TINKER AFB RCRA PERMIT

ATTACHMENT 7 - CORRECTIVE ACTION STRATEGY WORKPLAN

(Attached on CD)

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ATTACHMENT 7

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Corrective Action Strategy Workplan

For Tinker Air Force Base Oklahoma City, Oklahoma

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Note: Figures and Tables are inserted within the text.

Acronyms and Abbreviations

AF	Air Force
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
AFR	Air Force Regulation
AOC	Area of Concern
AWACS	Air Warning and Control System
B3001	Building 3001
BTEX	Benzene, Toluene, Ethyl benzene and Xylene
CAO	Corrective Action Objective
CAS	Corrective Action Strategy
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CGMU	Contaminated Groundwater Management Unit
CMS	Corrective Measures Study
COA	Central Oklahoma Aquifer
COCs	Contaminants of Concern
Cr	Chromium
CRP	Compliance Restoration Program
CVOC	Chlorinated Volatile Organic Compound
CSM	Conceptual Site Model
DCA	1,2-Dichloroethane
DCE	Cis-1,2-Dichloroethene
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DMM	Discarded Military Munitions
DQOs	Data Quality Objectives
EISB	Enhanced In Situ Bioremediation
ERPIMS	Environmental Restoration Program Information Management System
EVO	Emulsified Vegetable Oil
FFA	Federal Facilities Agreement
FPF	Fuel Purge Facility
FTA	Fire Training Area
FTMF	Fuel Truck Maintenance Facility
GTS	Geostatistical Temporal/Spatial
GWMU	Groundwater Management Unit

GWMSU	Groundwater Management Sub-Unit
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
IC	Institutional Control
ICM	Interim Corrective Measure
IRP	Installation Restoration Program
JETC	Jet Engine Test Cells
LUC	Land Use Control
LSZ	Lower Saturated Zone
LLSZ	Lower-Lower Saturated Zone
LTM	Long-Term Monitoring
MAAC	Maximum Ambient Air Concentration
MC	Munitions Constituents
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
MMRP	Military Munitions Response Program
MNA	Monitored Natural Attenuation
NCP	National Contingency Plan
NDL	North Drain Line
NFA	No Further Action
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OCC	Oklahoma Corporation Commission
ODEQ	Oklahoma Department of Environmental Quality
OSDH	Oklahoma Department of Health
OU	Operable Unit
OWRB	Oklahoma Water Resources Board
PCBs	Polychlorinated Biphenyls
PCE	Perchloroethene (also tetrachloroethene)
PDD	Positive Differential Displacement
POC	Point of Compliance
POL	Petroleum, Oil, Lubricants
PRB	Permeable Reactive Barrier
PZ	Producing Zone
P & T	Pump and Treat
QAPPs	Quality Assurance Project Plans

RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RIP	Remedy in Place
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SB	Statement of Basis
SDL	South Drain Line
SOP	Standard Operating Procedure
SVOCs	Semi-Volatile Organic Compounds
SWMU	Solid Waste Management Unit
SWTP	Sanitary Wastewater Treatment Plant
TAC	Toxic Air Contaminant
TAC1	Tinker Aerospace Complex
TCE	Trichloroethene
TCLP	Toxicity Leaching Characteristic Procedure
TVA	Tinker View Acres
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
USZ	Upper Saturated Zone
UXO	Unexploded Ordnance
VC	Vinyl Chloride
VEP	Vacuum Enhanced Pumping
VI	Vapor Intrusion
VOCs	Volatile Organic Compounds
WBZ	Water Bearing Zone
WSW	Water Supply Well

1.0 INTRODUCTION

This document presents the Corrective Action Strategy (CAS) Workplan for Tinker Air Force Base (Tinker AFB). Tinker AFB is located in central Oklahoma, approximately five miles southeast of downtown Oklahoma City. The Base is bounded on the west by Sooner Road, on the east by Douglas Boulevard, on the north by Interstate 40, and on the south by Southeast 74th Street. The CAS was developed in accordance with the August 2017 updated Section 10 of the Tinker AFB Permit Renewal Application using the Environmental Protection Agency (EPA) Corrective Action Strategy Guide, February 2015. The following information was obtained from existing reports, studies, and the current permit application and is reflective of 2017 conditions.

Tinker AFB is situated on a relatively flat expense of grassland. Prior to the development of the Base, the area was characterized by large tracts of private agricultural land. The Base currently occupies approximately 4,277 acres of semi-improved and unimproved grounds that are used for the airfield, golf course, housing area, offices, shops, and other uses characteristic of military installations. Property surrounding the Base includes residential, industrial and non- industrial businesses, and agricultural areas. Potential receptor populations include those related to off-base residences with private water wells, industrial facilities and other businesses with private wells where potable water might be available, potentially wells used for agricultural purposes such that crops may become contaminated, as well as on-base residents and workers. Municipal and private wells tap into a portion of the Garber-Wellington Aquifer, a subset of the Central Oklahoma Aquifer, the primary groundwater source in the area. Lake Stanley Draper, a local surface water supply reservoir with a small portion of its drainage basin located in the southeast part of Tinker AFB, is also used for recreational purposes and as a surface water supply for local municipal wells. Local streams, such as Soldier Creek and Crutcho Creek, which either transect the Base or have tributaries that extend onto the Base, may be used for recreation and fishing downstream. A vicinity map is attached as Figure 1-1.

Tinker AFB's mission is dedicated to providing worldwide technical logistics support to Air Force aerospace weapon systems, equipment, and commodity items, and encompasses a myriad of responsibilities. The logistics center manages or maintains the B-1B, B-2, B-52, E-3, and the C/KC-135 series aircraft. It performs annual depot-level maintenance on more than 120 aircraft and overhauls and maintains more than 1,100 engines from 11 major commands, as well as the Army, Navy, and numerous foreign countries. The center also manages various missile systems, and is the planned depot for the next generation refueling tanker, the KC-46A. Tinker AFB also accommodates a large family of associate organizations representing several major commands. Two large Air Combat Command support units add to the complex mission of the Base. Tinker AFB is the home operating base for the 552nd Air Control Wing flying the E-3 Sentry, and the Air Force Reserve's 507th Air Refueling Wing. Tinker AFB is also home to the Navy's E-6A Strategic Communications Wing One.

Tinker AFB has been and remains a major industrial complex for overhauling, modifying, and repairing military aircraft, aircraft engines, and accessory items. Base operations began in 1942 and

certain activities employing hazardous materials resulted in the generation of hazardous wastes. These wastes have included spent organic solvents, waste oils, waste paint strippers and sludge, electroplating wastewater and sludge, alkaline cleaners, acids, jet fuels, and radium paints. Wastes that currently are generated are managed at two permitted hazardous waste storage facilities. However, prior to enactment of the Resource Conservation and Recovery Act of 1976 (RCRA), industrial wastes were discharged into unlined landfills and waste pits, streams, sewers, and ponds. Past releases from these areas and from underground storage tanks (USTs) have occurred, resulting in soil, groundwater, and surface water contamination.

This CAS workplan includes investigative work, corrective measures, potential corrective measure activities, basewide groundwater monitoring and groundwater monitoring well optimization (plug and abandon) to remove source material, ensure containment of groundwater plumes and measure the effectiveness of the system.

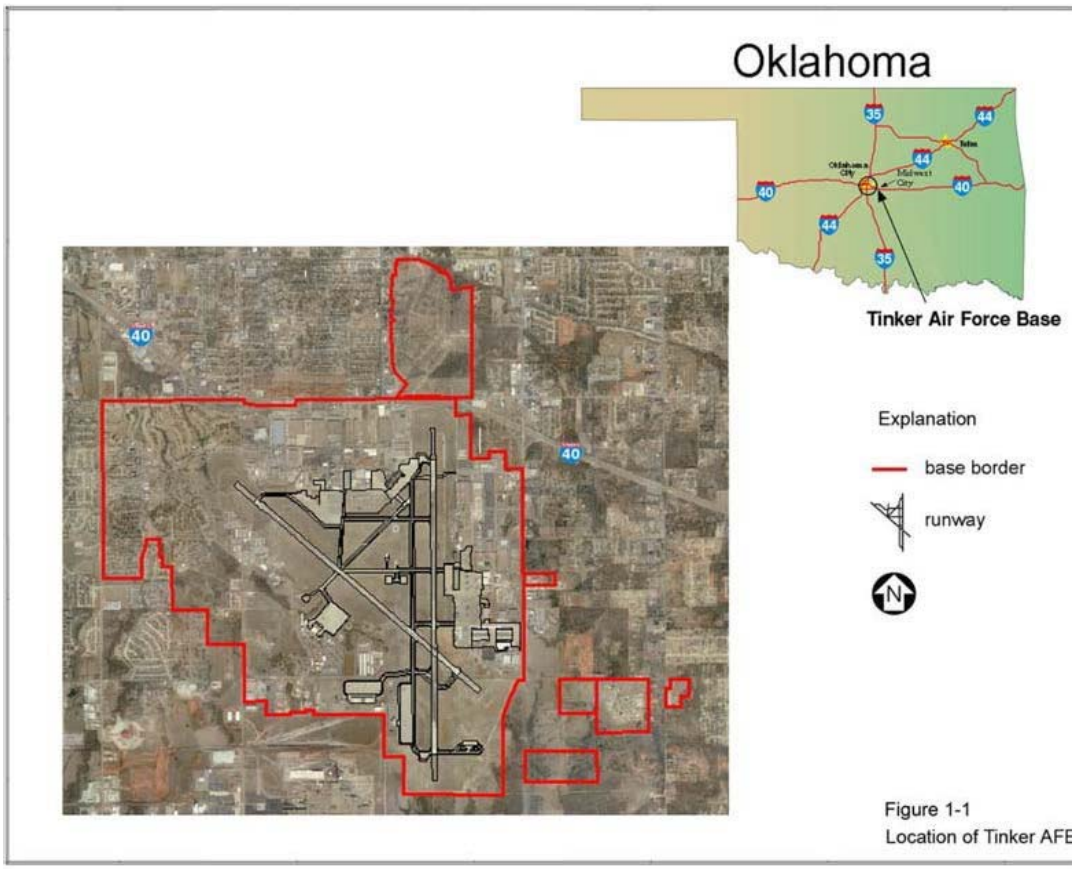

Figure 1-1
Location of Tinker AFE

1.1 OBJECTIVES

1.1.1 CAS WORK OBJECTIVES

This CAS Workplan outlines the following CAS work elements:

- CAS Implementation Strategy (Section 2.0)
- Proposed Site Investigations and Scope of Work (Section 3.0)
- Assessment of Solid Waste Management Units (SWMUs) (Section 4.0)
- Sampling and Analysis Plan (Section 5.0)
- CAS Management and Organization (Section 6.0) and
- CAS Implementation Schedule

1.1.2 DATA GAPS AND INFORMATIONAL NEEDS

A significant amount of site characterization data is available to proceed through the CAS process. In general, the releases at the facility have been well characterized. Additionally, groundwater interim measures have already been implemented and/or completed. Execution of the CAS will focus on the following actions:

- Initiate and complete the investigative efforts (RFI site report) for the following sites: AOC # 20 – Building 201 Vapor Intrusion (AF Site ST008), AOC #25 – Building 210.
- Complete the investigative efforts (RFI site reports) for the following sites: AOC #1 – 290 Fuel Farm (AF Site ST007), AOC #22 – AWACS Sector (AF Site CG041), AOC #23 – Jet Engine Test Cell (AF Site OT058), AOC #24 – Building 230 (AF Site OT062), AOC #26 – Buildings 283, 284 & 296, AOC #29 – Replaced Fuel Hydrant System (AF OT068), AOC #30 – Buildings 2121 & 2122 and AOC #32 – Building 3105.
- Initiate and complete a corrective measure study for any site recommended by a site RFI report.
- Implement any corrective measure clean up activity recommended and approved by a site Statement of Basis.
- Achieve Response Complete at the AOC #21 – Gator Groundwater Management Unit (AF Site CG040).
- Complete a non-time critical soil and Oil Water Separator removal at AOC #27 – Building 2110 (AF site OT066) unless it is removed through Demolition of Building 2110.
- Complete a non-time critical soil removal at AOC #28 – Building 2101 (AF Site OT067).
- Continue the corrective measures – chlorinated volatile organic compound concentration reduction at AOC #31 – Area A Service (Fuel) Station (current AF Site CG037 aka ST033) and reduction at groundwater treatment plan related plumes beneath Landfills 1 – 4.
- Complete a non-time critical soil removal at AOC #24 – Industrial Waste Treatment Plant (IWTP) Soils (AF Site OT034).

- Continue to monitor and maintain the RCRA landfill caps at SWMU #1 Landfill 6 (AF Site LF016), SWMU #2 – Landfill 5 (AF Site LF015), SWMU #3 – Landfill 1 (AF Site LF011), SWMU #4 – Landfill 2 (AF Site LF012), SWMU #5 – Landfill 3 (AF Site LF013) and SWMU #6 – Landfill 4 (AF Site LF014).
- Continue to conduct base-wide groundwater monitoring program per the Groundwater Management Units (GWMU), Northwest GWMU (AF Site CG037), Southwest GWMU (AF Site CG038), East GWMU (AF CG039) and NPL GWMU (AF Site OT001).
- Remove interim vapor extraction and groundwater extraction systems no longer being used.

1.2 WORKPLAN ORGANIZATION

2.0 CAS IMPLEMENTATION STRATEGY

2.1 CAS IMPLEMENTATION ACTIVITIES

Tinker Air Force Base has conducted corrective action activities within the installation since 1981; a significant amount of site characterization data is available to proceed through the CAS process. Groundwater interim actions have already been implemented and/or completed. Area (sites) needing continuing corrective action will be reviewed, and objectives stated and/or updated to achieve closure standards. The proposed strategy for using CAS includes:

- Holding a Scoping Meeting;
- Using the UFP-QAPP for Data Objective and Data Types;
- Continuing any active Interim Corrective Action Measures as necessary;
- Using the Risk-Based Priority Screening Procedures developed in the UFP-QAPP;
- Defining Site-Specific Risk criteria;
- Define Site-Specific Risk-Based Corrective Action Goals;
- Implementing Site-Specific Risk-Based Corrective Action when necessary;
- Continuing Basewide Groundwater Monitoring Program; and
- Obtaining No Further Action status or Closure Status.

2.2 CONCEPTUAL SITE MODEL SUMMARY

2.2.1 FACILITY SITE CONDITION

The Air Force implemented the Installation Restoration Program at Tinker AFB in July 1981. Since that time, the Air Force has maintained ongoing activities in environmental cleanup at Tinker AFB and has been committed to identification, investigation, and remediation of sites under the IRP and any other environmental restoration programs aimed at ensuring the health and safety of potential receptors. The following summary includes excerpts from the Tinker AFB Conceptual Site Model, AFCEC/CZOW (Bowen) December 2017.

The hydrogeology at and around Tinker Air Force Base is complex. Geologic units consist of Permian redbeds deposited as terrestrial and shallow sea sediments around 230 to 280 million years ago. The nature of these strata plays a significant role in both horizontal and vertical migration of contamination at the Base. Surface strata consist primarily of the Hennessey Group and the Garber Sandstone. The Wellington Formation, which together with the Garber Sandstone makes up the Garber-Wellington Aquifer, underlies the Garber Sandstone but outcrops east of the Base. The Garber-Wellington Aquifer is a subset of the Central Oklahoma Aquifer (COA), which underlies a large portion of central Oklahoma, including Oklahoma City.

The Garber Sandstone and the Wellington Formation have similar lithologies. In central Oklahoma, these units consist of lenticular beds of fine-grained, cross-bedded sandstone interbedded with siltstone and mudstone. Both of these formations were deposited in a fluvial- deltaic environment at the margin of a broad Permian basin located to the west. A Permian delta is reported to have existed generally in the vicinity of Oklahoma County. Because the units are lithologically similar and devoid of fossils or key beds, the Garber Sandstone and the Wellington Formation are difficult to distinguish; informally they are known as the Garber- Wellington. Together, these two units are approximately 1,000 to 1,200 feet thick at Tinker AFB.

Correlation of geologic units is difficult due to the discontinuous nature of the sandstone and mudstone beds. However, cross-sections demonstrate that two stratigraphic intervals can be correlated over large sections of the base in the conceptual model. These intervals are represented the numerous geologic cross-sections developed for the base. The first, and shallowest, correlatable interval is the contact between the Hennessey Group strata and the underlying Garber Sandstone. The next deeper interval that can be correlated across the Base is an aquitard (USZ/LSZ aquitard), which is delineated by a series of inter-bedded and overlapping finer grained (mudstone/siltstone) layers that separate an upper saturated zone (USZ) from deeper groundwater in a lower saturated zone (LSZ; the separation is defined by a significant potentiometric head difference of up to 40 feet that indicates the presence of a downward vertical flow component within these strata. This interval is mappable over the entire Base, although the difference in head decreases to the west. The third interval consists of a deeper zone of interbedded and overlapping mudstones within the Garber Sandstone which in places is comprised of a single shale layer and in other places of multiple shale layers and is defined by an even larger potentiometric head difference of up to 70 feet. This interval hydraulically separates the LSZ from the underlying producing zone (PZ), is more continuous than other shale intervals other than the USZ/LSZ aquitard, and in cross-sections appears mappable over a large part of the base. It is extrapolated under the central portion of Tinker where little well control exists. Stratigraphic correlations are based primarily on comparing geophysical logs in many monitoring wells, are continually tested by new well data, and are supported by water level data. A set of nearly 100 cross sections was generated over time; these have been hydrogeologically ‘tied’, The surficial geology of the north section of the Base is dominated by the Garber Sandstone, which

crops out across a broad area of Oklahoma County. Generally, a thin layer of soil and/or alluvium up to 20 feet thick covers the Garber Sandstone. To the south, the Garber Sandstone is overlain by outcropping strata of the Hennessey Group, including the Kingman Siltstone and the Fairmont Shale. Subsurface data acquired during geotechnical investigations and monitoring well installations confirm the presence of these units.

