Arkansas River Corridor Projects Preliminary Groundwater Review

TO:	Tulsa County
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FROM:	CH2M HILL
DATE:	March 23, 2010
PROJECT NUMBER:	386594

Background

Tulsa County, as part of the Arkansas River Corridor Master Plan (Carter & Burgess, 2004; C. H. Guernsey and Company et al., 2005), is undertaking an improvement project on the Arkansas River. The primary goals of the overall project are to improve least tern habitat, improve fish habitat and fish passage, improve the function of the river system itself, enhance economic development, increase recreational opportunities, and increase connectivity between the river and surrounding communities. The conceptual project components are described in detail in the Technical Memorandum (TM) entitled Baseline Project Summary for the Arkansas River Corridor Project (CH2M HILL, 2009). Key components include:

- Design of habitat improvements along the corridor
- Design of bank stabilization in select areas
- Design of a new Sand Springs low-head dam, pedestrian bridge, and amenities
- Design of modifications to Zink Dam and lake with whitewater features
- Design of a new South Tulsa/Jenks low-head dam, pedestrian bridge, and amenities

This TM presents a preliminary review of information and issues associated with potential groundwater effects to be considered during subsequent preparation of the project-related environmental documentation. It includes discussion of existing groundwater conditions that could be affected by the project--such as groundwater remediation of contaminant plumes--and those that could be indirectly affected by implementing the project, such as submersion of root zones of existing vegetation.

Based on recent computer modeling results, proposed conditions, etc., implementation of the proposed project will not raise the level of the Arkansas River above the historical river stage. The groundwater levels resulting from the project, therefore, are expected to be within historical ranges. Since the frequency and duration of inundation could vary from historic flooding and river operation, groundwater level responses would be different than what has occurred in the past. Assessing these potential changes in groundwater conditions and their effects, if any, will be the focus of subsequent project groundwater assessment. This TM presents a preliminary hydrogeologic conceptual model (generalized description of the aquifer system and the relationship between the river and the surrounding aquifer), describes known groundwater issues to be considered during environmental document preparation, and identifies what additional information is needed to support the environmental documents and assess potential project-related groundwater impacts.

Hydrogeologic Setting and Conceptual Model

The Arkansas River project corridor occurs generally within the limits of a shallow alluvial aquifer, as shown in Figure 1. The alluvium ranges in thickness from 20 to 40 feet, based on a partial review of well records along the river between Sand Springs and Tulsa (Oklahoma Water Resources Board [OWRB], 2009). The alluvium consists of relatively permeable coarse sand and fine gravel overlying the bedrock, which is in turn overlain by floodplain deposits of silt and fine sand (Marcher and Bingham, 1971). Bedrock is composed of low-permeability shale. An assessment of the hydrogeologic relationship between the alluvium and underlying shale was not available, but it is reasonable to assume there is little groundwater transfer between the shallow alluvial aquifer and deep regional aquifers in the project area.

Documents for several projects, including the Holly refinery (formerly the Sinclair and Sunoco refineries), are available in Oklahoma City at the Oklahoma Department of Environmental Quality. However, site-specific groundwater elevation maps depicting current and historical groundwater conditions were not available for review to identify project corridor groundwater flow patterns. It is assumed that the groundwater flow gradient in the alluvium is generally parallel to the river, but whether the river recharges the local aquifer or vice versa is not known. Depth-to-water data were available for some well completion reports (OWRB, 2009) and indicate that the water table ranges from about 8 to 29 feet below grade.

The Arkansas River level fluctuates based on local hydrologic conditions and the operation of Keystone Dam, located 15 miles upstream of Tulsa. How groundwater currently responds to changes in river stage has not been assessed because the data were not readily available. It is assumed that varying flow conditions would result in groundwater level changes within the alluvium that reflect river stage changes.

Because the dams will develop long-term impoundments of portions of the Arkansas River, local changes to groundwater conditions will occur. For example, water levels in the three dam and impoundment areas will be increased, increasing average groundwater levels in the alluvial aquifer in those areas. In addition, the overall range of seasonal groundwater fluctuations could be reduced. The magnitude and extent of groundwater level changes will depend on local groundwater conditions and the river stage changes, which will vary along the project corridor. It is expected that the alluvial aquifer will be most affected near the river.

