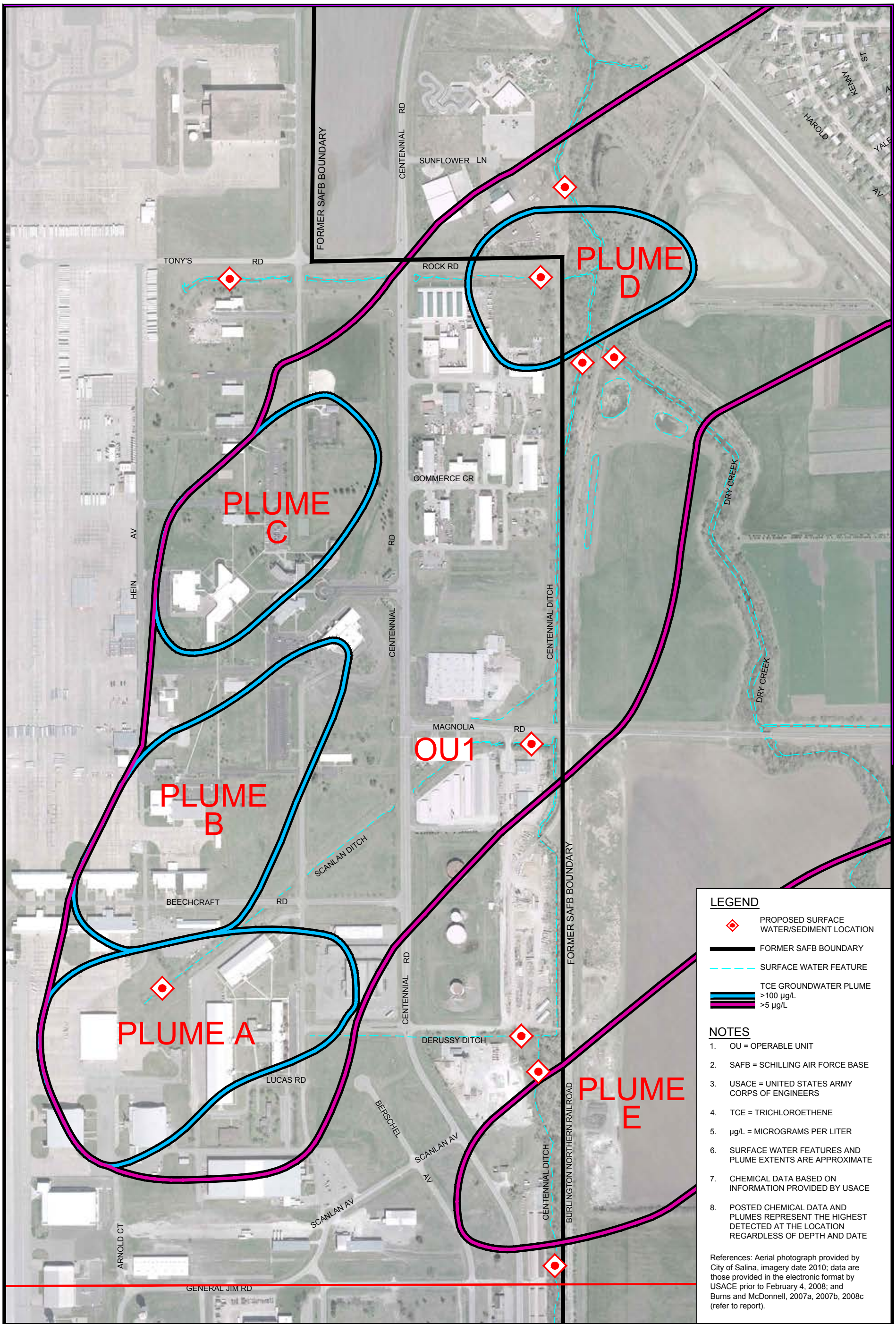

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SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 10
PROPOSED SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS, OU1

File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Fig 10.dwg
Date: 7.9.2014