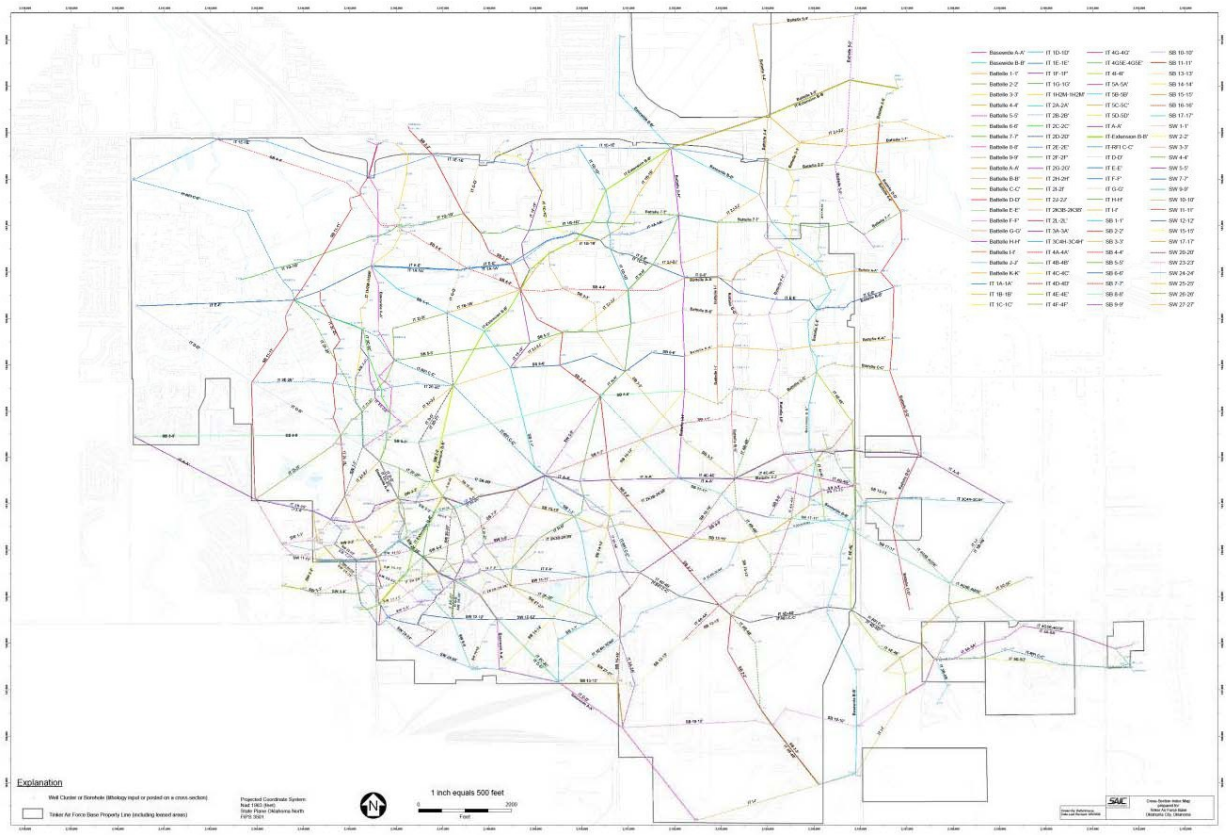

Figure 2.2.1 Cross Section Index Map

The most important source of potable groundwater in the Oklahoma City metropolitan area is the Central Oklahoma Aquifer (COA) System. Two of the primary water-bearing units of this system include the Garber Sandstone and the Wellington Formation. Together, they are commonly referred to as the Garber-Wellington Aquifer and are considered to form a single aquifer because the units were deposited under similar conditions and because many of the best producing wells are completed in this zone. Tinker AFB obtains much of its water from this source while local municipalities (Oklahoma City, Del City, Midwest City) have switched primarily to surface water

sources. The Base water supply wells (WSWs) are screened or perforated at depths of 200 to 750 ft below ground surface (BGS).

2.2.1.1 LOCAL HYDROGEOLOGY

Current (March 2015) potentiometric surface maps of the HWBZ, the USZ, the LSZ, and the LLSZ have been generated using over 1,200 existing monitoring wells and piezometers on Tinker AFB. These maps are revised each time that a Basewide Sampling and Water Level Measurements event is completed; maps can be compared over the years to help understand annual (and in some cases seasonal) variations in water levels in the different saturated zones. A PZ potentiometric map is not included since available well coverage in that zone is limited. The following text discusses each of these zones, including the PZ. The USZ, LSZ, and LLSZ potentiometric maps include isopleth contours for TCE, PCE, cis-1,2-DCE, Vinyl Chloride and 1,2-DCA in each zone as well as hexavalent chromium in the USZ. No plumes are included on the HWBZ figure since there is no mapped contamination in that zone. Figure 2.2.2 is an example cross-section that provides a basic conceptual representation of the saturated zones.

The Hennessey Group at Tinker AFB does not have a recognized aquifer but some saturation, identified as the Hennessey Water Bearing Zone (HWBZ) does exist. The HWBZ is absent in the northeastern portion of the Base where the Hennessey strata are thin. Three aquifer zones (in descending order) have been identified for the Garber Sandstone and Wellington Formation (Garber-Wellington Aquifer) under Tinker AFB; these zones are part of the regional Garber- Wellington Aquifer. The zones include the Upper Saturated Zone (USZ), the Lower Saturated Zone (LSZ), and the Producing Zone (PZ). The LSZ has been subdivided into an upper and lower (Lower- Lower Saturated Zone) to address a significant downward component of groundwater flow in the LSZ, which is noted within the aquifer under Tinker AFB. The magnitude of this vertical flow component varies across the Base and is much less under the western one-third of Tinker AFB where the overlying Hennessey Group is thicker. The HWBZ is present in the southwestern portion of Tinker AFB where the Hennessey Group thickens and becomes locally saturated with groundwater. The hydraulic conductivity is low; hydraulic conductivity (slug) test data indicate it is generally less than 0.5 ft/day. The HWBZ is not considered a significant source of drinking water. The unit receives recharge from precipitation where it is exposed at the surface, at localized areas where sandstone outcrops at the surface, and in locations of desiccation cracks with higher conductivity.

Generally, groundwater in this unit flows toward lower topographical elevations. In some areas, potentiometric lows mapped in the HWBZ are coincident with potentiometric highs on the USZ surface and suggest that vertical downward flow paths exist between the two zones. Downward vertical flow (and possibly lateral flow) and communication with the USZ are enhanced by the

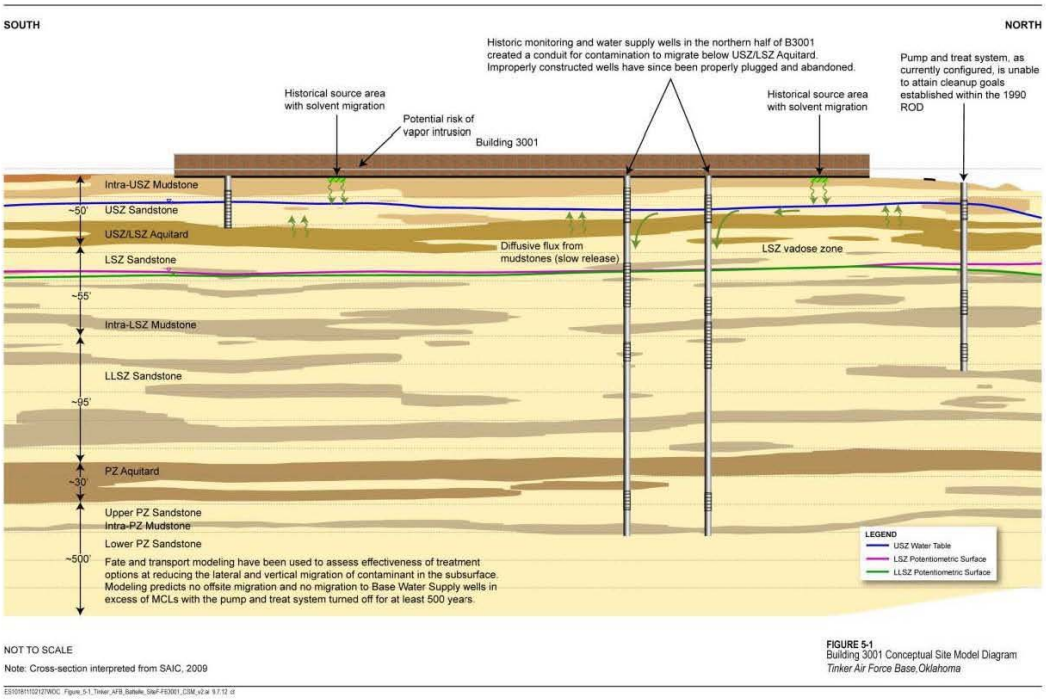

Figure 2.2.2 Conceptual Cross-Section (Building 3001 NPL Site)

presence of desiccation cracks where the Hennessey Group is 30 feet or less in thickness. The estimated 20 foot isopach thickness is the approximate limit of saturation (HWBZ) within this geologic unit. Locally however, where the Hennessey is less than 20 feet thick, some thin, perched saturated zones may exist.

The USZ is the uppermost saturated zone of the Garber-Wellington Aquifer and is delineated from the LSZ by a basal aquitard. The USZ is approximately 50 feet thick, measured from the base of the overlying Hennessey Group to the base of the underlying aquitard, except where portions have been removed by erosion along down-cutting streams such as Crutcho Creek.

The saturated portion typically ranges from less than 1 foot to 20 feet thick, and truncates along a line extending from near the Base boundary and the westward toward Douglas Boulevard to just west of West Soldier Creek in the northeast part of the Base, looping through the old Kimsey Addition located north of Building 3001, and turning northwestward around the north end of Runway

17/35. Truncation of the saturated zone is primarily due to westward geologic dip and stream erosion. Desiccation cracks are also present in the USZ where it is exposed at the surface. Vertical contaminant transport from surface spills may impact deeper portions of the USZ more quickly due to the presence of desiccation cracks. Open desiccation cracks would provide relatively little resistance to water and contaminant infiltration, and movement through the desiccation cracks in the unsaturated USZ could berapid.

The USZ has a large areal extent and occurs throughout Tinker AFB except in a small part of the northeast quadrant and east of the Base where Soldier Creek has eroded the Garber Sandstone to a point below the basal aquitard. Over much of the Base, the USZ occurs under unconfined conditions. In some areas, such as where fractures in the overlying Hennessey Group extend at depth, it may also be semi-confined. An orange line on the USZ potentiometric surface map, Figure 3, reflects the approximate up-dip extent of saturation in this zone. The extent of saturation has been confirmed by monitor well drilling as well as by comparing the elevation of several surface water bodies east of the Base to groundwater elevations in USZ wells located near them.

The USZ becomes confined in the farthest southwestern corner of the Base and to the west of the Base where it is locally confined by the overlying Hennessey Group. The depth to the top of the USZ potentiometric surface ranges from near the land surface in the northeastern portion of the Base where streams have cut deep enough (portions of Crutcho Creek and Kuhlman Creek) to 70 ft BGS in the southwestern portion of the Base. Hydraulic conductivity test data yield values that range from 0.04 to 6.7 ft/day.

Groundwater flow in the USZ under Tinker AFB is generally to the west or southwest due to geologic dip. However, local variations in flow direction exist on the western part of the Base, due either to structural features related to the Oklahoma City Anticline or to the presence of Crutcho Creek, and on the eastern part of the Base due to a leaky aquitard at the base of the USZ or man-made features. Locally, surface discharge of USZ groundwater occurs where creeks have eroded into the top of the Garber Sandstone, such as to Crutcho and Kuhlman Creeks in the northwest part of the Base, but most shallow groundwater leaves Tinker AFB as groundwater in the aquifer flowing southwestward. Eastward shallow groundwater flow off of the Oklahoma City Anticline is identified west of Crutcho Creek and locally at the eastern edge of the Base due to local groundwater mounding under Building 3001.

Numerous mudstone layers, which act as local aquitards, exist within the Garber-Wellington Aquifer saturated units. Most do not extend over great distances. However, two mudstone layers occur on a semi-regional basis under Tinker AFB; these are more laterally continuous and actually function as semi-regional aquitards. The uppermost aquitard occurs between the USZ and LSZ and is referred to as the USZ/LSZ aquitard. The second aquitard occurs between the LSZ and PZ and is referred to

as the PZ aquitard. These aquitards, however, do not consist of a single continuous mudstone unit. Instead, they are zones composed of interbedded mudstones and fine sandstones and siltstones with a higher proportion of clay relative to sand. They are recognized by significant groundwater pressure head differences (up to 70 feet of head difference across the PZ aquitard for example) at a well cluster location where wells are screened above and below the layers.

The USZ/LSZ aquitard is composed of overlapping discontinuous mudstone lenses with interbedded thin sand lenses. The aquitard interval varies in thickness from less than 10 feet to greater than 25 ft. A vadose zone exists under the eastern third of Tinker AFB between the base of the USZ/LSZ aquitard and the saturated portion of the LSZ. This vadose zone is roughly 10 to 20 feet thick in the northeastern portion of the Base, but thin s to the west and is no longer present west of north-south runway (Runway 17/35) where the LSZ potentiometric surface intersects the aquitard. Head differences of up to 6 feet occur between the USZ and LSZ at the western Base boundary and up to 40 feet on the east side of the Base. The USZ/LSZ aquitard outcrops between 15 and 20 feet above the creek along the west bank of Soldier Creek just south of the IWTP. Based on the distribution of chemical contaminants, the USZ/LSZ aquitard is believed locally to allow some hydraulic communication between the USZ and the LSZ through natural and man-made discontinuities.

The next deeper zone in the Garber-Wellington Aquifer is the LSZ. This saturated interval is approximately 150 feet thick. However, as previously noted, this zone is sub-divided into the LSZ and the LLSZ for modeling and discussion purposes based on the recognition of a vertical component of the flow gradient. Generally, the LSZ consists of the upper third of the section, while the LLSZ is considered, when included, as the lower two-thirds. The LSZ directly underlies the USZ/LSZ aquitard and exists under all of Tinker AFB. Hydraulic conductivity test data show the hydraulic conductivity of the LSZ ranges from 0.25 to 8.7 ft/day. Flow is generally to the west and southwest under the Base but, as with the USZ, local variations exist under the west portion of Tinker AFB due to structural features related to the Oklahoma City Anticline. Just east and north of Tinker AFB, changes in recharge and interaction with Soldier Creek create variable flow directions. Recharge to the LSZ occurs primarily by precipitation where units outcrop just east of the Base and locally by the downward movement of groundwater through the USZ/LSZ aquitard where the USZ overlies it and discontinuities in the aquitard occur.

Groundwater in the LLSZ generally flows in the same direction as groundwater in the LSZ at any given location on Tinker AFB. Recharge to the LLSZ is by downward leakage from the LSZ and by lateral inflow of groundwater from the area east of the Base. A pumping test was conducted at well cluster 1-91PW in the northeastern corner of the Base in November 1994 as part of the IWTP/Soldier Creek Groundwater OUs RI. The hydraulic conductivity values calculated from the pumping test ranged from 0.78 to 15.6 ft/day. The results from the pumping test indicate that the LLSZ is interconnected with the LSZ.

The PZ aquitard occurs at the base of the LSZ (LLSZ) and hydraulically separates the LSZ from the underlying PZ. The isolation of the PZ from the LLSZ is demonstrated by head differences of up to 70 feet across the unit. This aquitard appears to be similar to the USZ/LSZ aquitard, being formed by a series of overlapping mudstones with interbedded more permeable sandstone/siltstone lenses. Well log data suggest that the PZ aquitard is present beneath the entire Base. The aquitard appears to be at least 30 feet thick; however, studies suggest that this aquitard may be up to 80 feet thick locally.

The PZ lies below the PZ aquitard and extends downward approximately another 500 to 600 ft. At around 700 to 800 feet BGS, the PZ grades progressively into saline water, which forms the lower limit of potable water. A physical boundary between the PZ and underlying units (i.e., the Chase, Council Grove, and Admire Formations) occurs somewhat deeper. The natural flow direction in the PZ is difficult to identify due to the influence of water supply wells (WSW) and limited data coverage but is most likely to the west. Data supplied by Wood and Burton (1968) from the Nichols Hills area to the west of the Base and results of the U. S. Army Corps of Engineers pump test involving Tinker WSW-14, WSW-15, and WSW-16, originally located just east of Building 3001, suggest that there is little vertical communication between the PZ and shallower zones. Several shallow wells in the LSZ were monitored during the pump test and none of the wells exhibited any measurable drawdown. An average hydraulic conductivity of approximately 5 ft/day has been calculated for the Garber-Wellington sandstones and from production well data in the Oklahoma City area. A total of 34 Tinker AFB WSWs have been completed in the PZ; twelve have since been plugged, and one new well (#34) was recently placed in operation. Twenty-one of the wells are currently operational, although this number varies over time. Base water supply wells are screened at 200 to 750 feet below ground surface.