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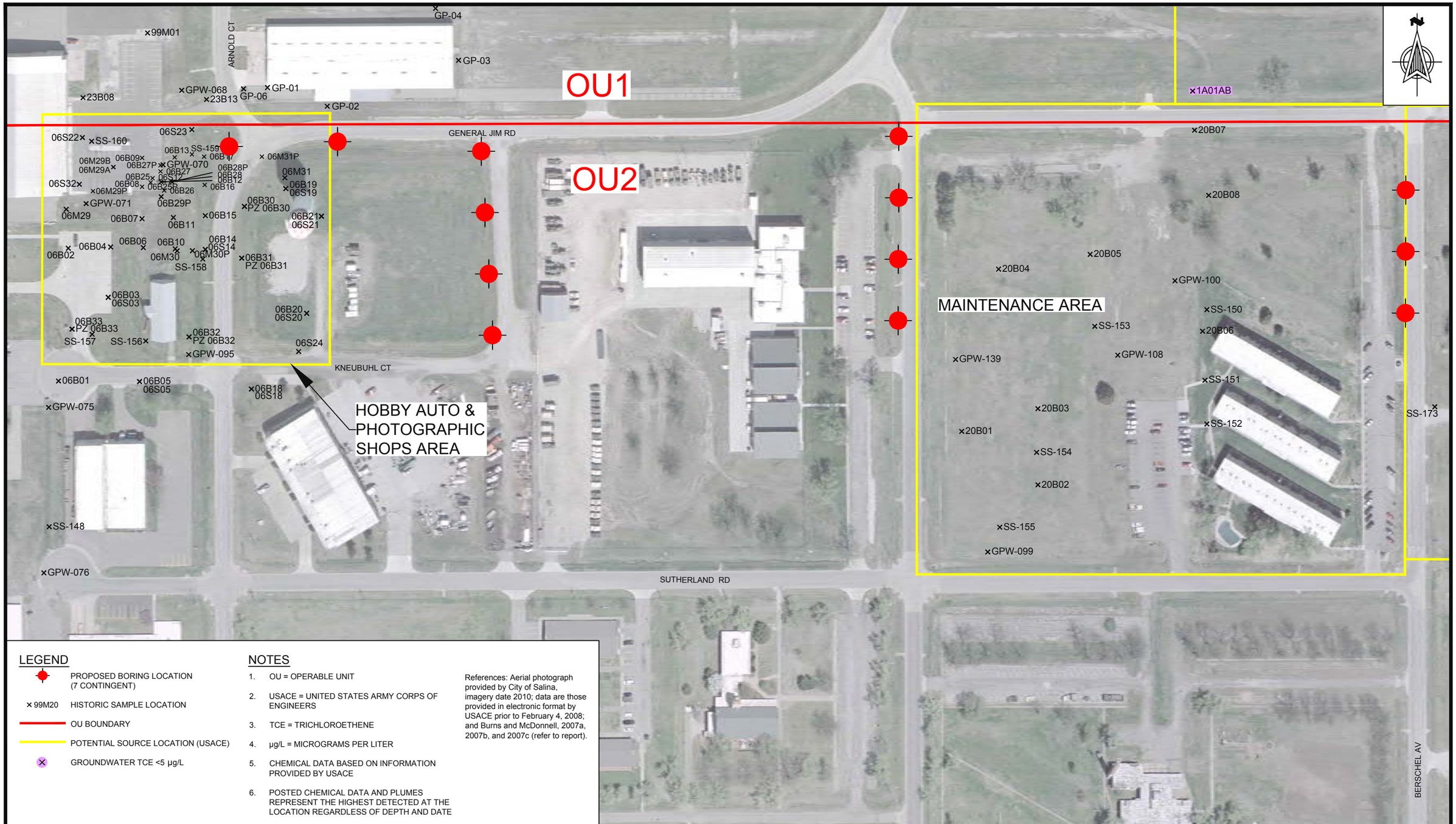

LEGEND

- PROPOSED BORING LOCATION (7 CONTINGENT)
- × 99M20 HISTORIC SAMPLE LOCATION
- OU BOUNDARY
- POTENTIAL SOURCE LOCATION (USACE)
- GROUNDWATER TCE <5 µg/L

NOTES

1. OU = OPERABLE UNIT
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3. TCE = TRICHLOROETHENE
4. µg/L = MICROGRAMS PER LITER
5. CHEMICAL DATA BASED ON INFORMATION PROVIDED BY USACE
6. POSTED CHEMICAL DATA AND PLUMES REPRESENT THE HIGHEST DETECTED AT THE LOCATION REGARDLESS OF DEPTH AND DATE

References: Aerial photograph provided by City of Salina, imagery date 2010; data are those provided in electronic format by USACE prior to February 4, 2008; and Burns and McDonnell, 2007a, 2007b, and 2007c (refer to report).

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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Figs 8,9,11.dwg

Date: 7.9.2014

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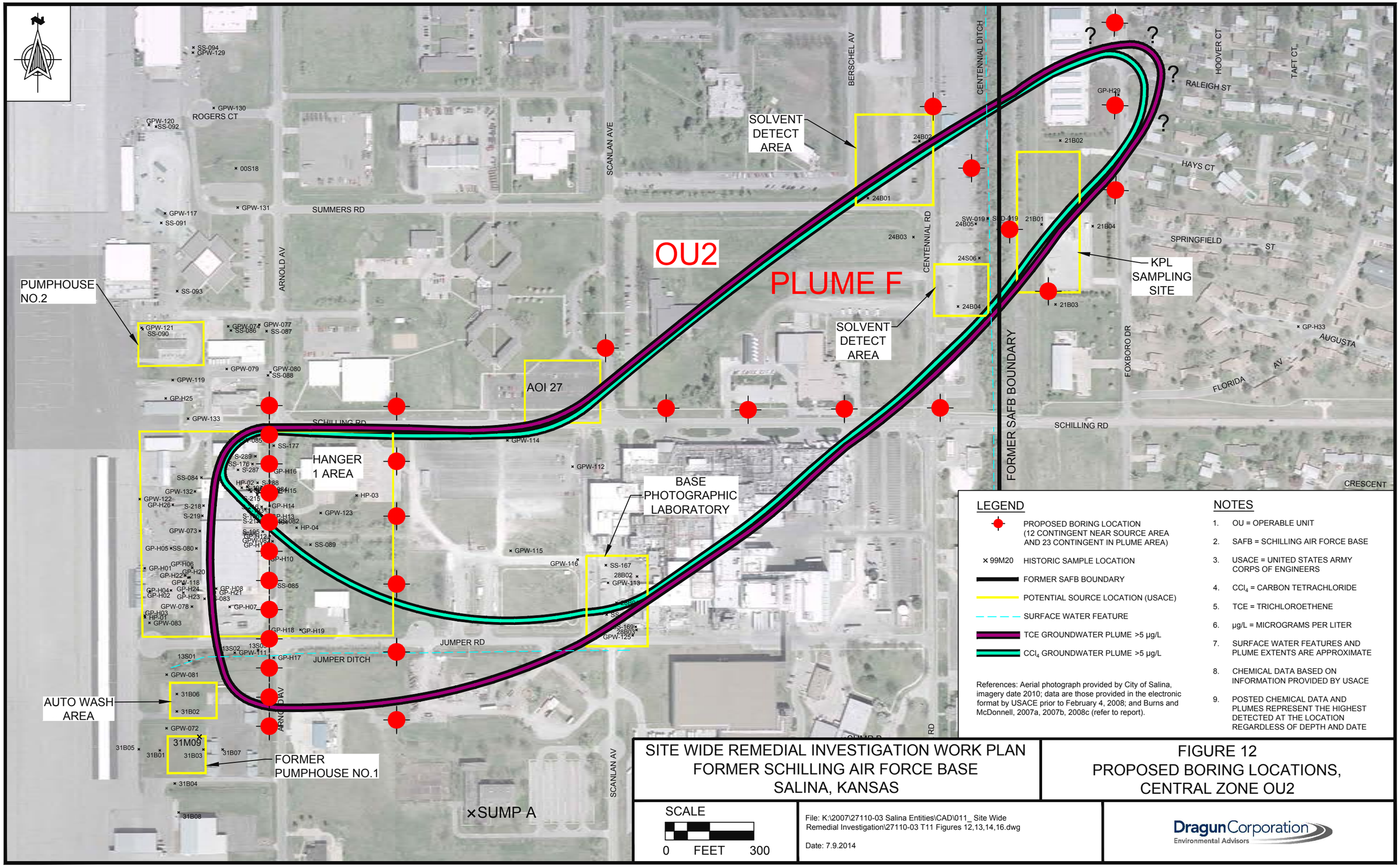
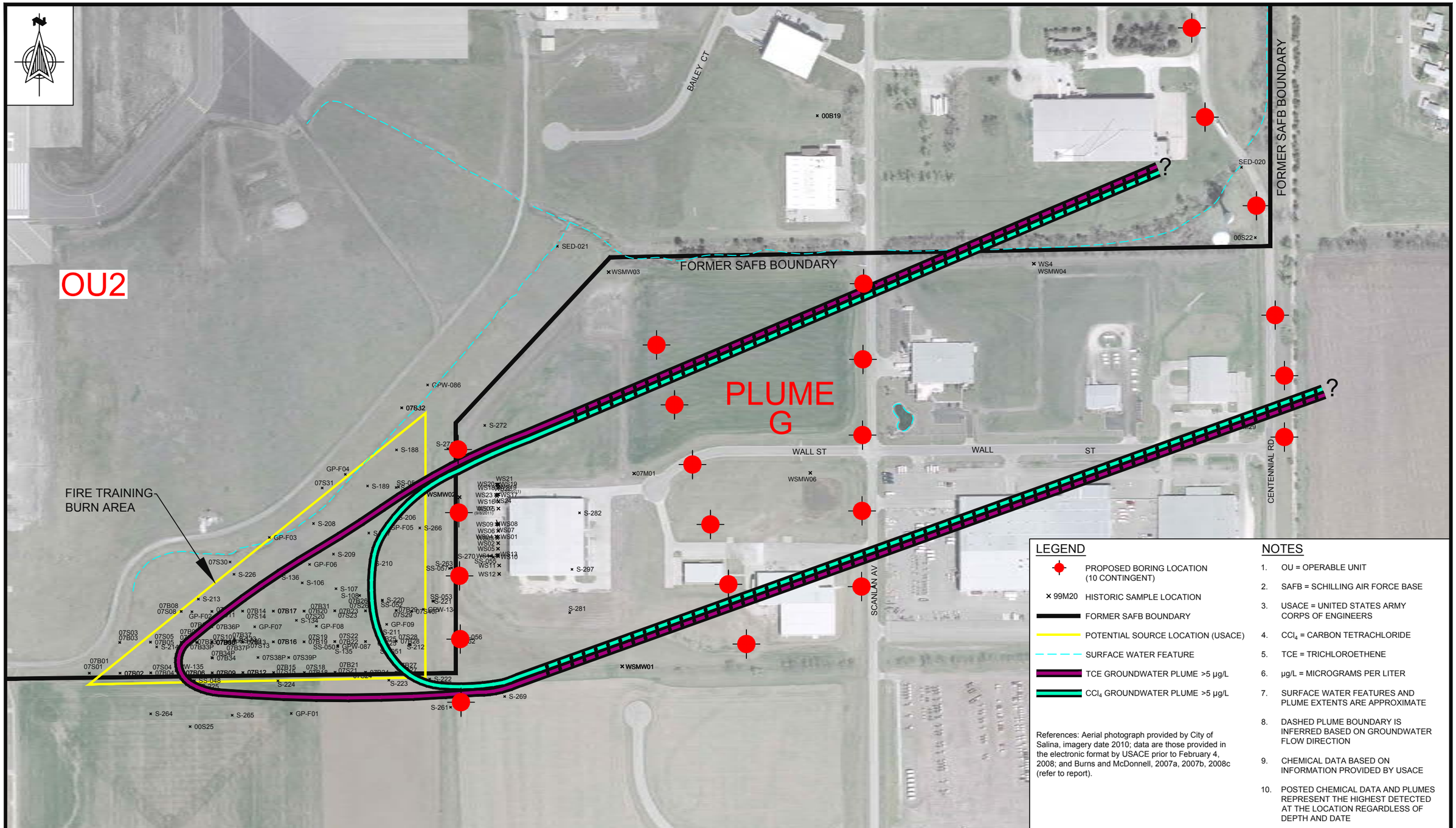
SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 11
PROPOSED BORING LOCATIONS,
NORTH ZONE OU2



SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 12
PROPOSED BORING LOCATIONS,
CENTRAL ZONE OU2



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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Figures 12,13,14,16.dwg