Shallow aquifers exist temporarily in zones of alluvium that border streams, or where sandy residual soils overly bedrock at shallow depths. Soil aquifers are typically recharged directly by precipitation, gradually running dry seasonally as base flow to local streams and recharging of underlying rock aquifers deplete limited supplies. The significance of shallow aquifers is that they may facilitate the contamination of important lower aquifers or surface waters by generation and mobilization of wastes. Shallow aquifers may not facilitate the detection of developing ground- water contamination problems because of their localized nature and ephemeral character.

The hydrogeologic conceptual model of Tinker Air Force Base integrates geologic and hydrologic data from across the base. Such a conceptual model involves a comprehensive review of available data, including those from direct measurement sources (borings, water level measurements, pump/slug tests, stream studies) as well as indirect sources (aerial photographs, topographic maps, published reports). The hydrogeologic system at Tinker is complex, but the model provides both an approximation of depth to water and an estimated direction of groundwater movement and is therefore useful as a basis for designing field investigations. As information is derived from investigations the model is continually updated and refined.

The aquifer zones in the conceptual model are hydraulically connected, although sometimes only to a

very local extent, either directly as in the west part of the base or indirectly through leakage and/or recharge/discharge patterns related to local streams. Because Tinker is located in a recharge zone for the Central Oklahoma Aquifer both horizontal and vertical (downward) components of groundwater flow exist. Measured potentiometric levels from well clusters with screens and filter packs placed at varying depths within the lower saturated zone show that hydraulic heads decrease with depth and that the magnitude of the vertical component of flow varies with location. This is particularly important to recognize where data from these wells is being used to generate potentiometric contour maps.

Although the variability in the geology and the recharge system at Tinker makes it difficult to predict local flow paths, Central Oklahoma Aquifer water table data taken from the 1992 U.S.G.S. Hydrologic Atlas shows that regional groundwater flow under Tinker varies from west/north-west to southwest depending on location. This is supported by contoured potentiometric data from base monitoring wells that show groundwater movement in the upper aquifer zones to generally follow regional dip. On a simplified basis, evaluation of flow in each zone measured normal to potentiometric contours suggests that flow gradients range from 10 to 30 feet per mile. However, because flow in the near surface portions of the aquifer at Tinker are strongly influenced by topography, local stream base-levels, complex subsurface geology, location in a recharge area, and proximity to water supply wells, both direction and magnitude of groundwater movement is highly variable. The interaction of these factors not only influences regional flow but gives rise to complicated local, often transient, flow patterns at individual sites.

Several examples demonstrate this variability. Historical water level data around Crutcho Creek indicates that groundwater flow in that area is predominantly to the southwest. However, during high flow conditions bank recharge occurs and shallow local flow patterns close to the creek may be reversed. This pattern is probably in effect at other streams as well. In the northeast quadrant of the base several factors contribute to groundwater "mounding" in the USZ and to formation of a groundwater high in the LSZ. This leads to radial or semi-radial groundwater flow at shallow depths. Finally, in the northeast part of the base where sufficient data exists, comparison of potentiometric contours from successively deeper levels in the LSZ suggests that groundwater flow directions may change with depth, gradually turning from west/southwest to northwest. This change in regional flow is attributed either to effects of pumping from deep water supply wells in the area and/or to the presence of the Deep Fork River located to the north. This river, along with the Canadian River south of Tinker, has been demonstrated by the U.S.G.S. to act as a major discharge point for regional ground water in Central Oklahoma.

The *Tinker AFB Conceptual Site Model* (AFCEC/CZOW, December 2017), has more comprehensive information and figures that describes the Hydrogeology of Tinker AFB.

2.2.2 POTENTIAL RECEPTORS AND EXPOSURE PATHWAYS

This subsection provides general information on potential human and ecological receptors of groundwater contamination at Tinker AFB.

2.2.2.1 HUMAN RECEPTORS

Potential receptor populations include those related to residences with private water wells, industrial facilities & other businesses with private wells, & potentially wells used for agricultural purposes. The newly acquired Tinker aerospace complex (TAC former GM bldg.) obtains its water from local city water supplies. To date, no soil or GW contamination requiring active remediation has been detected beneath Base housing areas, although some low-level soil screening vapor hits have been detected. Vapor Intrusion is limited to specific industrial buildings; therefore non-workers are unlikely to be exposed to any air contamination. The existence of LUCs (Section 10.2.4 of the current permit application] tend to limit exposure to soil, GW or vapor contamination. Since TAFB has LUCs, the soil & GW exposure is generally mitigated. The potential for exposure to contamination is provided in more detail in individual Site reports: RFI or CMS. Several solvent plumes previously extended off-site. However the risk of exposure to off-site populations is considered to be incomplete. Monitoring of compliance & sentinel wells continues as part of the Basewide sampling program.

Tinker AFB is situated on a relatively flat expense of grassland. Prior to the development of the Base, the area was characterized by large tracts of private agricultural land. The Base currently occupies approximately 4,277 acres of semi-improved and unimproved grounds that are used for the airfield, golf course, housing area, offices, shops, and other uses characteristic of military installations. Property surrounding the Base includes residential, industrial and non-industrial businesses, and agricultural areas. Potential receptor populations include those related to residences with private water wells, industrial facilities and other businesses with private wells where potable water might be available, and potentially wells used for agricultural purposes such that crops may become contaminated. All of these wells tap into a portion of the Garber-Wellington Aquifer. Lake Stanley Draper, a local surface water supply reservoir with a small portion of its drainage basin in the southeast part of Tinker AFB, is also used for recreational purposes. Local streams, such as Soldier Creek and Crutcho Creek, which either transect the Base or have tributaries that extend onto the Base, may be used for recreation and fishing downstream.

The Garber-Wellington Aquifer, which underlies Tinker AFB and the surrounding area, is the single most important source of potable groundwater in the Oklahoma City area. Currently, the main part of the Base's water supply is obtained from production wells pumping from this

aquifer; however, the newly acquired Tinker Aerospace Complex (TAC1) (formerly the General Motors plant) obtains its water from local city water supplies. Industrial operations, individual homes, farm irrigation, and small communities not served by municipal distribution systems also depend on the Garber-Wellington Aquifer. Communities such as Oklahoma City, Midwest City and Del City depend on surface water supplies but at least one local municipality also maintains a well system that taps this aquifer as a standby source of water in the event of drought.

Tinker AFB employs approximately 27,000 military and civilian personnel. Of these personnel, approximately 2,800 personnel occupy on-Base housing, which consists of around 530 family housing units and seven dormitories. Of base housed families, roughly 1,300 residents are children. Military personnel and their families who reside on Base represent the nearest receptors to releases from Tinker AFB. However, access to areas impacted by Base activities is restricted in most cases, and direct contact by Base residents is not likely. The current land use at and near the Base is not expected to change because the facilities have decades of useful life remaining and the Base has an important and continuing mission. To date, no soil or groundwater contamination requiring active remediation has been detected beneath Base housing areas, although some low level soil screening vapor hits have been detected.

The closest human receptor populations include on-Base residents, government personnel working at the Base, and contract workers since these (other than those working at the TAC1 facility) depend on Base water supply wells for drinking water and water for industrial activities. Because Tinker water wells are not contaminated, and it is unlikely that they will become contaminated in the future, this receptor scenario is considered incomplete. Non-industrial Tinker facilities such as day cares, hospitals, schools, and restaurants all rely on this same water system. Because Base surface water bodies have been determined to be uncontaminated, this pathway is also considered incomplete for all on-Base entities. Vapor intrusion is limited to specific industrial buildings, and therefore non-workers, including sensitive populations, are unlikely to be exposed to any air contamination. The existence of LUCs, presented in Section 10.2.4, also tends to limit exposure to soil, groundwater, or vapor contamination.

However, workers on base, whether they are government or contract, can potentially be exposed to soil, groundwater, and air contamination. Activities such as trenching, cutting through building slabs, excavating foundations for buildings or removing a lift station, drilling wells, or other ground intrusive activities, have the potential to have workers encounter either soil or groundwater contamination, depending on the depth to which they go and the depth to groundwater. In addition, exposure to vapor intrusion is also a possibility where either soil or

groundwater intrusive activities, have the potential to have workers encounter either soil or groundwater contamination, depending on the depth to which they go and the depth to groundwater. In addition, exposure to vapor intrusion is also a possibility where either soil or groundwater contamination is present. Because the Base has robust, and active, land use controls (both institutional and engineering), soil and groundwater exposure is generally mitigated. Because vapor intrusion is limited to a few industrial sites, where air monitoring can occur, vapor intrusion has also not been a major issue. In all cases the potential for exposure exists, but is generally incomplete since contaminated sites are well documented and construction type activities on Base are governed by LUCs. The potential for exposure to contamination is provided in more detail in individual site reports, such as an RFI or CMS.

As discussed below in the section on migration pathways, several groundwater solvent plumes once extended off-Site. However, since these plumes no longer extend past the fence line above MCLs due to mitigation by years of remediation, the risk of exposure to off-Base populations is currently considered to be incomplete. In addition, groundwater contamination once thought to have migrated off Tinker to the northeast from near Building 3001, is now known to be contained on Base due to a groundwater divide which extends across the northeast corner of the Base. Although this is related to NPL Site OU-1 (Building 3001 Soil and Groundwater), it demonstrates how groundwater migration pathways may be controlled by aquifer hydraulic properties; evaluation of RCRA sites should include this type of information. Monitoring of compliance and sentinel wells continues as part of the Basewide Sampling Program; data is used to evaluate plume stability, including the extent of groundwater plumes as well as the rate of migration.

2.2.2.2. ECOLOGICAL RECEPTORS

Tinker AFB lies within a grassland ecosystem, which is typically composed of grasses and riparian (trees, shrubs, and vines associated with water courses) vegetation. This ecosystem has generally experienced fragmentation and disturbance as a result of urbanization and industrialization at and near the Base. While no threatened or endangered plant species occur on the Base, the Oklahoma penstemon (Penstemon oklahomensis), identified as a rare plant under the Oklahoma Natural Heritage Inventory Program, thrives in several locations on Base. Tinker AFB policy (AFR 126-1) is to treat rare species as if they were threatened or endangered and provide equivalent protection for these species.

In general, wildlife on the Base is tolerant of human activities and urban environments. No federal threatened or endangered species have been reported at the Base. The Oklahoma Department of Wildlife Conservation also lists several species within the state as Species of Special Concern. Information on these species suggests declining populations but information is inadequate to

support listing, and additional monitoring of populations is needed to determine the species status. These species also receive protection by Tinker AFB as if they were threatened or endangered. Of these species, the Swainson's hawk (Buteo swainsoni) and the burrowing owl (Athene cunicularia) have been sighted on Tinker AFB. Swainson's hawk, a summer visitor and prairie/meadow inhabitant, has been encountered Basewide. The burrowing owl has been known to inhabit the airfield at the Base.

2.3 PERFORMANCE STANDARD APPROACH

The description of the CAS Performance Standards applying to Tinker AFB is provided below:

2.3.1 Source Control Performance Standard: Tinker AFB will use CAS procedures to determine the most effective source control standard utilizing historical and current information.

2.3.2 Statutory and Regulatory Performance Standard: Tinker AFB will utilize the risk based statutory and regulatory standards for the facility. Applicable and Relevant Federal, state and local laws and regulations will be adhered to during this process

2.3.3 Final Risk Goal Performance Standard: The risk goal for Tinker AFB will be for industrial land use unless otherwise a specified goal for complete site closeout at residential standards.

2.4 SITE PERFORMANCE STANDARD APPROACH

At a minimum, the following performance standard elements will be included:

2.4.1 GROUNDWATER MONITORING and WELL MAINTENANCE PLAN

Tinker AFB has an active groundwater remediation program that is monitored using a series of monitoring points located both on base and off base. The program is described in the approved Basewide Non-NPL Groundwater Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs Addendum 3 (September 2001) as well as described for individual sites in site specific RCRA documents submitted since the early 1990s. The most recent completed sampling data, plume maps and potentiometric maps are provided in the *2014-2015 (Event 4) Basewide Sampling and Water Level Measurements* report (VERSAR, 2017). Remedial action status updates are presented in individual site reports as they are prepared. Tinker AFB will continue to collect and evaluate data and provide updates to remediation activities.

2.4.2 COMPLIANCE MONITORING

According to the February 2015 CAS guidance, “For RCRA-regulated units, the point of compliance is described as the location closest to the waste management area (which can be one or more SWMUs) where the cleanup standard must be met. For risk-based corrective action, the POC is the point at which the risk-based cleanup standard must be met. In groundwater corrective action, the POC is often described as the point at which the facility must meet MCLs – which may be at the facility boundary or at another defined point of exposure. In these cases, an ACL (or other risk-based number) is met at the closest location to the waste management area.” For Tinker, the point of compliance (POC) is the location where the groundwater protection standard applies. This location lies at the on-base "hydraulically down-gradient limit" of the waste management area, or down-gradient of a collection of waste management areas. The complex facility hydrogeology and 70-year history of site operations, waste management, and corrective action necessitate a POC approach where the POC consists of all those portions of the site boundary that are hydraulically down-gradient of identified waste management sites. Groundwater plumes are widespread across the facility, but only certain plumes have reached the base boundary, or are thought to potentially impact the boundary. There are no compliance point issues related to the Hennessey Water Bearing Zone or Producing Zone since any identified contamination in these zones is either below the MCL or is not anticipated to reach the Base boundary. Compliance points are shown, along with TCE groundwater plumes, on Figures 10-2 for the Upper Saturated Zone and on Figure 10-3 for the Lower Saturated Zone. Because groundwater contamination has reached the base fence line in some locations in these zones, compliance monitoring distinguishes two categories of monitoring points, including:

2.4.2.1 Uncontaminated monitoring points near the property boundary that are down-gradient of a groundwater plume and are reasonably anticipated to be impacted by a migrating plume within the next decade. The ten year time frame is thought to be reasonable for many sites based on results of groundwater and fate and transport modeling (modeling results are presented in individual site reports for Air Force designated sites CG037, CG038, CG039, and CG040 which have been previously submitted and approved by the ODEQ), as well as analysis via plume concentration graphs of actual plume migration over the last fifteen years. Current potentiometric maps that help demonstrate groundwater flow direction as well as contaminant plume maps can be found in the 2014-2015 (Event 4) Basewide Sampling and Water Level Measurements report.

2.4.2.2 Contaminated monitoring points that are located at the leading edge of a plume that has reached, or previously passed, the property boundary. A remedial strategy, whether active or passive in nature, is in place at each of these sites.

Uncontaminated wells located off-base down gradient of contaminated wells described above are monitored as part of the base’s general monitoring program. These wells are herein termed ‘sentinel’ wells (as detailed in Section 10.5.4 of the permit application) and will be monitored on

a regular basis. These sentinel wells were added to monitor for any groundwater contamination that might pass, or might already have passed, the Base boundary.

From a practical standpoint, compliance wells are not actually located at the base boundary but have been placed as near as allowed by AF setbacks and regulations. In instances where the closest on-base boundary wells have detected contamination, additional wells outside the boundary (sentinel wells) have been added to monitor for any groundwater contamination that might pass, or might have passed, the boundary. Except for specific instances at CG038 and CG040, sentinel wells are uncontaminated. At CG038 and CG040, contaminant detections that were once above respective MCLs have been mostly reduced to below this value by active remediation at the site. Site histories for these areas, with further description of ongoing remedial activities in Section 4.0.

Seventy (70) compliance points and sentinel wells are identified in Table 2-1. On the table, compliance wells are identified by 'POC' and sentinel wells by an 'S' in the category column. Should the list of compliance and sentinel wells change, the ODEQ will be notified and a formal RCRA Permit modification requested. In addition, during each sampling event, some wells may not be accessible, or may not be sampled for other technical reasons. These wells will be re- evaluated as soon as practically possible. Upper Saturated Zone Compliance Wells are shown on Figure 2.3.2. Lower Saturated Zone and Lower-Lower Saturated Compliance Wells are presented on Figure 2.3.3.

Since the early 1990s Tinker AFB has taken a phased RCRA Facility Investigation (RFI) approach to characterizing and cleaning up contaminated non-NPL sites at the base. During the implementation of the initial (Phase I) RFIs at SWMUs and AOCs at Tinker, the base recognized the inefficiency of investigating groundwater impacts utilizing a unit by unit approach since 1) designated contaminated sites under the Air Force's Installation Restoration Program (IRP) have not always been recognized or included as SWMUs or AOCs under RCRA, 2) plumes from multiple sources were sometimes comingled and 2) discrete sources could not be identified for all plumes. In July 1994, Tinker AFB and the EPA agreed that the most efficient way to investigate groundwater impacts was to perform a Phase II RFI that focused on determining the full extent of groundwater contamination resulting from RCRA units across the base in a holistic approach. As a result, Tinker recommended that groundwater at the Base be treated and monitored as a separate unit.