Date: 7.9.2014

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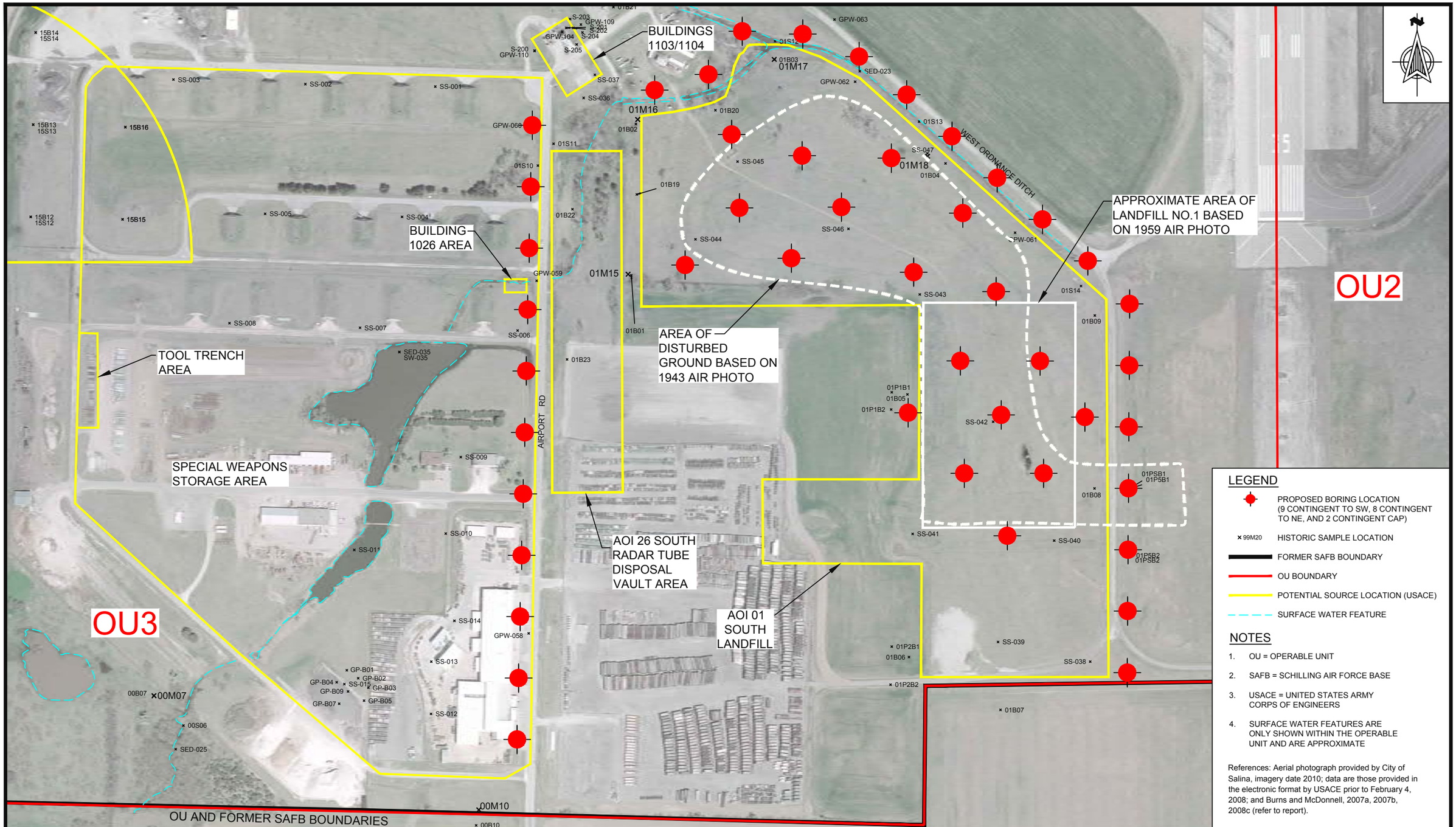
SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 13
PROPOSED BORING LOCATIONS,
SOUTH ZONE OU2



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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Figures 12,13,14,16.dwg

Date: 7.9.2014

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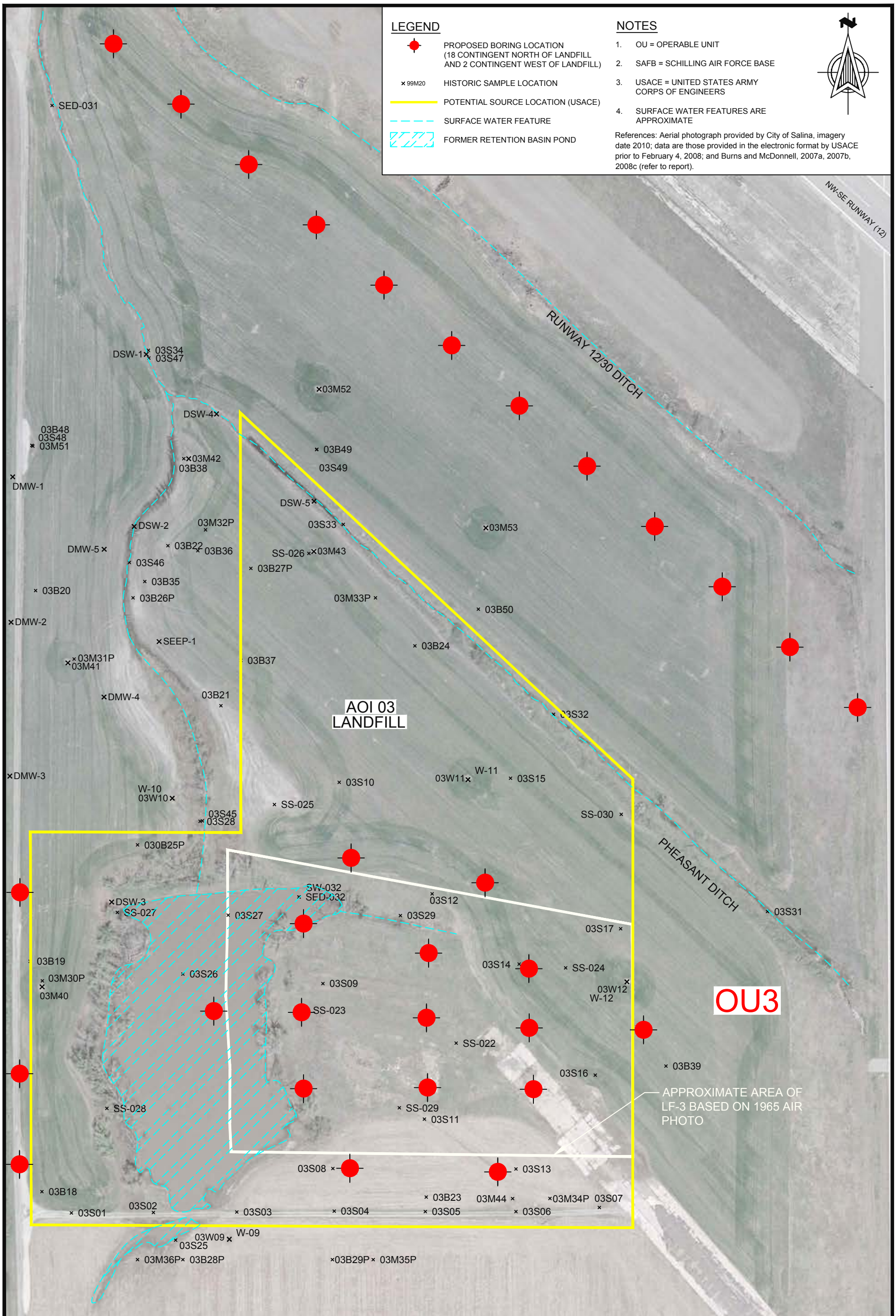
SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 14
PROPOSED BORING LOCATIONS, LANDFILL #1, OU3