Over the past two decades, various groundwater units or areas have been identified at Tinker AFB for use in managing groundwater contamination issues. As part of the basewide groundwater investigation, it was decided that the groundwater contaminant plumes could be more efficiently investigated and addressed as separate groundwater IRP sites. Four contaminated groundwater management units (CGMUs), and identified as Air Force Installation Restoration Program (IRP) sites, were established:

2.4.2.3 CG037, contaminated groundwater in the northwest quadrant of the Base;
2.4.2.4 CG038, contaminated groundwater in the southwest quadrant of the Base;
2.4.2.5 CG039, contaminated groundwater in the southeast quadrant of the Base;

2.4.2.6 CG040, contaminated groundwater in an area located east of the main Base.

Many of the SWMUs and AOCs at Tinker AFB are in close proximity to one another, resulting in difficulty in linking detected groundwater contaminants to specific contaminant sources. During the Phase II RFI, and to provide a framework for discussion of groundwater contamination from RCRA units and other sources within the relatively large project area, the Base was further divided into Groundwater Management Units (GWMUs) and subunits (GWMSUs).

GWMUs provide the most efficient way to evaluate groundwater by grouping together adjacent SWMUs, AOCs, and other sources that may have contributed to a general area of groundwater contamination, or "plume." Within these areas, it was anticipated that it would be convenient to treat similar nearby plumes as a GWMU. Data from the GWMUs has been coordinated with CERCLA data available in the NE Quadrant (NPL site) to provide continuity in potentiometric and isopleth maps. Plumes are individually identified under groundwater management units as 'sub-units' and designated with modifiers which included the main GMWU number and a letter identifier (such as GWMU 2E).

The IRP or CGMU sites only approximately coincide with the groundwater management units (GWMUs) or RCRA SWMUs and AOCs. Figure 2.3.1 shows the location of the four groundwater IRP sites Contaminated Groundwater Site 037 (CG037), Contaminated Groundwater Site 038 (CG038), Contaminated Groundwater Site 039 (CG039), and Contaminated Groundwater Site 040 (CG040) established in 1996 as well as the NPL Site. It also shows GWMUs 1, 2, 3, 4, and 5 established later in 1996 along with GWMSUs and associated sub-units. The GWMUs were selected based on contaminant distribution and extent and are used primarily as a management tool. Note that contaminated groundwater management unit boundaries are not considered static and have been adjusted over time based on data from continuing investigations, and/or changes to plume extent.

The four CGs do not fully cover all contaminated sites on Tinker AFB, but address issues at most of the non-NPL sites (the NPL Site is located in the northeast quadrant of the Base). The only additional sites not covered by CGMUs are Landfill 6 (SWMU 01) and the Industrial Waste Treatment Plant (IWTP) soils, designated as SWMU 24; both fall under RCRA authority. Landfill 6 has been investigated and does not pose a significant threat to human health or the environment; the IWTP has been partly excavated and remediated. Note that the CGMUs include most surface water bodies except Soldier Creek, which falls under CERCLA.

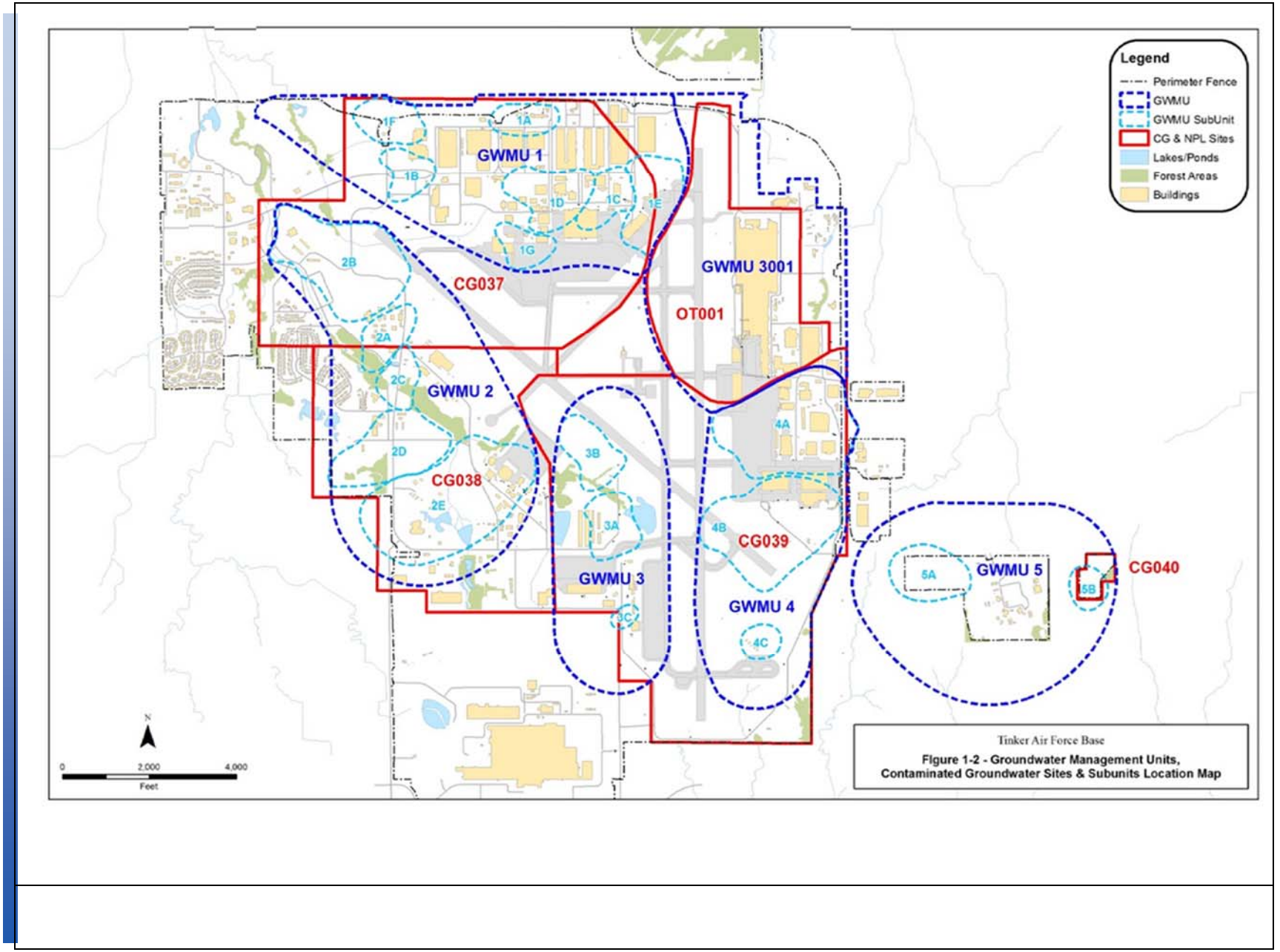

Figure 2.3.1: AF Contaminated Groundwater Units Sites, Basewide Groundwater Management Units and Subunits Location Map

The CGMUs noted above do not entirely coincide with either the GWMUs designated during the Phase II RFI or with individual SWMUs. The four CGMUs incorporate most of the base with just a few exceptions such as Landfill 6. Three CGMUs contain multiple SWMUs and AOCs; only CG040 is comprised of a single contaminated site or plume. CGMUs may include multiple groundwater plumes and their sources that fall within areas where groundwater flow directions are generally similar. In addition, plumes within a CGMU may be comingled or have more than one source within the CGMU.

Active remedial actions are in place at several groundwater plumes at three of the contaminated groundwater management units: at CG038, also known as the Southwest CGMU (Air Force designated plumes 2D, 2E, and 2F); at CG040, also known as the Gator CGMU; and at one of two plumes at the Area A Service Station (AF Site ST033) within CG037, the Northwest CGMU. Original remedies consisted mainly of pump and treat (P&T) or dual phase VEP systems installed in the 1990s designed either to contain further off-base migration, or prevent it. These have been reported in various individual site reports previously provided to the ODEQ. At CG038 and CG040, groundwater contamination above the constituent MCLs was noted to have migrated beyond the base boundary. To address this issue at CG038, a permeable reactive barrier was added at the base boundary across the north (2D) plume where the extraction wells did not appear to adequately contain migration of TCE. Analytical results at both CG038 and CG040 indicate that existing remedies have reduced off-site concentrations of solvents once above MCL to near or below the MCL, and that concentrations are continuing to decline at the compliance point, the base boundary. At the Area A Service Station location within CG037, solvent concentration at the compliance point appears to have remained stable at roughly two times the MCL (monitoring well 2-166B) since 2005, and non-detect at the sentinel well, 2- 165B. However, within the last year, because concentrations at or above the MCL are recognized at compliance point wells, additional remedies aimed at hot spot reduction and furthering reduction of plume extent have been, or are being, added at the three sites.

Two sites where groundwater contamination has reached the base boundary, and therefore the compliance point, have no active remediation. A second (west) plume at the Northwest CGMU (CG037) has no active remediation since contaminant concentrations in a single well at the boundary are currently at the MCL, having decreased from around two times the MCL in 2005; this well will continue to be monitored for any changes, and contingency measures as noted below will go into effect if concentrations increase. At the fourth site, located within CG039 (also known as the East CGMU), migration off-site is prevented by the local hydrogeology; shallow (USZ) contamination that appears to be migrating off-base toward the east is actually migrating vertically downward to the next lower saturated zone (LSZ) on Base, which flows westward back under the base. Monitoring wells, which have existed and been tested at this location since 1994, show that saturation in the USZ ends just east of the base boundary, while contamination is contained on base. The limited saturated extent within the USZ to the east precludes eastward migration.

Although the point of compliance is recognized as the base boundary, additional monitoring wells are located off-site just beyond the base fence line; some within 500 feet or closer. Several of these are included as sentinel wells; most are uncontaminated.

Originally installed to characterize areas where groundwater contamination was thought to have migrated off-site, these points are now monitored to either help evaluate the effectiveness of an existing active remedy where those have been installed, or where concentrations are at MCL or above near the boundary but monitored natural attenuation has been approved for the site, to ascertain whether contaminants have migrated off-site. These wells are labeled as 'sentinel' wells. Sentinel wells are those currently uncontaminated monitoring points or those with concentrations at or near the MCL that are located just outside the base fence line opposite of, and generally down gradient to, an on-base plume with concentrations above the MCL, but where either 1) the plume has not migrated off-base due to site hydrogeologic conditions or 2) remediation activities have reduced off-site concentrations to much lower levels. Sentinel wells at CG038 for example document that wells which once had solvent concentrations well above the MCL, are now either non-detect or have concentrations greatly reduced to just below the MCL. Figures 2.3.2 and 2.3.3 illustrate the location of the Compliance and Sentinel Well locations for the upper saturated and lower saturated zones respectfully. Clarification of compliance point and sentinel well rationale, site histories and an update of ongoing remedial activities, as well as corrective action objectives are provided in the Tinker AFB, RCRA Permit Renewal Application Section 10, Attachment A, December 2017.

2.4.3 CONTINGENCY MEASURES

Contingency measures will take effect if 1) the concentration of contaminants in compliance point wells at sites where these are currently at or below the MCL is found to exceed the MCL or 2) the concentration of contaminants surpasses MCLs in sentinel wells at sites where concentrations in compliance wells currently exceed the MCL. In these instances, additional samples will be taken 30 days after data have been received from the laboratory and verified by a data reviewer. If concentrations exceed the MCL on the ensuing analysis, a second verification sample will be taken and analyzed within 30 days of verification of final data results of the initial verification round of sampling. The ODEQ will be notified of results within 30 days of the verification of the final results. If results from the second validation sample round remain above the MCL, contingency measures consisting of additional investigation and/or a corrective action following RCRA will be implemented. As noted earlier and further described in Attachment A of the permit application, sites where off-base wells were found to be contaminated above the MCL are already undergoing additional remediation (primarily emulsified vegetable oil injection and/or installation of bioreactors) to more rapidly clean up the site.

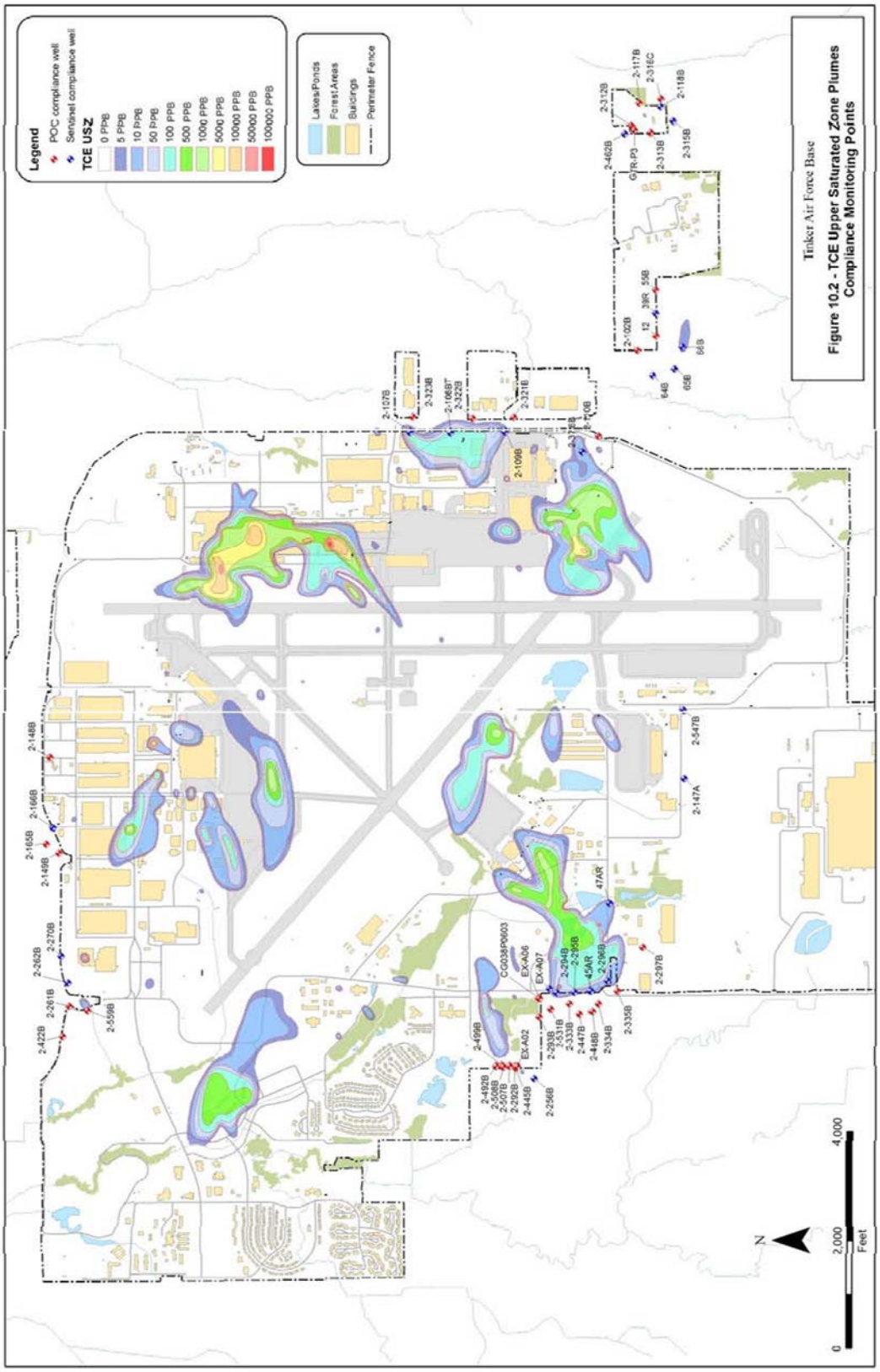

Figure 2.3.2: USZ Compliance Wells

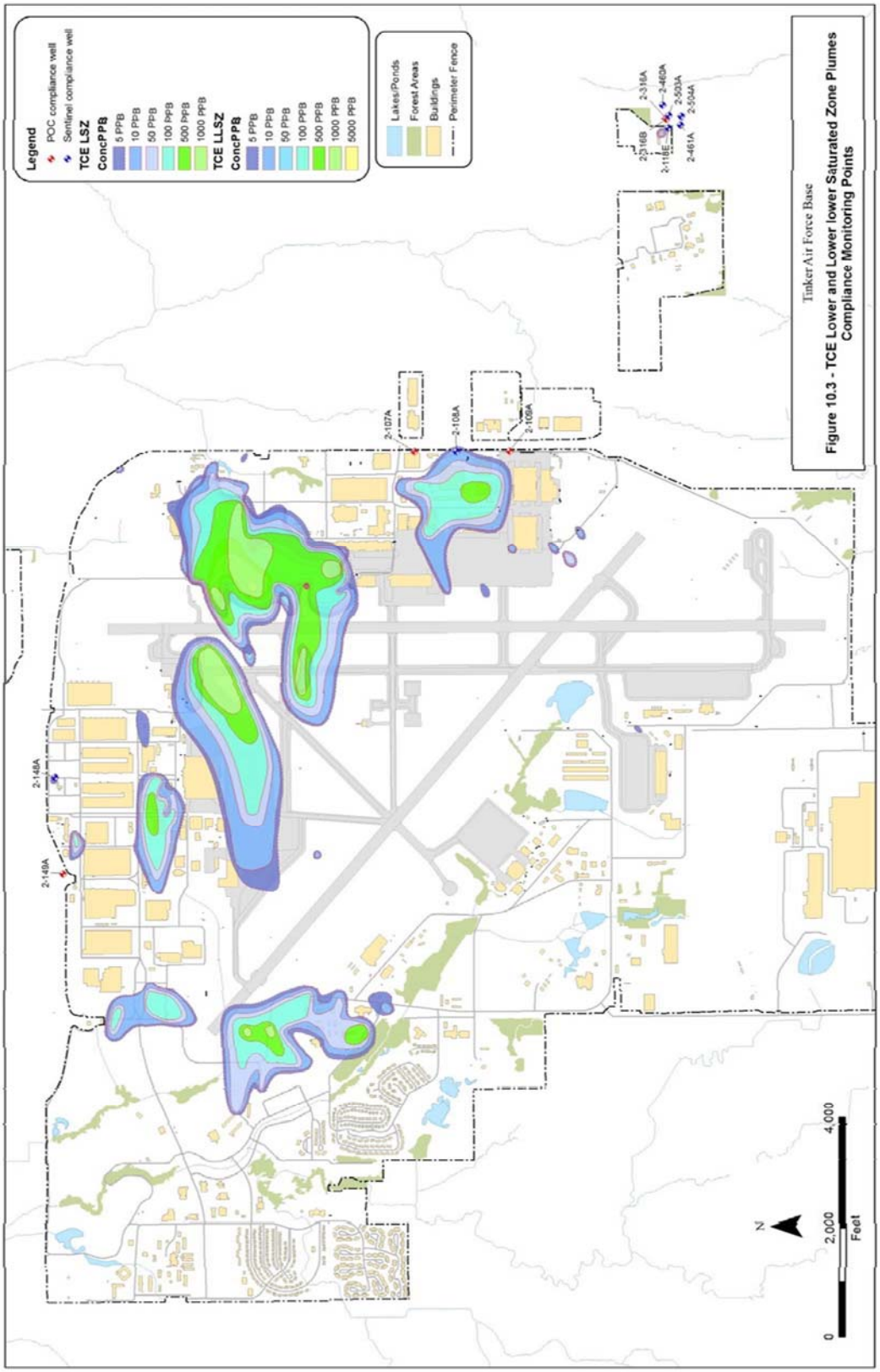

Figure 2.3.3: LSZ/LLSZ Compliance Wells

2.4.4 CONCENTRATION LIMITS

The maximum concentration allowed at compliance wells for AF sites CG037, CG038, CG039, and CG040 will be the maximum contaminant limit (MCL). For all other plumes where performance monitoring is in effect, concentration limits will be determined on a site by site basis based on risk, potential for a completed pathway, and demonstration through groundwater modeling or other analysis that the plume is unlikely to reach the base boundary. For compliance wells with current contaminant concentrations above respective MCLs, the future maximum concentration will be the MCL beginning at such time as corrective actions have reduced levels to MCLs. Attachment A of the permit application describes those sites and documents the existence of ongoing remedial activities taken as voluntary corrective actions by Tinker when it was recognized that contaminated groundwater had either reached or passed the fence line in those areas.

2.4.5 DETECTION MONITORING PROGRAM

In addition to the above compliance and sentinel wells, Tinker AFB maintains a monitoring network comprised of roughly 1175 wells used initially to characterize groundwater contamination and now used to monitor and evaluate changes to existing plumes. Under the current basewide monitoring program, a large percentage of these wells are sampled on a periodic basis. In the current permit renewal application, Tinker proposes that 793 monitoring points be included in the active groundwater monitoring program. Seventy (70) of these are identified as compliance and sentinel wells in Table 2.1. The remaining 722 proposed monitoring points are designated as 'performance monitoring points'. These sampling points are part of a performance monitoring network which derives primarily from a 2005 in-house optimization of the entire monitoring well network supported by an independent geostatistical confirmation of the in-house evaluation, in which many of the same wells were recommended to be deleted from further sampling. During optimization analysis, 482 wells were found that could be deleted with no significant reduction in plume evaluation and tracking. Note that although a subset of the total network is sampled, all existing monitoring wells, whether sampled or not, have water levels measured in them at the same frequency as wells are sampled. In addition, other wells such as the vapor extraction system wells, are periodically sampled, although these systems are currently shut down. All sample and water level data, including field parameters, is entered into the Air Force's environmental data base known as ERPIMS (Environmental Restoration Program Information System). A copy of the September 2005 report, *Final Report Long- Term Monitoring Groundwater Optimization, Tinker AFB, Oklahoma Using the Geostatistical Temporal/Spatial (GTS) Algorithm*, is available from the Tinker AFB Environmental Restoration Office.

The selection of performance network wells also reflects updates based on recent analytical and water level data, in particular the 2009 Basewide Sampling and Water Level Measurement Report, June 2009, and reflects new wells and updates to the conceptual site model (CSM) that have occurred since 2005. Performance wells will be used to evaluate changes to plumes, to characterize background concentrations, and to evaluate remedial technologies at those sites, but are not specifically related to compliance monitoring. Analytical and water data from these wells will be

reported in the basewide sampling reports, with data evaluation and analysis as described below. Additional wells have been added to the performance well network since the 2005 modification request. New wells may also be added, and existing wells may be deleted evaluation analysis performed by an Air Force contractor. The two methods, one performed in- house by Tinker AFB Restoration personnel using a traditional data evaluation approach and the other using a Geostatistical Temporal Spatial (GTS) algorithm, are briefly described below.

During the in-house evaluation, visual comparison of plume maps over time, time versus concentration plots, hydrographs, and EXCEL spreadsheets were used. The chemicals of concern that were retained include PCE, TCE, DCE, VC, BTEX, CR (VI), and CR total. The basic criterion for retaining and evaluating a well for optimization was that a minimum of five years of data was available; wells without this basic data set were excluded from further evaluation. Contaminant plumes and well locations were compared to potential exposure points using groundwater flow data and potential migration pathway information to evaluate potential future risk and to derive a list of performance wells that address the corrective action objectives.

The analysis based on the GTS algorithm had two parts: (1) a temporal optimization component and (2) a spatial optimization component. This alternate method was used to determine a statistically sound sampling frequency and which locations could be optimized to avoid redundancy. However, the GTS method did not include hydrogeologic parameters such as contaminant velocities and contaminant migration data, did not separate either the hydraulically or chemically the Hennessey Water Bearing Zone from the Upper Saturated Zone, and combined the LSZ (LSZ plus LLSZ) with the PZ, hydrostratigraphic units that are separated by a competent aquitard.

However, ultimately, very similar results regarding the number of wells to be retained in the proposed well sampling network were obtained, but the final list was based on the traditional method because it also accounted for groundwater pathways, groundwater velocities, and potential receptors.

Data from the list of performance wells will be submitted to the ODEQ for review approximately every 15 months with basewide groundwater sampling reports. Performance wells are used to evaluate changes to plumes, to characterize background concentrations, and to evaluate remedial technologies at those sites, but are not specifically related to compliance monitoring. During both optimization analyses, the monitoring network was also evaluated for wells that might be dropped from sampling; 482 wells were found that could be deleted from the network, but still allow for statistical confidence that plume evaluation and tracking would not be significantly reduced. The number of wells remaining to be deleted has been reduced to 184 as 298 wells have already been plugged in the interim. In the current permit application, Tinker proposes that this subset of wells be deleted from sampling requirements based on the optimization performed in 2005. The ODEQ previously approved plugging and abandonment of the 482 well list in a letter dated May 12, 2017 based on the discussion below and approval of the 2006 Class 2 permit modification.

Additional wells have been added since the 2006 permit modification so, along with well abandonments, the number of performance wells has changed, and may again change over time.

New wells sampled as performance wells are included with each new Basewide sampling and water level report submitted roughly every 15 months. This includes new monitoring wells installed since 2011 under the ongoing Performance Based Contract. The addition of new wells is also typically documented in site reports, which are submitted to the ODEQ when completed. The selection of performance network wells also reflects updates based on recent analytical and water level data, in particular the *2009 Basewide Sampling and Water Level Measurement Report*, June 2009, and reflects new wells and updates to the conceptual site model (CSM) that have occurred since 2005.

Basewide groundwater sampling and water level reports will include compliance and sentinel well information for completeness. These reports will be styled on previous documents already submitted for past sample rounds such as the *2014-2015 (Event 4) Basewide Sampling and Water Level Measurements Report*. Future reports will contain, at a minimum, the same basic information. The type of information presented in the basewide reports includes mapping of listed COCs (plume or isopleth maps) as well as basewide potentiometric surface maps for various aquifer zones, primarily the HWBZ, the USZ, the LSZ and the LLSZ. The Producing Zone (PZ) is not mapped due to a dearth of monitoring points. However, specific PZ wells are sampled and have water levels measured based on results of optimization evaluations, and any water supply well that is operational and accessible is also sampled.

Additional information such as groundwater flow analysis, statistical data analysis, natural attenuation evaluation, and remedial technology performance characteristics may also be included in this report, or may be submitted in separate reports. Basewide reports will focus discussion/evaluation primarily on analytical parameters specified as COCs although the entire suite of EPA SW-8260 (volatile organics) analytes is collected and entered into the Air Force's ERPIMS data base. Water levels will be measured in sampled wells at the time of sampling. All existing wells that remain accessible during the permit time frame, will also have water levels measured in them within a five-day window at 15 month intervals to allow for periodic 'snapshots' of water data that can be used to generate the potentiometric surface maps for the reports.

Table 2.1: Compliance and Sentinel Wells

USZ Compliance/Sentinel Wells

LOCID	Category
2-508B	POC
2-507B	POC
2-292B	POC
EX-A02	POC
2-445B	POC
2-256B	S
2-492B	POC
2-499B	POC
EX-A06	POC
CG038P0603	POC
2-293B	POC
EX-A07	S
2-294B	S
2-295B	S
45AR	S
2-296B	S
2-335B	POC
2-334B	POC
2-333B	POC
2-448BR	POC
2-447BR	POC
2-531B	POC
2-297B	POC
47AR	S
2-147A	S
2-547B	S
66B	S
65B	S
64B	S
2-102B	POC
12	POC
39R	S
55B	POC
2-422B	POC
2-261B	POC
2-262B	S
2-270B	S
2-149B	POC
2-165B	POC
2-166B	S
2-148B	POC
2-316C	POC
2-118B	S
2-315B	S

USZ Compliance/Sentinel Wells (cont.)

LOCID	Category
2-462B	S
2-313B	POC
GTR-P3	POC
2-117B	POC
2-312B	POC
2-322B	POC
2-321B	POC
2-323B	POC
2-107B	S
2-108BT	S
2-109B	S
2-110B	POC
2-376B	S
2-559B	POC

LSZ/LLSZ Compliance/Sentinel Wells

LOCID	Category
2-316A	S
2-316B	S
2-503A	S
2-504A	S
2-460A	S
2-461A	S
2-118E	S
2-149A	POC
2-148A	S
2-107A	POC
2-108A	S
2-109A	POC

Tinker AFB will continually evaluate and update the Conceptual Site Model (CSM) as well as the long-term monitoring program, and a new statistical well optimization effort is scheduled within the Permit period. Any statistical method will be submitted for review and approval before it is implemented. An updated report documenting CSM changes, if found, will be made to the ODEQ as part of the Basewide Sampling Program report to be submitted roughly every fifteen months Changes to the long-term monitoring (LTM) program will require formal modification. Optimization of well locations and sampling parameters will be reviewed, approved, and implemented to increase the efficiency of determining from monitoring data that the CAOs are met. An additional available type of performance monitoring point not included in the above described monitoring network is primarily associated with existing VEP systems; there are roughly 80 wells in several VEP systems on Base.

Analytical and water data from these points will typically be reported and evaluated in individual reports separate from the basewide report, with reporting frequency determined on a site by site basis. Like the performance wells, these wells are not directly associated with Permit compliance requirements. However, because many of these wells extract groundwater and may impact solvent plumes and the local potentiometric surface around them, it is important to include related data from VEP wells and/or nearby monitoring wells sampled as part of those systems on basewide maps with other monitoring wells. Therefore, analytical data and water level data closest in time of a given system will be integrated on maps produced for the basewide reports to help evaluate general plume changes and more accurately reflect existing conditions. Under an ongoing Operations and Maintenance contract, VEP system wells are currently sampled and have water levels measured semi-annually, and water levels are measured monthly. If or when, any of these systems are approved for closure during the course of this Permit, the need to include data from those wells will end with system shut down.

2.4.6 GENERAL GROUNDWATER MONITORING REQUIREMENTS

Tinker AFB has met, and will continue to meet, all appropriate requirements set out under 40 CFR 264.101 for corrective action at SWMUs and AOCs. The current groundwater well monitoring network consists of around 1175 points installed at appropriate locations and depths to yield representative samples for contaminant plumes in all aquifer zones. Specific requirements of this section are described below. Under this permit renewal, the network is anticipated to be reduced by 482 wells over time as noted in Section 10.5.4. Background values for groundwater contamination have been discussed in several previous reports. Since no alternate compliance concentrations are proposed, these reports are not discussed in this permit application, but these documents are available from the Environmental Restoration Office.

2.4.7 WELL CONSTRUCTION

Extraction/containment and monitoring well construction adheres to Oklahoma Water Resources Board (OWRB) Title 785, Chapter 35 requirements. Depending on the site, each well is located to detect or extract constituents that have migrated to the uppermost aquifer zone, or have migrated to a deeper aquifer zone. Each well is cased in a manner that maintains the integrity of the well borehole. Each well is screened, sand packed, and sealed to prevent contamination of groundwater and enable collection of representative groundwater samples. Construction drawings for existing wells are available from the Tinker AFB Environmental Restoration Office (AFCEC/CZO, 7701 Arnold Street, Suite 221, Tinker AFB OK, 73145-9100).

Tinker AFB will, if needed, construct and maintain additional and/or replacement monitoring wells in accordance with plans and specifications that meet, or exceed, requirements set out by the Oklahoma Water Resources Board. Tinker AFB will report to the ODEQ the surveyed locations and elevations of new monitoring wells with as-built drawings, and a map designating any change in the point of compliance.

2.4.8 GROUNDWATER COLLECTION PROCEDURES

Groundwater collection procedures, specific data quality objectives (DQOs) as well as sampling and analysis procedures for the performance monitoring are presented in the *Basewide Work Plan Performance Based Remediation Tinker Air Force Base, Oklahoma,* formatted per the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) for Tinker AFB. The UFP- QAPP was formulated jointly and has been adopted for use by the Environmental Protection Agency, the Department of Defense, and the Department of Energy. QAPPs written in the UFP format integrate all technical and quality aspects of a project, including planning, implementation, and assessment. A QAPP written in the UFP format is not restricted to laboratory quality requirements and will contain information that may previously have been presented in a work plan or field sampling plan. The UFP-QAPP Manual states, “The QAPP document may be referred to by another name or incorporated into other project planning documents. The document for some programs or projects may be referred to as a Sampling and Analysis Plan (SAP), Work Plan, Field Sampling Plan, etc.” Although the title of the document may differ, a plan written following the UFP-QAPP contains all of the information required by the National Contingency Plan. All groundwater samples will be analyzed using an Oklahoma certified laboratory.

2.4.9 MONITORING FREQUENCIES

POC and sentinel wells will be sampled at a fifteen month frequency as determined under the 2005 optimization, and approved in December 2006 under a Class 2 Modification to the RCRA Permit. This frequency is the product of reviewing plume migration rates and groundwater flow velocities over a period of 20 years which indicates that groundwater flow in most instances is relatively slow

and that many plumes are relatively stable. Plume stability was evaluated in 2006 using concentration trend data; trend maps are included in the *2006 Basewide Groundwater Sampling and Water Level Measurements Report, Tinker Air Force Base* (February 2008) submitted on to the ODEQ on December 10, 2008. Analysis includes all basewide wells under the holistic approach taken by Tinker AFB. Statistical trend analysis involved the Mann-Kendall trend test and Sen's slope estimate for quantifying changes in groundwater concentrations in monitoring wells. Compliance monitoring frequency may be adjusted at certain sites due to specific needs, but the frequency will not exceed the fifteen month time frame except as specified in this permit application. The monitoring frequency for performance wells will also be fifteen months. As above, if the sampling frequency is adjusted for performance monitoring points, the frequency will not exceed the fifteen month time frame except as specified in this permit application.

2.5 REQUIRED PROGRAMS

Tinker AFB has met, and will continue to meet, requirements for a corrective action program under 264.91. All SWMUs listed in the 2002 permit at the base currently have either an approved active or passive remedy in place with appropriate groundwater monitoring. Newly proposed units under this permit application will comply with requirements and standards outlined under the RCRA Corrective Action Program and this permit application.

2.6 HAZARDOUS CONSTITUENTS

During the initial phase of site investigation and characterization at Tinker AFB, a large suite of constituents was collected and analyzed for under EPA Methods SW-8260, SW-8270, RCRA metals, pesticides and polychlorinated biphenyls (PCBs), etc. As approved in the 2002 permit, the required list of constituents was reduced at that time. Principal changes included suspending monitoring for pesticides and PCBs. In 2005, a modification to the permit was requested which further reduced the list of analytes required for monitoring, reduced the number of wells to be monitored, and changed the monitoring frequency from annual to a fifteen month time frame. This approach was approved by the ODEQ on December 6, 2006. However, many of the changes addressed in the modification request have been included in this permit application. The current list of hazardous constituents is based on roughly 20 years of groundwater data collection and analysis, the previously approved reduction in 2002, as well as collaboration with the ODEQ in 2005 on a well optimization strategy. The final list of COCs was determined from a review of various approved documents for all contaminant sites at Tinker AFB; types of documents reviewed include Decision Documents, Corrective Measures Studies, and RCRA Facility Investigation Reports, subject and site specific reports, and the optimization effort that took place in 2005. The optimization process and results are outlined in the report included as Attachment 3. All other listed types of documents not already submitted to the ODEQ are available by contacting the Tinker AFB Environmental Restoration (AFCEC/CZO) office.