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SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 15
PROPOSED BORING LOCATIONS,
LANDFILL #3, OU3

File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Fig 15.dwg
Date: 7.9.2014

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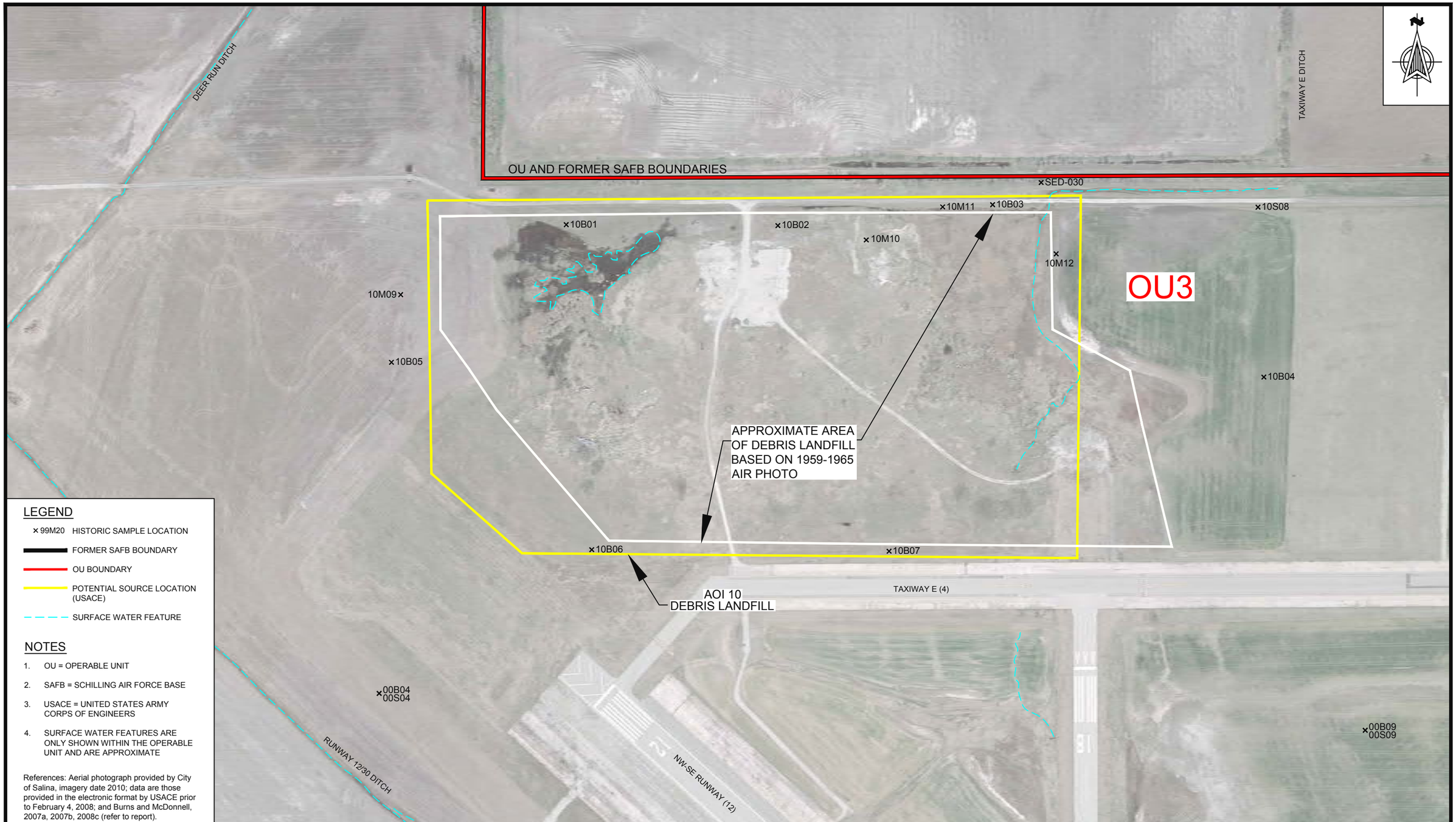

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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Figures 12,13,14,16.dwg

Date: 7.9.2014

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SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 16
DEBRIS LANDFILL, OU3

LEGEND

- PROPOSED BORING LOCATION
- × 99M20 HISTORIC SAMPLE LOCATION
- FORMER SAFB BOUNDARY
- OU BOUNDARY
- POTENTIAL SOURCE LOCATION (USACE)
- SURFACE WATER FEATURE
- FORMER RETENTION BASIN POND

NOTES

1. OU = OPERABLE UNIT
2. SAFB = SCHILLING AIR FORCE BASE
3. USACE = UNITED STATES ARMY CORPS OF ENGINEERS
4. SURFACE WATER FEATURES ARE ONLY SHOWN WITHIN THE OPERABLE UNIT AND ARE APPROXIMATE

References: Aerial photograph provided by City of Salina, imagery date 2010; data are those provided in the electronic format by USACE prior to February 4, 2008; and Burns and McDonnell, 2007a, 2007b, 2008c (refer to report).