The selected chemicals of concern approved by the ODEQ in 2005 request include the chlorinated volatile organic compounds (CVOCs) tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (DCE), vinyl chloride (VC), 1,2-dichloroethane (DCA) analyzed under EPA Method

SW-846 8260B and the metal hexavalent chromium (Cr[VI]), analyzed for under EPA Method SW-846 7196A. These chemicals of concern (COCs) will be analyzed for and reported on a basewide scale for the duration of this permit, as well as being included in any site specific reports. For a few specific wells, BTEX will also be included, particularly in areas where fuel is a concern along with solvents. Additional parameters that will be reported include total organic carbon, total dissolved solids and all field generated analytical data (including but not limited to temperature, turbidity, dissolved oxygen, pH, and conductivity). Monitored natural attenuation (MNA) parameters will be reported on a site by site basis whenever generated to evaluate anaerobic conditions or to demonstrate degradation of COCs by processes other than anaerobic degradation. Both filtered and unfiltered total chromium data (SW-846 6010B) will also be collected at each well where hexavalent chromium data is collected. Solid and liquid waste that is slated to be disposed off-site at a permitted disposal facility will be characterized by a TCLP using approved methods. Groundwater sampling protocols, analytical methods/protocols, and quality assurance/quality control procedures are listed in the UFP-QAPP for Tinker AFB.

Other volatile organic compounds exist at Tinker AFB. Typically, the footprint of these compounds falls within the boundary of any TCE plume in the same aquifer zone. This information is used by Tinker AFB to locate compliance points based on the extent of TCE. As noted above, in addition to TCE, several other volatile organic constituents are recognized as COCs. However, the entire SW-846 8260B suite of volatile organic compounds will be analyzed in both compliance and performance monitoring points. Analytical results that are not compliance related will be provided in electronic format to the ODEQ as well as stored in the Air Force Environmental Restoration Program Information Management System (ERPIMS) database. ERPIMS is the Air Force system for validation and management of data from environmental projects at all Air Force bases. This data contains analytical chemistry samples, tests, and results as well as hydrogeological information, site/location descriptions, and monitoring well characteristics. Data in ERPIMS is available on request from the Tinker AFB Environmental Restoration Office.

3.0 INVESTIGATIONS, PROPOSED INVESTIGATIONS & RELATED DATA

Figure 3.1 shows the location of the seven Solid Waste Management Units (SWMUs), and the fourteen Area of Concern (AOCs).

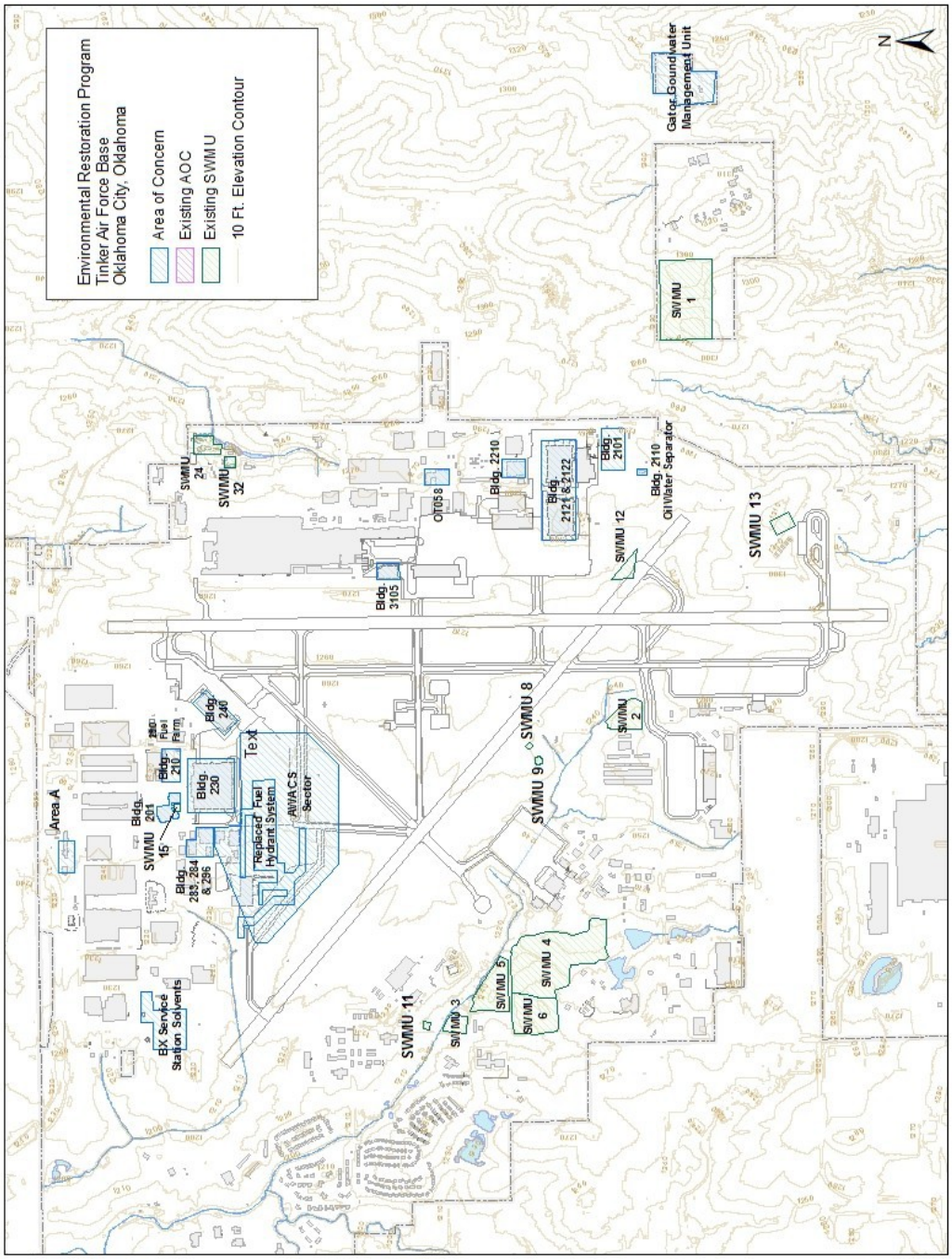

Figure 5: Location of Existing SWMUs and Other Release Areas at Tinker AFB

Tables 3.1 and 3.2 list, summarize and provide the current/ongoing activities for the ongoing seven Solid Waste Management Units and fourteen Areas of Concern sites. The tables also provide the next anticipated deliverable and/or project implementation schedule.

Table 3-1: Schedule for Ongoing Solid Waste Management Units

Current SWMU No.	AF Site Number	Original Site Name	Activity History	Current Status
1	LF016	Landfill 6	Listed as a SWMU in the 1991 and 2002 RCRA Permits. Final Phase I RFI report completed September 1994. Final Phase II RFI report completed June 1997. RCRA landfill cap upgrades were completed in 2001. Long term monitoring and care of the RCRA cap was approved as the remedy for this site in a letter from ODEQ dated 6/1/2001.	Recurring: Long Term Monitoring and Care of the RCRA cap. Annual Report: September
2	LF015	Landfill 5	Listed as a SWMU in the 1991 and 2002 RCRA Permits. Final Phase I RFI report completed September 1994. Final Phase II RFI completed September 1995. RCRA landfill cap installed in 1998. Long term monitoring and care of the RCRA cap as the remedy for this site was documented in a letter from ODEQ dated 10/4/2001.	Recurring: Long Term Monitoring and Care of the RCRA cap. Annual Report: September
3	LF011	Landfill 1	Listed as a SWMU in the 1991 and 2002 RCRA Permits. RCRA landfill cap installed in 1991. Final Phase I RFI report completed September 1994. Final Phase II RFI completed April 1999. Long term monitoring and care of the RCRA cap as the remedy for this site was documented in a letter from ODEQ dated 7/25/2001.	Recurring: Long Term Monitoring and Care of the RCRA cap. Annual Report: September
4	LF012	Landfill 2	Listed as a SWMU in the 1991 and 2002 RCRA Permits. Final Phase I RFI report completed September 1994. RCRA landfill cap installed in 1998. Final Phase II RFI completed April 1999. Long term monitoring and care of the RCRA cap as the remedy for this site was documented in a letter from ODEQ dated 7/25/2001.	Recurring: Long Term Monitoring and Care of the RCRA cap. Annual Report: September
5	LF013	Landfill 3	Listed as a SWMU in the 1991 and 2002 RCRA Permits. RCRA landfill cap installed in December 1991. Final Phase I RFI report completed September 1994. Final Phase II RFI completed April 1999. Long term monitoring and care of the RCRA cap as the remedy for this site was documented in a letter from ODEQ dated 7/11/2001.	Recurring: Long Term Monitoring and Care of the RCRA cap. Annual Report: September
6	LF014	Landfill 4	Listed as a SWMU in the 1991 and 2002 RCRA Permits. RCRA landfill cap installed in December 1991. Final Phase I RFI report completed September 1994. RCRA landfill cap installed in 1998. Final Phase II RFI completed April 1999. Long term monitoring and care of the RCRA cap as the remedy for this site was documented in a letter from ODEQ dated 10/29/2001.	Recurring: Long Term Monitoring and Care of the RCRA cap. Annual Report: September
24	OT034	IWTP - Industrial Wastewater Treatment Plant Soils	Identified as a RCRA SWMU in the 1991 and 2002 RCRA Permits. Phase I RFI report completed April 1994, Phase II RFI report completed July 1996. CMS report completed June 2003. The Air Force submitted a decision document to ODEQ (April 23, 2004) proposing the selected remedy be vapor extraction from the soils. The ODEQ concurred with the Air Force in a letter dated May 5, 2004. In 2016, an additional non-time critical removal was performed to remove soil hot spots discovered to be slightly above industrial levels. A Corrective Action Completion report for soils was completed and approved by DEQ on 1/25/2019.	Corrective Action complete - soil removal Construction Completion Report: January 2019

Table 3-2: Schedule for Ongoing Areas Of Concern Sites

Current AOC No.	AF Site Number	Site Name	Activity History	Current Status
1	ST007	Fuel Farm (290 POL Facility)	AOC 1 was identified in the 6/15/89 USEPA Region 6 RFA, but was not listed as an AOC in the 1991 RCRA Permit. As required by the 1991 RCRA Permit, a summary of previous studies was documented in the December 1992 Description Of Current Conditions for Tinker AFB. This AOC was not listed in the 2002 RCRA Permit. However, a RFI report was completed in 1995, and an additional Draft Site Investigation Report was completed in December 1996. Two vacuum enhanced pumping (VEP) systems were installed at the site between 1998 and 2000 as interim corrective measures. Collectively, the two systems extract groundwater and soil vapor from 34 recovery wells around Building 214, the former Building 210, near Tank 349, and near Building 117. The two systems where shut down in April 2012.	ICM – completed in 2012. New RFI underway RFI Report: July 2018
20	ST008	Building 201 Vapor Intrusion	A potential vapor intrusion condition was identified at Building 201 during a base-wide vapor intrusion survey (inventory) in 2010.	RFA completed for soil vapors RFI effort: FY2022
21	CG040	Gator Groundwater Management Unit	CG040 encompasses chlorinated solvent impacted groundwater underneath an adjunct facility approximately one mile east of the eastern boundary of Tinker AFB near the intersection of SE 59th St. and Post Road. The facility is non-industrial; only one building used for administrative purposes was found at the site. No unique source has been identified for this contamination. A groundwater extraction and treatment system began operation as an interim action in October 1999. The RFI report was completed in December 2003 and the CMS report was completed in July 2006. A Statement of Basis was completed as a decision document between Tinker AFB and the ODEQ, and was signed by ODEQ on July 31, 2006. Ultimate goal is to achieve UU/UE site close out.	Corrective Actoin - GW extraction system and bioreactor with insitu remediation Construction Completion Report (for RC): January 2018
22	CG041	AWACS Sector	CG041 encompasses impacted groundwater beneath the tarmac and taxiways south of Building 230. This site was introduced to ODEQ at the October 2009 RAB meeting.	RFI Report completed in December 2015 CMS underway CMS Report: September 2018
23	OT058	Jet Engine Test Cells (Bldg. 3703)	A site investigation report was completed in July 2002; Interim Corrective action using soil gas vapor and groundwater extraction was initiated in 2002 with the report issued in May 2003. A CMS was completed in May 2005. The VEP system continues to operate until the interim remedy in place (RIP) is either adopted or an improved remedy is selected.	RFI underway RFI Report: March 2018
24	OT062	Building 230	A RFI report was completed in March 2004. A VEP system was installed as an interim corrective measure to mitigate the potential risk posed by subsurface contaminants along the north and west sides of Building 230. A Phase I CMS was completed in April 2007 and a draft Phase II CMS was completed in May 2011. The VEP system continues to operate until the interim RIP is either adopted or an improved remedy is selected.	RFI underway RFI Report: March 2018
25	OT064	Building 210	A Draft Final RFA was completed in July 2008. A potential vapor intrusion condition was identified.	RFI suspended. Funding scheduled for FY22.
26	OT065	Building 283, Building 284, Building 296	A potential vapor intrusion condition was identified at Buildings 283, 284, and 296 during a base-wide vapor intrusion survey (inventory) in 2010.	RFI Report completed in December 2015 CMS underway CMS Report: September 2018
27	OT066	Building 2110 Oil Water Separator	Same Location as the Fuel Truck Maintenance Area AOC (see Table 10-1). The ODEQ approved the Air Force's NFA request in the 8/12/2002 RCRA Operations Permit Renewal. However, a fuel leak from the oil water separator to the oil was noticed in 2004. The RFI report was completed in 2016. Ultimate goal is to achieve UU/UE site close out.	Corrective Action - Non-time critical OWS removal work plan should be completed by March 2018

Current AOC No.	AF Site Number	Site Name	Activity History	Current Status
28	OT067	Building 2101	This building is the former motor pool which has been demolished and will not be replaced. Due to the nature of the motor pool operations, solvent and fuel leaks are suspected. The RFI report was completed in June 2015. The CMA workplan completed in March 2017. A non-time critical soil removal action is planed for late 2017. Ultimate goal is to achieve UU/UE site close out.	Corrective Action – is scheduled start January 2018.
29	OT068	Replaced" Fuel Hydrant System	In 1992, fuel releases from the hydrant system were detected when fuel would seep to the surface between the joints in the concrete of the tarmac. .	RFI Report completed in December 2015 CMS underway CMS Report: September 2018
30	OT069	Building 2121 and Building 2122	A RFA/RFI report was completed in March 2001 followed by a supplemental SI/RFI report in September 2001 and a CMS Report in October 2001 at Building 2122. Soil contamination was identified, but concluded that it was not impacting the groundwater. Similar process activities occurred at Building 2121 in the past, though no investigations have been performed at building 2121. Results for sub slab soil gas sampling beneath Building 2121 and 2122 were reported in a Vapor Intrusion Assessment that was completed in August 2011.	RFI underway RFI Report: March 2018
31	ST033	Area A Service (Fuel) Station	Soil and groundwater investigations conducted in 1990 and 1992 showed the presence of motor vehicle gas contamination. A product recovery system was installed in 1992 to pump fuel from the groundwater. By 1996, the extent of soil contamination was delineated, the USTs were removed and the product recovery system expanded. VEP remediation began June 1997, and fuel product recovery was completed by 1999. The OCC approved site closure on December 18, 2000; however, this is limited to only petroleum hydrocarbons in soil and groundwater. A TCE plume (along with other chlorinated compounds) has been identified in the groundwater beneath the site. The VEP system was shut down in November, 2012 and replaced with an Emulsified vegetable oil mixture injection – In Situ.	Corrective Action – In Situ Remediation for CVOCs ongoing.
32	VI080	Building 3105	Suspected releases of solvents from drain lines beneath Building 3105 were reported at this site in August 2009.	RFI underway RFI Report: September 2018

4.0ASSESSMENT OF SOLID WASTE MANAGEMENT UNITS (SWMU) AND AREAS OF CONCERN (AOC)

4.1 LANDFILLS POSTCLOSURE (equivalent)

Six landfills were operated at Tinker AFB during successive time periods between 1942 and 1979. Tinker AFB's six closed landfills are carefully and routinely monitored to insure that erosion and settlement do not compromise the final RCRA cover systems. In addition, the landfills are monitored to detect ground water contamination in accordance with the basewide groundwater monitoring program (subsection 10.5). It is no longer necessary to monitor migration of landfill gases per the *Landfill Gas Survey and Ready for Reuse Study* (Parsons, May 2007) since this study concluded that, with respect to state standards, no Oklahoma toxic air contaminant (TAC) maximum ambient air concentration (MAAC) levels are being exceeded.

ODEQ issued a certificate of "Ready for Anticipated Use" for landfills 1, 2, 3, 4 and 6 on March 28, 2008.

Annual post-closure inspection reports will be provided to demonstrate that each site has been inspected on a regular basis to evaluate the integrity and stability of the final cover and surface water diversion systems. If post-closure inspections of any landfill identify problems which require maintenance or repair, these problems and associated remedies will be discussed in detail within the site report. The purpose of these reports, inclusive of photos, will be to demonstrate that the surface and subsurface of the landfill continues to be stable and will not require further maintenance or repairs.