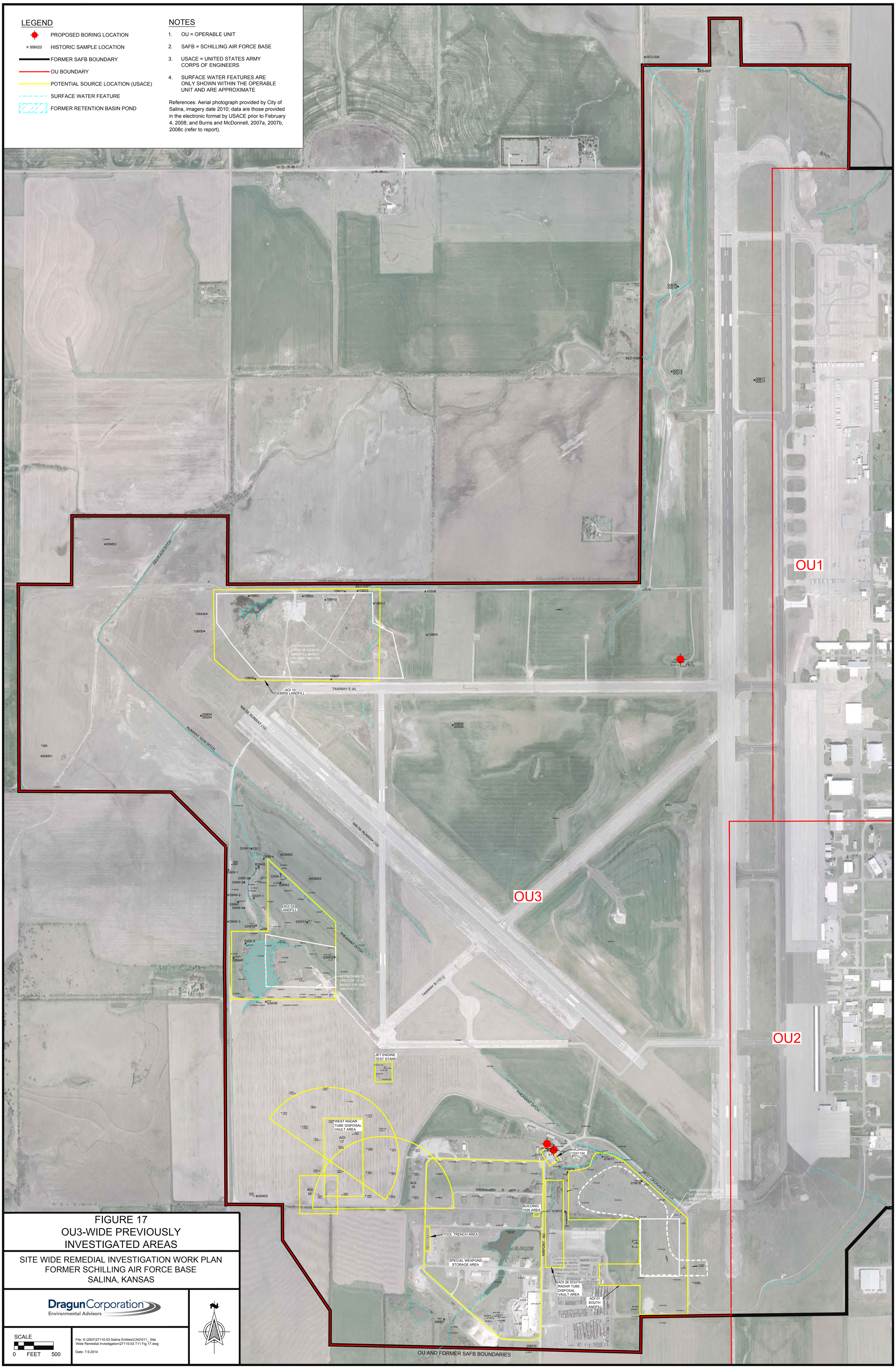

FIGURE 17
OU3-WIDE PREVIOUSLY INVESTIGATED AREAS

SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

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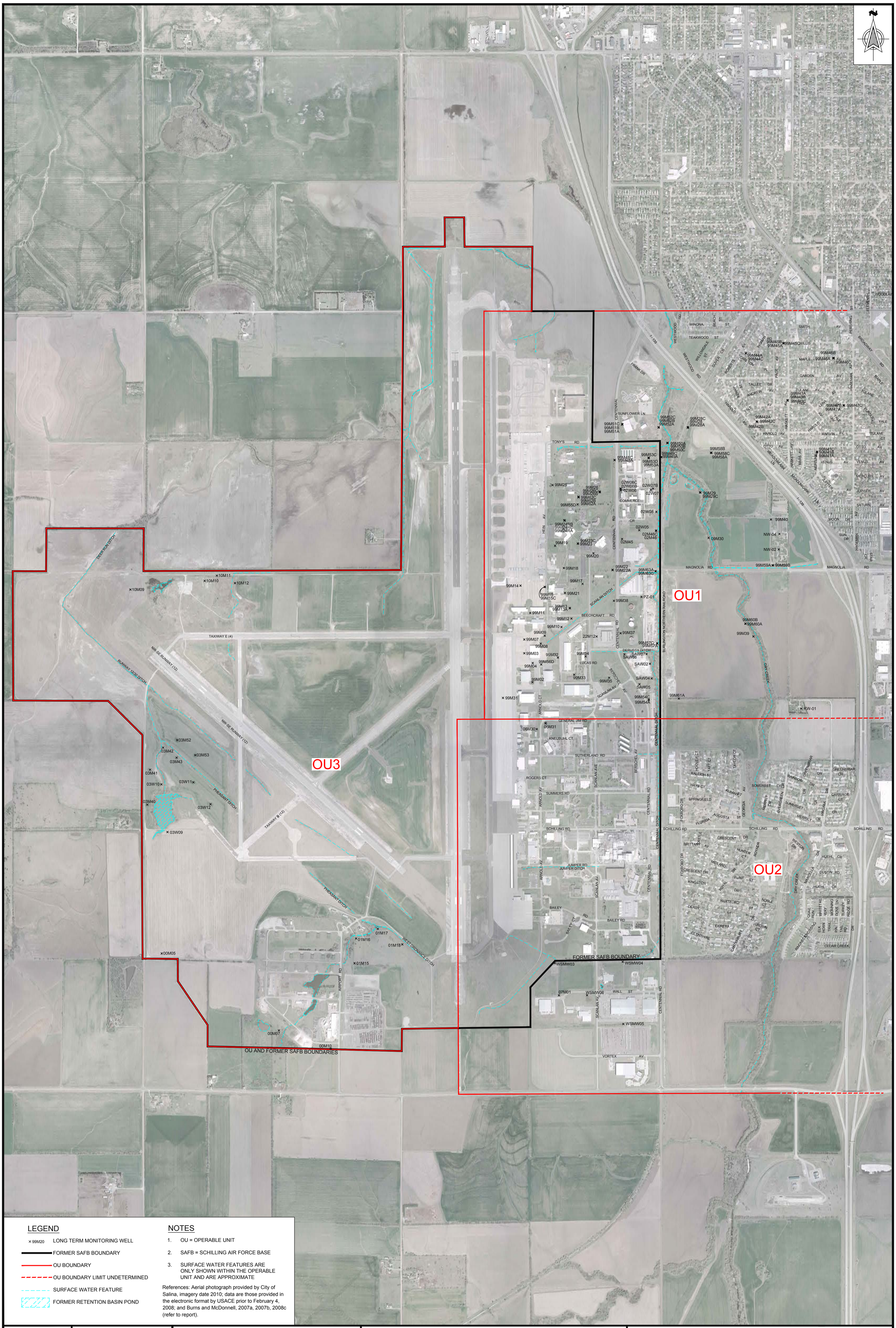
Date: 7.9.2014



LEGEND

- ×99M20 LONG TERM MONITORING WELL
- FORMER SAFB BOUNDARY
- OU BOUNDARY
- OU BOUNDARY LIMIT UNDETERMINED
- SURFACE WATER FEATURE
- FORMER RETENTION BASIN POND

NOTES

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3. SURFACE WATER FEATURES ARE ONLY SHOWN WITHIN THE OPERABLE UNIT AND ARE APPROXIMATE

References: Aerial photograph provided by City of Salina, imagery date 2010; data are those provided in the electronic format by USACE prior to February 4, 2008; and Burns and McDonnell, 2007a, 2007b, 2008c (refer to report).

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File: K:\2007\27110-03 Salina Entities\CAD\011_ Site Wide Remedial Investigation\27110-03 T11 Fig 18.dwg

Date: 7.14.2014

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SITE WIDE REMEDIAL INVESTIGATION WORK PLAN
FORMER SCHILLING AIR FORCE BASE
SALINA, KANSAS

FIGURE 18
LONG TERM MONITORING WELLS

Dragun Corporation
Environmental Advisors

30445 Northwestern Hwy., Suite 260, Farmington Hills, MI 48334 • Phone: 248.932.0228 • Fax: 248.932.0618

August 25, 2014

Ms. Maggie Weiser
Remedial Section
Bureau of Environmental Remediation/KDHE
Curtis State Office Building
1000 S.W. Jackson St., Suite 410
Topeka, KS 66612

SUBJECT: Final Remedial Investigation Work Plan
Addendum #1
Former Schilling Air Force Base
Salina, Kansas
Project #27110-03

Dear Ms. Weiser:

Pursuant to our telephone conversations on August 14 and 21, 2014, Dragun Corporation (Dragun) has prepared this Addendum #1 to the Final Remedial Investigation Work Plan (the Work Plan) for the Former Schilling Air Force Base in Salina, Kansas (Consent Agreement and Final Order (CAFO) for the environmental contamination, BER File No. C5-085-03013, CAFO Case No. 12-E-21 BER).

Background:

This addendum addresses monitoring well construction methods for the Work Plan:

- The agreed upon budget in the settlement between the Salina Entities and the United States of America assumed permanent monitoring wells would be installed using direct-push drilling methods.

- However, during discussions with KDHE about the Plume D Delineation Work Plan, Dragun understood that KDHE required minimum two-inch diameter, permanent monitoring wells (e.g. letter from Bob Jurgens, KDHE, to Matt Schroeder, Dragun, dated February 17, 2014, Comments 2d and 19).

As a result, Dragun revised the Draft, Draft Final, and, ultimately, the Final Work Plan such that no permanent monitoring wells would be installed using direct push.

- Dragun estimated that installing monitoring wells using hollow-stem auger or equivalent would cost our clients approximately $100,000 more than budgeted in the settlement. We informed our client, The Salina Entities, about this additional cost.

- The Salina Entities asked Dragun to ask KDHE for specific references that support KDHE's position on direct-push wells so they (the Salina Entities) could explain the additional costs to their respective boards.

- Dragun asked to speak with KDHE (email from Matt Schroeder to Bob Jurgens and Joe Dom, dated July 31, 2014) about this issue. Dragun researched the performance of direct-push monitoring wells, which indicated direct-push installed monitoring wells acceptable for most hydraulic and groundwater chemistry monitoring.