4.1.1 SWMU #1, Landfill 6

Landfill 6 (AF Site #LF016) is situated east of the main base south of Southeast 59th Street and ½ mile east of Douglas Boulevard. Landfill 6 is designated as SWMU #1. It occupies about 25 acres of a 40 acre site that Tinker AFB has leased from Oklahoma City from 1969 to the present. The landfill was operated from 1970 through 1979. The landfill was used to dispose of approximately 500,000 cubic yards of general refuse. There are reports that some paints, insecticides, solvent containers and Industrial Waste Treatment Plant sludge was also disposed of at the landfill. After the landfill ceased operating in 1979, the trenches were covered with several feet of compacted soil, and then planted with grasses.

A private well was sampled north of the site in 1983, and results of the sampling indicated some contamination. A follow-on sampling effort of several private wells in the area was performed by the OSDH (now ODEQ), but no contamination was found in any of these wells. The residence where contamination was discovered was connected to the Tinker AFB water supply at that time, but the residence no longer exists.

In January 1986, a compacted clay cap cover system was installed over much of the landfill as part of an interim action. Subsequently, investigations revealed that additional uncapped trenches existed and an extension to the cap cover system was constructed in 1988. During the site investigation in 1990, solid waste samples of the trenches revealed VOCs and some metals. The upper saturated zone (USZ) at the site also was sampled with the majority of contamination (arsenic, barium and cadmium) found in the western portion of the landfill. Groundwater is the primary route of contamination migration at the landfill. A 25-acre RCRA cap was installed over the landfill in 2000 as part of an interim corrective measure to reduce surface water infiltration, minimize the possibility of leachate migrating into the groundwater, and prevent any direct contact with the site. Long term care of the RCRA cap for Landfill 6, and groundwater monitoring around the site will continue as part of the ongoing corrective measure.

4.1.2 SWMU #2, Landfill 5

Designated as SWMU #2, Landfill 5 (AF Site #LF015) encompasses about 6.0 acres and is located in the south central portion of Tinker AFB. The landfill is bordered by Tower Road on the west, the TACAMO (Navy) ramp to the south and Crutcho Creek to the north and east. While it was in operation from 1968 to 1970, the landfill accepted approximately 75,000 cubic yards of general refuse with small quantities of industrial waste. Preliminary sampling indicated the presence of both metals and organic compounds including TCE. An interim 12-inch compacted clay cap was installed in August 1990 to minimize infiltration of surface water into the landfill. In 1998, a 6-acre RCRA cap was installed over the landfill as part of an interim corrective measure to reduce surface water infiltration, minimize the possibility of leachate migrating into the groundwater, and prevent any direct contact with the site. Landfill 5 lies within the boundary of the East Contaminated Groundwater Management Unit (AF Site #CG039). Long term care of the RCRA cap will continue for Landfill 5, and monitoring of groundwater around the site will continue as part of the AF Site # CG039 (basewide groundwater monitoring program).

4.1.3 SWMU #3, Landfill 1

Landfill 1 (AF Site #LF011) is designated as SWMU #3. It is located east of Patrol Road and south of Crutcho Creek, it covers an area of 1.5 acres. During its operation from 1942 through 1945, the landfill received general refuse and industrial waste generated at Tinker AFB. Trench water sampling and soil borings revealed low concentrations of VOCs and semi-volatile organic compounds (SVOCs) along with low levels of metals. An investigation of Crutcho Creek did not reveal any indication that contamination had migrated into the creek. Land use near the site does not include any ecologically sensitive areas, but military housing is located roughly 1500 feet to the west. A 2-acre RCRA cap was installed over the landfill in 1991 as part of an interim corrective measure to reduce surface water infiltration, minimize the possibility of leachate migrating into the groundwater, and prevent any direct contact with the site. The site lies within the boundary of the Southwest Contaminated Groundwater Management Unit, AF Site #CG038. The 2002 RFI for AF Site CG038 concluded that Landfill 1 does not appear to be a source of contamination to AF Site #CG038. Long term care of the RCRA cap will continue for Landfill 1, and monitoring of groundwater around the site will continue as part of the AF Site CG038 (basewide groundwater monitoring program) .

4.1.4 SWMU #4, Landfill 2

Landfill 2 (AF Site #LF012) covers 27.5 acres and is located south of Vanaman Road and adjacent to Landfill 4 on the southwest side of the base. This landfill is designated as SWMU #4. Dates of operation for Landfill 2 have been reported as being from 1945 through 1952; however, aerial photos suggest that the range of use of the site might be closer to 1945 through 1963. This landfill primarily received general refuse from the base, including sanitary and industrial waste. Soil and groundwater investigations were performed between 1985 and 1990 to determine if

environmental contamination in the area occurred as a result of disposal and management practices. Trench water sampling showed low concentrations of VOCs (including TCE and vinyl chloride) and SVOCs. Low levels of metals such as barium, cadmium, chromium, lead and nickel were also detected. The possibility of leachate migrating into Crutcho Creek from the landfill was thought to exist; however, samples collected in the creek do not indicate that this occurred. In addition, a radiological waste disposal site once located within Landfill 2, was remediated through soil removal actions performed in 1992 and 1997.

A 28-acre RCRA cap was installed over the Landfill 2 in 1998 as part of an interim corrective measure to reduce surface water infiltration, minimize the possibility of leachate migrating into the groundwater or to the creek, and prevent any direct contact with the site. Landfill 2 lies within the boundary of the Southwest Contaminated Groundwater Management Unit, AF Site #CG038. A RFI/CMS was conducted between 2002 and 2004 for AF Site #CG038, and concluded that the burial trenches and other waste management activities within Landfill 2 are a likely source of chlorinated hydrocarbon contamination to AF Site #CG038. Between 2004 and 2008 additional studies have identified and delineated hexavalent chromium contamination in the groundwater beneath Landfill 2. Long term care of the RCRA cap will continue for Landfill 2, and monitoring of groundwater around the site will continue as part of the AF Site #CG038 (basewide groundwater monitoring program).

4.1.5 SWMU #5, Landfill 3

Landfill 3 (AF Site #LF013), designated as SWMU #5, covers approximately eight acres and is located north of Vanaman Road and south of Crutcho Creek in the southwestern portion of the base. It is reported to have been in operation from 1952 through 1961, although aerial photo evidence suggests trenching may have started around 1951. The landfill was used primarily for disposal of general refuse, but included some industrial waste as well. The waste burial trenches were closed in 1961, but a sludge dump operated in the south-central area of the landfill from roughly 1961 until 1968. Soil and groundwater investigations were performed between 1986 and 1990 to determine if environmental contamination in the area occurred as a result of disposal and management practices. Trench water sampling revealed low concentrations of VOCs including TCE, methyl ethyl ketone (MEK) and toluene as well as SVOCs. Metals in the trench water samples included barium, chromium, cadmium, lead, mercury and zinc. In addition, laboratory results for soil samples recovered from 3 to 18 foot deep borings around the sludge pit were indicative of high concentrations of both solvent and fuel compounds.

An 8-acre RCRA cap was installed over the landfill in 1991 as part of an interim corrective action to reduce surface water infiltration, minimize the possibility of leachate migrating into the groundwater, and prevent any direct contact with the site. An investigation and report of landfills 1 through 4 incorporating data back to 1987, was completed in 1993. After the landfill was capped, additional groundwater investigations were conducted to delineate the

contaminant plumes beneath the landfill. The site lies within the boundary of the Southwest Contaminated Groundwater Management Unit, Site #CG038. A RFI/CMS conducted between 2002 and 2004 for CG038 concluded that the former Sludge Dump Area in Landfill 3 was the primary source of the chlorinated hydrocarbon contamination at the north solvent plume in CG038. Near the southern boundary of Landfill 3, high concentrations of several VOCs, including vinyl chloride and cis-1,2-dichloroethene (DCE) have been detected in groundwater. Long term care of the RCRA cap will continue for Landfill 3, and monitoring of groundwater around the site will continue as part of the AF Site #CG038 (baswide groundwater monitoring program).

4.1.6 SWMU #6, Landfill 4

Landfill 4 (AF Site #LF014) covers 12.4 acres and is located immediately west of Landfill 2. Landfill 4, designated as SWMU # 6, is south of Vanaman Road and was mainly operated from 1961 through 1968. Aerial photo evidence, however, suggests that trenching occurred as early as 1948 in the northwest corner of the landfill, and again in 1953. Waste placed in the landfill consisted mostly of general refuse with some drums containing solidified solvent and metal shavings. Soil and groundwater investigations were performed between 1985 and 1990 to determine if environmental contamination in the area occurred as a result of disposal and management practices. Trench water sampling showed low concentrations of VOCs including TCE, MEK, and toluene as well as SVOCs. Metals in the trench water contained chromium and manganese. Soil samples obtained from 5 to 18 foot below surface revealed acetone, MEK and chromium. The possibility of leachate migrating into Crutcho Creek was thought to exist. However, an investigation of Crutcho Creek did not show any indication that this has ever occurred. A 13-acre RCRA cap was installed over the landfill in 1998 as part of an interim corrective measure to reduce surface water infiltration, minimize the possibility of leachate migrating into the groundwater or to the creek, and prevent any direct contact with the site. Landfill 4 lies within the boundary of the Southwest Contaminated Groundwater Management Unit, AF Site #CG038. A RFI/CMS was conducted between 2002 and 2004 for CG038, and concluded that the burial trenches within Landfill 4 are potentially sources of chlorinated hydrocarbon and hexavalent chromium contamination to AF Site #CG038. Long term care of the RCRA cap will continue for Landfill 4, and monitoring of groundwater around the site will continue as part of the AF Site # CG038 (basewide groundwater monitoring program).

4.2 SWMU #24 IWTP – Industrial Wastewater Treatment Plant – Soils.

The IWTP (SWMU #24), a component of AF Site #OT034, is located in the northeast corner of Tinker AFB and is the process pre-treatment plant for all industrial and sanitary wastewater generated at Tinker AFB. The IWTP was constructed in 1972 to treat industrial wastewater generated at the base, including electroplating, chemical cleaning and paint-stripping operations. These operations generated wastewater containing oil, grease, metals and organic solvents. In April 1996, Tinker AFB permanently diverted discharge from both the IWTP and sanitary sewer sources to the Oklahoma City wastewater collection system under a City of Oklahoma City Industrial User Permit. Since 1996, the IWTP no longer discharges into Soldier Creek.

Subsequent to the 1988 Federal Facilities Agreement (FFA), it was decided that the soils associated with the IWTP would be managed under RCRA guidance, and the groundwater media would be managed under CERCLA. Under RCRA, the remedial action at SWMU #24 is only concerned with the soils associated with the IWTP. The original SWMU #24 was defined as consisting of thirty-three process units, thirteen of which were designated SWMUs.

A RFI, which included soil, was conducted between 1993 and 1996. Results of the investigations indicated the presence of chlorinated and non-chlorinated VOCs, SVOCs, phenolic compounds and metals in the soil, as well as VOCs in the soil gas. The 1996 Phase II RFI concluded that soil contamination existed at IWTP and corrective measures were implemented to treat the soil media within the IWTP facility.

In 2000, the industrial waste sludge drying beds were removed as an interim corrective measure and a vacuum enhanced pumping (VEP) system with five extraction wells was installed to recover subsurface liquids and soil gas in the vicinity of the former drying beds. In 2001, the former industrial waste tanks D-1 and D-2 were demolished and removed from the IWTP.

In 2003, the VEP system was expanded to recover vapors and liquids from the soils beneath the former tanks D-1 and D-2. The Air Force submitted a decision document to ODEQ in February 2004 selecting VEP as the corrective measure for treating the remaining IWTP soils (above industrial risk screening levels). ODEQ approved the selected corrective measure for IWTP soils on May 5, 2004. During the summer of 2016, a non-time critical soil removal was conducted to remove additional soil contamination that was discovered to be above industrial risk screening levels. A RCRA Corrective Action Completion Report is being developed.

4.3 AOC #1, Fuel Farm (290 POL Facility)

The 290 Fuel Farm site (AF Site #ST007) is located in the north-central area of the base. The site is bounded by First and Arnold Streets on the north and south and by “A” and “B” Avenues on the east and west, respectively. The original Fuel Farm consisted of five 18,000-gallon USTs and 20 25,000-gallon USTs. The tanks were used to store motor fuel, aviation gasoline and JP-4. Two major spills of 6,000 and 10,000 gallons, respectively, occurred in 1979 and 1980. The USTs were removed and replaced with above-ground storage tanks (ASTs) in 1988. Investigations conducted in 1985, 1987, and 1988 found fuel-related contaminants in the soil and groundwater. An additional investigation was conducted at the site in 1994 to determine the amount of fuel remaining in the soil and the full extent of groundwater contamination. TCE and other chlorinated solvents were also identified in the RI. In 1986, a two-well pump and treatment system was installed at the site as part of an interim action. This operated until 1989 when it was shut down. Two VEP systems were installed at the site, as second interim corrective measure, between 1998 and 2000. Collectively, the two systems extract groundwater and soil vapor from 34 recovery wells around Building 214, the former Building 210, near Tank 349, and near Building 117. The two VEP systems were shut down in April, 2012 to allow for the groundwater to rebound in order to conduct a site investigation to evaluate the current nature and extent of the contamination. An RFI report is scheduled to be completed by early 2018.

4.4 AOC #20, Building 201 (VaporIntrusion)

Building 201 (AOC #20) is currently the base personnel and training office. It is used for administrative processing of employees on Tinker AFB. There are no current industrial activities ongoing inside of the building; however, the building was used for industrial purposes for a number of years after it was constructed in the 1940s. Sub slab soil gas sampling was conducted in 2009 and 2010 and the investigations indicated that a vapor intrusion condition may exist within the building. Building 201 is part of AF site ST008, which includes 4 SWMUs that have reached NFA status. Three of these SWMUs are located in close proximity to Building 201 but are not considered the sources of the soil gas measurements obtained in 2009 and 2010. However, there are several industrial waste lines to the south and east of the building and a chlorinated hydrocarbon plume in the USZ groundwater is located underneath most of Building 201. Analytical results at one subslab location indicate significant levels of TCE in the soil gas media, although the areal extent has not been determined. Additional site investigative efforts have been programmed and awaitingfunding.

4.5 AOC #21, Gator Contaminated Groundwater Management Unit

AOC #21, the Gator Contaminated Groundwater Management Unit (AF Site #CG040), was designated as a groundwater management unit site in 1996. It is located at an adjunct (satellite) facility approximately one mile east of the eastern boundary of Tinker AFB near the intersection of SE 59th St. and Post Road. The facility is non-industrial; only one building used for administrative purposes is found at the site. Chlorinated solvents including TCE have been detected above regulatory limits in the groundwater since the first monitoring wells were installed in 1995. No unique source has been identified for this contamination. A chlorinated plume has impacted shallow groundwater in the USZ and Lower Saturated Zone (LSZ); both are part of the Garber-Wellington Aquifer. Residences with private wells are extremely close to the site, one within 50 feet. This well has been tested several times by Tinker AFB and shows no contamination.

A groundwater extraction and treatment system began operation as an interim corrective measure in October 1999. The extraction system consists of two French drain segments in the USZ and a single pumping well in the LSZ. Contaminated groundwater is being pumped to an air stripper designed to treat contaminated groundwater to drinking water standards or better. The single pumping well in the LSZ was designed to capture the entire LSZ plume. Surrounding wells are monitored to ensure capture. Treated groundwater is discharged into a base operated sanitary sewer line near the site. The RFI report was completed in December 2003 and the CMS report was completed in July 2006. A Statement of Basis was completed as a decision document between Tinker AFB and the ODEQ, and was signed by ODEQ on July 31, 2006. The selected remedy consisted of continued operation of the

groundwater extraction and treatment system along with institutional and engineering controls. In 2013, an in-situ bioremediation treatment system was installed to further treat the higher concentrations of VCOCs within the plumes. The overall goal of the in-situ system is to treat the groundwater contamination below MCLs and achieve Site Closeout at residential levels – Unlimited Use/Unrestricted Exposure (UU/UE).

4.6 AOC #22, AWACS Sector

AOC #22, known as the Air Warning and Control System (AWACS) Sector Contaminated Groundwater Management Unit (AF Site #CG041), consists of chlorinated solvent groundwater plumes in the vicinity of the AWACS flight apron. The site is in the north central portion of Tinker AFB and encompasses the contaminated groundwater beneath the tarmac and taxiways south of Building 230. The site also extends beneath several industrial buildings to the west of Building 230 and unpaved areas to the south, east, and west of the tarmac. The facilities overlying CG041 have been used for industrial purposes since 1942.

Two chlorinated solvent plumes exist within CG041. One is largely under the industrial buildings on the north side of CG041, while the other plume is on the southern border of CG041 underneath the tarmac and taxiways. The northern plume has impacted only the USZ, whereas the southern plume has impacted both the USZ and LSZ. For the northern plume, suspected sources of the contamination include: 1) USTs containing unknown materials that were located adjacent to the former Building 267 (a demolished vehicle maintenance shop), 2) former Building 227 (a demolished motor repair shop), 3) an abandoned waste tank (tank 226) located near the former Building 228 that contained miscellaneous contaminated oil, 4) two 50,000 gallon USTs formerly located under the southwest corner of Building 289, and 5) potential leaks and breaks in the industrial waste lines in the vicinity of Building 289. For the southern plume, historical solvent usage on the tarmac from the 1940s to the 1970s is the suspected source. Currently, concentrations of chlorinated compounds are generally either stable or decreasing in the USZ and generally stable in the LSZ. A RCRA Facility Investigation (RFI) was conducted to evaluate the nature and extent of the contamination. The RFI report was completed in August, 2014 with a recommendation to conduct a Corrective Measure Study – currently underway.