During our call with KDHE on August 14, 2014, Bob Jurgens indicated that Dragun can use direct-push monitoring wells because other divisions in KDHE have been using them. The purpose of this addendum is to describe where and how we intend to use direct-push monitoring wells.

<u>Monitoring Well Installation Revised – Includes Using Direct-Push Methods:</u>

This section of the letter is a revision of Section 8.3.b of the Work Plan:

8.3.b Permanent Monitoring Wells

Table 8.1 outlines the various components of typical permanent monitoring wells to be used during this investigation. Where modifications are required due to location-specific conditions, Dragun will contact KDHE in advance, if possible, and document any special conditions. Temporary monitoring wells, double-cased monitoring wells, and hand-driven monitoring wells will be modifications of the permanent monitoring well.

Table 8.1 is generally consistent with (1) KDHE Standard Operating Procedures BER-06 and BER-29 (see Attachment 1) and (2) Dragun SOPs 8.01.

No sooner than 24 hours following installation, the drilling contractor will develop the wells using either over-pumping, by alternately using pumping and a surge block, or equivalent. After each development cycle, the field geologist will check turbidity using a turbidity meter. Well development will continue until the turbidity value is less than 50 NTU or 90 minutes of development, whichever comes first. A minimum of five borehole volumes, casing plus annulus

(assumed 30% porosity), and three times any water added during construction will be removed during development. Well development details are provided in Dragun SOP 8.01.

Table 8.1 Typical Monitoring Well Construction

Well Component	Sub-component	Details and Description
Pipe	Riser (casing)	• if installed using a hollow-stem auger rig or similar, 2-inch inside diameter, Schedule 40 PVC plastic, flush joint threaded • if using direct-push technology, largest practical diameter using pre-pack screens, Schedule 40 PVC plastic, flush joint threaded • factory sealed • centralizers used for wells greater than 30 feet deep if not installed through HSA or temporary casing
	Screen	• if installed using a hollow-stem auger rig or similar, 5-foot long, 2-inch inside diameter, Schedule 40 PVC plastic, 10-slot screen, flush joint threaded. • if using direct-push technology, largest practical diameter using pre-pack screens, 5-foot long, Schedule 40 PVC plastic, 10-slot screen, flush joint threaded. Shorter screens may be used for formations less than five feet thick. • factory sealed
Annular Fill/Seal	Annular fill	• bentonite grout or cement-bentonite grout tremied from lower bentonite seal to surface • minimum 20 feet where possible
	Lower bentonite seal	• minimum 24-inch thick above sand pack • either bentonite chips or pellets, hydrated according to the manufacturers specifications, but not less than 30 minutes, if using a hollow-stem auger rig or similar. • pre-pack bentonite seal, minimum 24-inch thick above sand pack, hydrated according to the manufacturers specifications, but not less than 30 minutes, if using direct-push technology.
	Sand/gravel pack	• if using a hollow-stem auger rig or similar, minimum 2-inch thick, filled to 24 inches above top of screen, clean silica sand appropriate for 10-slot screen (1020 or 2040, depending on the formation and discussions with the driller) • if using direct-push technology, minimum 2-inch thick, filled to 24 inches above top of screen, thickest pre-pack assembly practical.
Protection	Lock	• lockable J-plug • all new wells keyed alike, locked on well completion
	Protective casing	• lockable 4-inch steel standup protective casing or flush mount casing • standup casings to extend 3 feet above grade • protective casings firmly set into concrete apron
	Concrete apron	• 2-3-foot square, minimum 5-inch thick • raised above normal ground level and sloped to shed precipitation
	Bollards	• as needed to protect standup casings • extend one foot above protective casing and painted for visibility
Other	Drainage	• location selected or modified to avoid ponding of runoff at well

Well Component	Sub-component	Details and Description
	North mark	• the north side of the inner casing of the monitoring well will be notched for subsequent water level measurements
	Documentation	• well details and hydrogeologic information logged by on-site geologist

Table 8.2 lists other monitoring well considerations for specific monitoring well use.

Table 8.2 Other Monitoring Well Considerations

Situation	Procedures
Water table well	• Screen straddles water table
Suspected LNAPL	• Screen straddles water table
Suspected DNAPL	• Screened at interface between hydraulic conductivity types
Monitoring well nest	• Screens at various depths, all in separate boreholes
Aquifer test – pumping well	• Longer screen • Fully penetrating aquifer if possible
Aquifer test – observation well	• Screened opposite middle of pumping well screen for aquifer parameter estimation • Screened in separate hydrostratigraphic units to evaluate connection
Stream piezometer	• Driven well point • Screen must be entirely below stream bed
Well Abandonment	• All monitoring wells will be abandoned according to procedures described elsewhere in this document.

<u>Monitoring Well Use:</u>

1. Dragun will use direct-push methods to install monitoring wells in all applications except:
    a. Wells used for determining hydraulic conductivity using single well methods (three monitoring wells in the South Zone, see Section 3.3).
    b. Wells greater than 50 feet deep.
    c. Sentinel wells.

    Tables 3.1a, 3.2a, 3.3a, 4.1a, and 4.2a are the tables that should include direct-push wells as a monitoring well installation choice.

2. Dragun will evaluate direct-push installed monitoring wells during each quarterly monitoring event to determine whether groundwater chemistry and groundwater elevation data are consistent with nearby monitoring wells installed by hollow-stem auger or sonic methods. Dragun will report the results of this analysis to KDHE.

If you have any questions about this work plan addendum or any other issues, please call one of us at 248-932-0228.

Sincerely,

DRAGUN CORPORATION

Matthew C. Schroeder, P.E.
Project Manager

Michael G. Sklash, Ph.D., P.Eng
Senior Hydrogeologist

MCS/MGS/amr

cc: Bob Jurgens, KDHE
Joe Dom, KDHE
Martha Tasker, City of Salina
Mark Johnson, Stinson Leonard Street, LLP