4.7 AOC #23, Jet Engine Test Cells (Building3703)

Area of Concern #23 (AF Site #OT058), consisting of Building 3703, is located within CG039. The Jet Engine Test Cells (JETC) site is in the eastern portion of Tinker AFB, on Turbine Drive between East Drive to the west and Cells Road on the east. The combined facility serves to mechanically test and service rebuilt jet engines and after-burners prior to redeployment. Wastewater associated with jet engine testing and cleaning is discharged to the industrial wastewater collection system. Building 3703 was constructed in 1951 and originally included four test cell chambers. Subsequently, four additional chambers were added. Currently, all eight jet engine test cell chambers are operational. Solvents, such as TCE, were reportedly used at both buildings in the past to clean the jet engines. Presently, JP-5 is the most commonly used fuel for engine testing. The fuel is transported to the facility by pipeline from the 3700

Fuel Yard. These fuel lines were entirely underground until the 1970s, at which time a portion were converted to aboveground. The fuel system is also known as the Nancy Hydrant System.

There are two known release sources at Building 3703: 1) leaks in the JP-5 supply line to Building 3703 within the building's underground duct bank; and 2) the oil-water-separator (OWS) system on the western side of Building 3703, which released industrial wastewater to the subsurface. Since 1992, actions performed to remediate contaminant leakage at Building 3703 include the replacement of various industrial waste lines and OWS upgrades. A RFI was conducted between 2000 and 2002. An interim remedial action began in May 2002 to extract groundwater, vapor, and mobile nonaqueous phase liquids from the subsurface, and is still operating. A CMS was completed in 2005.

The same RFI also identified the possibility that contamination at the northwest corner of Building 3234 is the result of JP-5 fuel releases from the nearby Nancy Hydrant system. The contaminant releases at the northeast corner of Building 3234 are a result of faulty installation of an industrial waste line that has since been corrected and/or replaced.

The most prevalent contaminants found in groundwater at this AOC are fuel-related compounds (i.e., TPH-gasoline, TPH-diesel, and BTEX) and chlorinated solvents (including PCE, TCE, and their anaerobic degradation products such as cis-1,2-DCE, 1,2-DCA, and vinyl chloride). Chlorinated solvent contamination in the USZ and LSZ extends beyond the boundary of OT058 to the east, south, and west. Some of the highest concentrations of TCE are directly south of OT058 near a former Industrial Waste Evaporation Basin which overlies the USZ. Groundwater contamination beyond the boundaries of OT058 is being evaluated as part of CG039. Within the boundaries of the site, substantial amounts of dissolved and vapor phase contaminants have been recovered; however, no free product has been observed at the site. Nevertheless, significant contamination remains throughout OT058, particularly petroleum hydrocarbons and chlorinated compounds.

Soil gas sampling conducted in 2007 near Building 3703 indicates that there are probable contaminant sources beneath Building 3703 either in the soil, the groundwater, or both. PCE was detected in soil gas beneath Building 3703 at 41,000 parts per billion by volume. Therefore, contaminants in soil and/or groundwater beneath the building have the potential to migrate into indoor air via vapor intrusion (VI). A RCRA Facility Investigation (RFI) has been conducted to evaluate the nature and extent of the contamination with a report due to be completed by late 2017.

4.8 AOC #24, Building 230

Building 230 (AF Site #OT062) is in the north central portion of Tinker AFB, between First Street and the ramp area at "C" Avenue. Building 230 is a four-bay hangar with support facilities that was used as a central repair hangar during World War II. Industrial activities in the building included aircraft overhaul, cleaning, retrofitting, upgrades, and general maintenance. Industrial processes are still conducted on the north end of the building, but are primarily limited to dry

operations. There is an extensive network of industrial waste water drain lines along the north side of Building 230 and running north-south beneath the building.

Chemicals were released to the environment from leaks in sumps and the industrial waste water drain lines at Building 230 as well as from spills, allowing chemicals to percolate into the soil. The migrating contaminants have reached the uppermost units of the Garber Sandstone in the vadose zone above the USZ. Contaminants in soil are primarily located on the north and west sides of Building 230 from approximately 2 to 9 feet below ground surface (bgs). The primary contaminants at the site are BTEX, carbon tetrachloride, cis-1,2-DCE, Freon 113 (1,1,2- trichloro- 1,2,2-triflouroethane), methane, MEK, TCE, and vinyl chloride.

The initial RFI report was completed in 2003. A VEP system was installed as an interim corrective measure to mitigate the potential risk posed by subsurface contaminants along the north and west sides of Building 230. The VEP system was operated continuously since startup in May 2005 until shutdown in 2011. The system uses groundwater extraction wells and horizontal soil vapor extraction wells to remove contaminated groundwater and soil gas, respectively, that is then directed to a treatment plant constructed specifically for this cleanup action. An updated RCRA Facility Investigation (RFI) has been conducted to evaluate the nature and extent of the contamination with a report due to be completed by late 2017.

4.9 AOC #25 Building 210

The Building 210 site (AF Site #OT064) is located in the north-central area of the base and consists of Buildings 210 and 213, an unpaved grassy area, and a parking lot. The site, designated as AOC #25, is situated north of First Street between "B" and "C" Avenues. The original Building 210 structure was built in 1942 and was used to refabricate and overhaul hydraulic and pneumatic control systems. The building included a paint shop, parts cleaning area, machine shop, test cells, and instrument repair area. Activities at the original Building 210 required the extensive use and storage of fuels, lubricants, and degreasing solvents. In addition, mercury filled manometers and temperature/pressure controls were used in the former test cells. In 2003-2004, approximately 90 percent of the building was demolished and removed. Most of the former Building 210 is now a paved parking lot. The northeast corner of the former Building 210 remains intact and contains a compressor room that serves a repair and maintenance facility located directly north in Building 200. This remnant of the original Building 210 is also currently used as a turbine maintenance and repair shop. In addition, Building 213, which is another turbine maintenance and repair shop built in 1993, is located in the southeast corner of OT064.

When a 6,000 gallon UST at the site was removed in August 1997, several holes were observed on the underside. Approximately 1,500 gallons of mixed residual solvents and gasoline remained in the tank during excavation, and free product was also encountered on the shallow groundwater during the removal of the UST. At least three additional USTs were also located within the boundaries of OT064, although these are indicated as having been abandoned prior to 1987. Two of these USTs stored fuels and one stored solvents. During demolition of the test

cell area of Building 210 in 2003-2004, free-phase mercury was encountered in the test cell drain lines and surrounding soil. The drain lines and the surrounding mercury-impacted soil were excavated and removed in 2004

VOCs have been detected in groundwater at the site; however, no groundwater plumes have been identified previously within OT064. There are chlorinated solvent groundwater plumes to the east, west, and south of OT064 in both the USZ and LSZ and fuel plumes to the east, northeast, and west of OT064 in the USZ. Soil gas data from 9 near slab soil gas probes collected from 2005 to 2009 around Buildings 210 and 208 indicate soil gas vapors exist along the northern boundary of OT064 at concentrations that may impact Building 200 directly to the north. As an interim remedial action, VEP extraction and recovery wells were installed in 1998 in the eastern portion of OT064. An additional VEP well was installed along the northern boundary of OT064 in 2007 near Building 200. These wells have been removing both contaminated soil vapor and groundwater from the site and continue to operate.

A recent site investigation has indicated that a solvent plume may exist under the site and further study is planned to be conducted in the near future (budget pending).

4.10 AOC #26, Buildings 283, 284 and 296

AOC #26 is located in the north-central portion of Tinker AFB and consists of three buildings: Building 283 (Flight Simulator Training Facility & 552nd Squadron Operations Facility), Building 284 (Data Processing and AWACS Training Facility), and Building 296 (AWACS Supply Warehouse). Although currently used for administrative and storage purposes, these buildings were once industrial in nature. The buildings are collectively referred to as AF Site #OT065. Sentry Road runs east-west through the center of OT065 with Building 284 on the north side and Building 283 and Building 296 on the south side of Sentry Road. The intersection of Sentry Road and “D” Avenue is adjacent to the northeast corner of Building 296.

Past waste streams associated with OT065 include fuels (i.e., JP-4, JP-5, JP-8, and motor gasoline) and photographic developer waste from Building 283. In 1992, during the construction of Building 296, several abandoned utility lines were found containing jet fuel from a leaking adjacent JP-4 transfer line. Subsequently, the leaking JP-4 transfer line was cleaned of the remaining fuel and abandoned in place. The abandoned JP-4 transfer line runs north-south under the eastern portion of Building 296. Several other utility lines run under the east side of Building 296, including the main Tinker AFB industrial waste water line and a fuel distribution line. There is also an OWS south of Building 296, just beyond the boundary of the site. Wash racks, a radar maintenance facility, and a motor repair shop previously existed in the vicinity of Buildings 283, 284, and 296 as well.

Sub-slab soil gas sampling conducted in 2009 at Building 296 revealed concentrations of TCE as high as 7630 parts per billion by volume. In the USZ, a TCE plume exists beneath the southeastern corner of B296 and extends beyond the boundary of OT065 to the northeast, south and southwest. High concentrations of TCE exist in the USZ directly south of Building 296,

and at the southeastern corner of Building 289. In addition, cis-1,2-DCE and vinyl chloride plumes in the USZ have been found below the eastern portion of Building 296. There is also a BTEX groundwater plume underneath Building 296 that extends west under Building 283 and northwest to Sentry Road. A LSZ TCE plume identified beneath Building 283 and Building 296 extends beyond the boundary of OT065 to the northeast.

4.11 AOC #27, Building 2110 Oil-Water Separator

Building 2110 (AF Site #OT066) is used as a fuel truck maintenance facility (FTMF). In operation since 1957, Building 2110 includes a wash rack oil water separator (OWS); residual fuel is released to the OWS and is then recycled. The OWS, designated as AOC #27, includes potentially impacted soil and groundwater. During construction operations at Building 2110 in November 1990, soil and water contamination were discovered under the concrete floor. A RFI of the soils was conducted at Building 2110 between 1993 and 1994. Contaminants within the soils were found to consist of petroleum hydrocarbons including BTEX and chlorinated compounds typical of degreasers (acetone, chlorobenzene, and PCE). The 1994 RFI determined that these contaminants were released to the soils from the floor drain of Building 2110, but the report contended that contamination attributed to the FTMF is limited to the upper 15 feet of soils and does not extend down to the water table. However, chlorinated solvent groundwater contamination in the USZ was independently found to occur beneath Building 2110 and could potentially originate with the OWS. The RFI report has been completed and approved by ODEQ in October, 2016. The OWS, and any associated contaminated soil is planned to be removed with the demolition of Building 2110, currently planned for 2023.

4.12 AOC #28, Building 2101

Building 2101 (AF Site #OT067) was built in the 1940s and was the original location of the motor pool. The suspected source of the groundwater contamination at AOC #28 is leaks in the wastewater drain lines for Building 2101. This site includes contaminant releases from Building 2101 to environmental media including soil and groundwater. Chlorinated solvent groundwater contamination is located immediately downgradient of Building 2101, and may be present under the building. A facility inspection was completed in August 2009. The building has been demolished (2011). A RFI report was finalized in June 2015 and ODEQ has approved the workplan for a non-time critical soil removal of hot spots. The removal action is scheduled for late 2017.

4.13 AOC #29, "Replaced" Fuel Hydrant System

AOC #29 (AF Site OT068) is known as either the Phillips Hydrant System #66230, the "Replaced" Fuel Hydrant System. It is located in the north central portion of Tinker AFB. The fuel hydrant system is contained mostly within AF site CG041. The Phillips Hydrant System is an underground fueling system used to deliver fuel to aircraft on the north tarmac at Tinker AFB.

The fuel hydrant system is constructed beneath the tarmac and extends eastward from Building 260 to a point approximately 500 feet south of the center of Building 230.

Prior to system upgrades conducted in 1992, fuel releases from the hydrant system were detected when fuel would seep to the surface between the joints in the concrete of the tarmac. At least six fuel releases from the hydrant system have been reported, with each release resulting in the removal of approximately 500 cubic yards of contaminated soil. A plan to replace the fuel hydrant system included a component to remove contaminated soil. Test borings were drilled in the area subsequent to the hydrant replacement activities. Field measurements from one soil boring sample indicated high levels of volatile vapors at a depth of 4.5 feet bgs. BTEX has been detected at low concentrations in two wells in the USZ near the southern portion of the hydrant system. The RFI report was completed in August, 2014 with a recommendation to conduct a Corrective Measure Study – currently underway.

4.14 AOC #30, Building 2121 and Building 2122

The area including Buildings 2121 and 2122 (AF Site #OT069) is designated as AOC #30. The two buildings are hangars located in the southeast quadrant of Tinker AFB. Aircraft maintenance has been conducted in both buildings since the early 1940s, including the use of solvents and stripping agents. More recently Building 2121 has been used for non-chemical maintenance operations; however, Building 2122 is still one of the main hangars for paint stripping operations using a variety of solvents. Products containing dichloromethane, phenol, monoethanolamine, and chromic acid were still in use in 2001. Degradation in caulking in the floor expansion joints has resulted in approximately 3/4-inch gaps open to the subgrade adjacent to the wastewater collection trenches. The solvents and wastewater have been observed to migrate through the expansion joints to the subgrade. A SI/RFI was performed at Building 2122 between 1999 and 2000, followed by a Supplemental SI/RFI in 2002, and a CMS (soil media only) in 2003. Results of the investigations at Building 2122 indicated that the soils beneath Building 2122 were impacted by waste water leaking through floor/drains joints. Subsurface soil was impacted but localized and shallow. The identified levels of soil contamination have not impacted the shallow groundwater zone, primarily due to presence of the building floor slabs and foundation. The CMS stated that the current level of soil contamination does not pose significant risk to human health and environment, and there are no significant routes for further migration, provided that potential future releases are controlled. Current controls include using proper materials to seal the floor joints. In 2006, sub slab and indoor air sampling was performed in the administrative area of Building 2122. It was determined that contaminants were left in receptacles beneath the floor from shop activities performed in the past. The receptacles were drained and the contamination mitigated. In 2009 and 2010, sub slab soil gas sampling was performed at Buildings 2121 and 2122 to evaluate potential contaminant sources beneath the buildings. Groundwater releases are addressed under groundwater management unit AF Site #CG039. An RFI is currently underway with the report scheduled to be submitted in late 2017.

4.15 AOC #31, Area A Service (Fuel) Station

AOC #31, located south of the original Building 414, is known as the former Area A Service Station. This area served as a motor fuel station from 1942 until it closed in 1990. Gasoline and diesel fuels were stored in four USTs. Two of the tanks were used for leaded and unleaded gasoline storage, a third tank stored unleaded gasoline, and the fourth tank, installed in 1975, was used for diesel storage. The third and fourth tanks noted above were taken out of service when the station closed in 1990. Soil and groundwater investigations conducted in 1990 and 1992 showed the presence of mogas contamination. A product recovery system was installed in 1992 to pump fuel from the groundwater. By 1996, the extent of soil contamination was delineated, the remaining USTs were removed and the product recovery system expanded. VEP remediation began June 1997, and fuel product recovery was completed by 1999. The Oklahoma Corporation Commission (OCC) approved site closure on December 18, 2000; however, this is limited to only petroleum hydrocarbons in soil and groundwater. A TCE plume (along with other chlorinated compounds) was also identified in the groundwater beneath the site as part of the Northwest Groundwater Contaminated Management Unit, AF Site #CG037. The TCE groundwater plume borders the base boundary. The VEP system was shut down in November, 2012 and replaced with an Emulsified vegetable oil mixture injection – In Situ remedy as the current interim corrective measure.

4.16 AOC #32, Building 3105

AOC #32, Building 3105 (AF Site #VI080), was used for aircraft maintenance, including mechanical sanding, calibration of hydraulic fuel pumps, and maintenance of electrical systems. This building is located approximately 700 feet east of the North-South Runway between West Drive and the southern extent of Building 3001. Building 3105 is suspected to have leaking drain lines. A TCE groundwater plume immediately downgradient of Building 3105 has TCE concentrations up to 1,180 parts per billion. This site includes contaminant releases from Building 3105 to environmental media including soil. The groundwater is addressed as part of the Soldier Creek/Building 3001 NPL site. An RFI is currently underway.

5.0 SAMPLING AND ANALYSIS PLAN

Tinker AFB, will conduct all the sampling and analysis effort in accordance with the ODEQ approved Unified Federal Policy – Quality Assurance Project Plan (UFP-QAPP).

6.0 PROJECT MANAGEMENT ORGANIZATION

The Organization for the Correction Action Strategy (CAS) involved key individuals for Tinker AFB. The offices and key individual are identified below.

Local Tinker AFB Installation Support Section office (Tinker ISS)

Tinker 72 ABW Commander
Tinker Base Civil Engineer
Tinker ISS Chief
Tinker ISS Remedial Project Manager (RPM)
Tinker ISS ERP Staff

Other Air Force Civil Engineering Center (AFCEC) personnel

AFCEC CZR ERP Division Chief
AFCEC CZR ERP Central Branch Chief
AFCEC CZR ERP Program Manger Operation

6.1 RESPONSIBILITIES

The Air Force is the principal party responsible for the implementation of the CAS and proposed activities in this workplan. The local Tinker AFB ISS ERP staff will establish project requirements and be providing contractor oversight that will execute this workplan.

7.0 REFERENCES

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