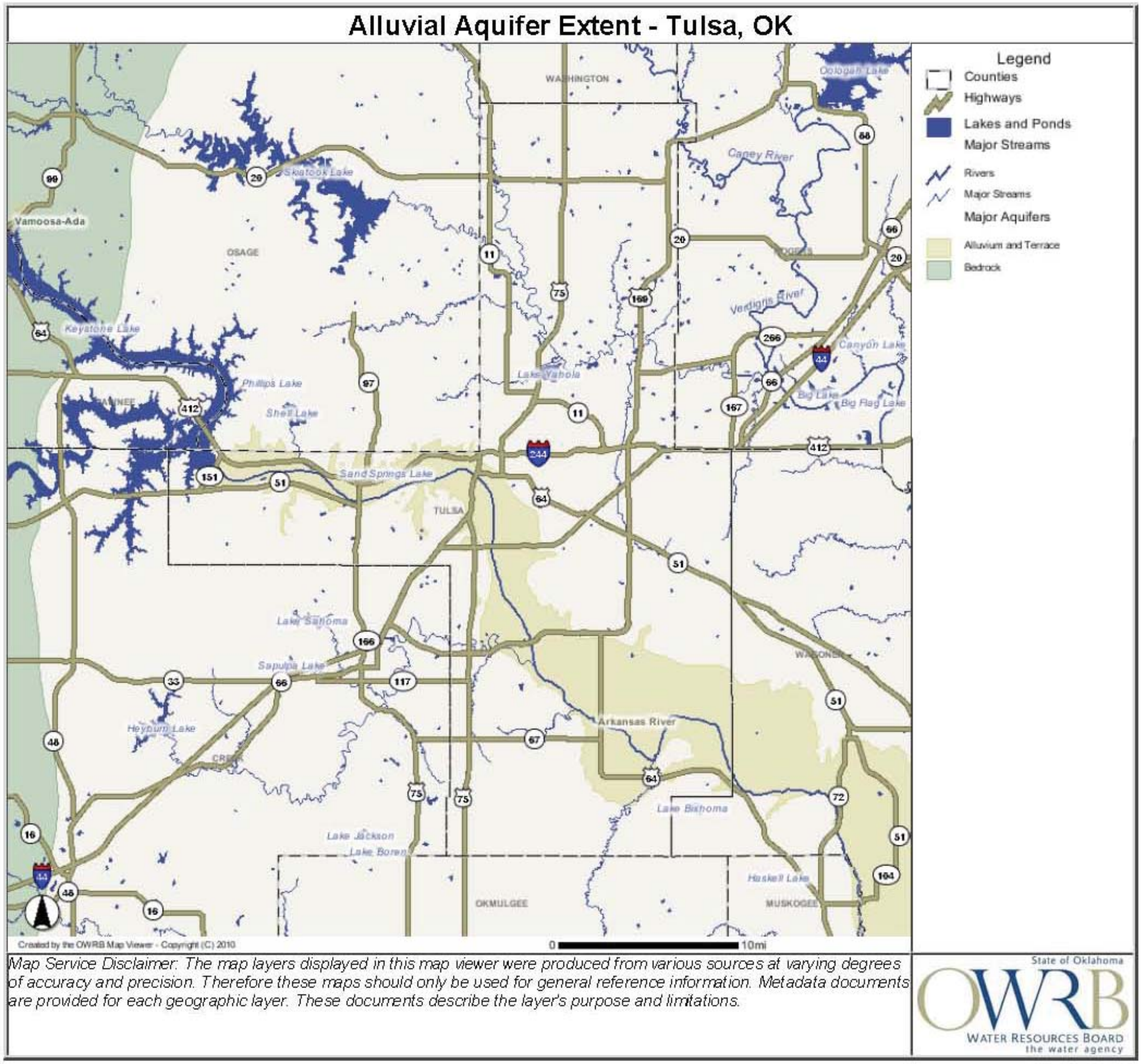


Figure 1
Extent of Alluvial Aquifer in the Tulsa Area

Local Groundwater Use

A brief review of available groundwater well records identified 154 wells near the Arkansas River through the project reach (OWRB, 2009). For this review, only well records within 1 mile of the mapped river centerline were included. A series of five maps, documenting the search area limits and the recorded location and well type (from the OWRB database), are presented in the appendix. It is assumed that there are additional wells that may not be included in the database and that this brief review did not identify all of the wells within these areas.

As presented in Table 1, 57 of the wells identified are designated as supply wells (commercial, domestic, industrial, irrigation, or public supply). One of the wells was listed as a domestic well for a Sand Springs public school. The remaining wells are either dewatering/corrosion protection wells or monitoring wells/extraction wells, presumably installed for the previous or ongoing water quality investigations in the area (see discussion below).

TABLE 1
Well Records Summary (OWRB, 2009)

USE	Total
Commercial	2
Corrosion Protection	1
Dewatering	2
Domestic	30
Industrial	1
Irrigation	23
Observation Well	1
Public Water Supply	1
Pump and Treat	2
Site Assessment	24
Soil Evaluation	17
Water Location	4
Water Quality	46
Total Wells	**154**

Most of the available well records for the groundwater supply wells in the OWRB database include well yield information. These values ranged between 2 and 100 gallons per minute (gpm). This range is consistent with the regional review conducted by Marcher and Bingham (1971), which indicates "wells yield from 10 to 80 gpm, but yields as much as 125 gpm could be obtained."

In general, the proposed impoundments would tend to increase the availability of groundwater in the alluvial aquifer by raising the average groundwater levels. Given the high percentage of sand in the alluvial aquifer, it is not anticipated that significant degradation of groundwater quality would result from the potential increased contributions of river water in the vicinity of the impoundments. As such, no adverse impacts to existing supply wells are anticipated.

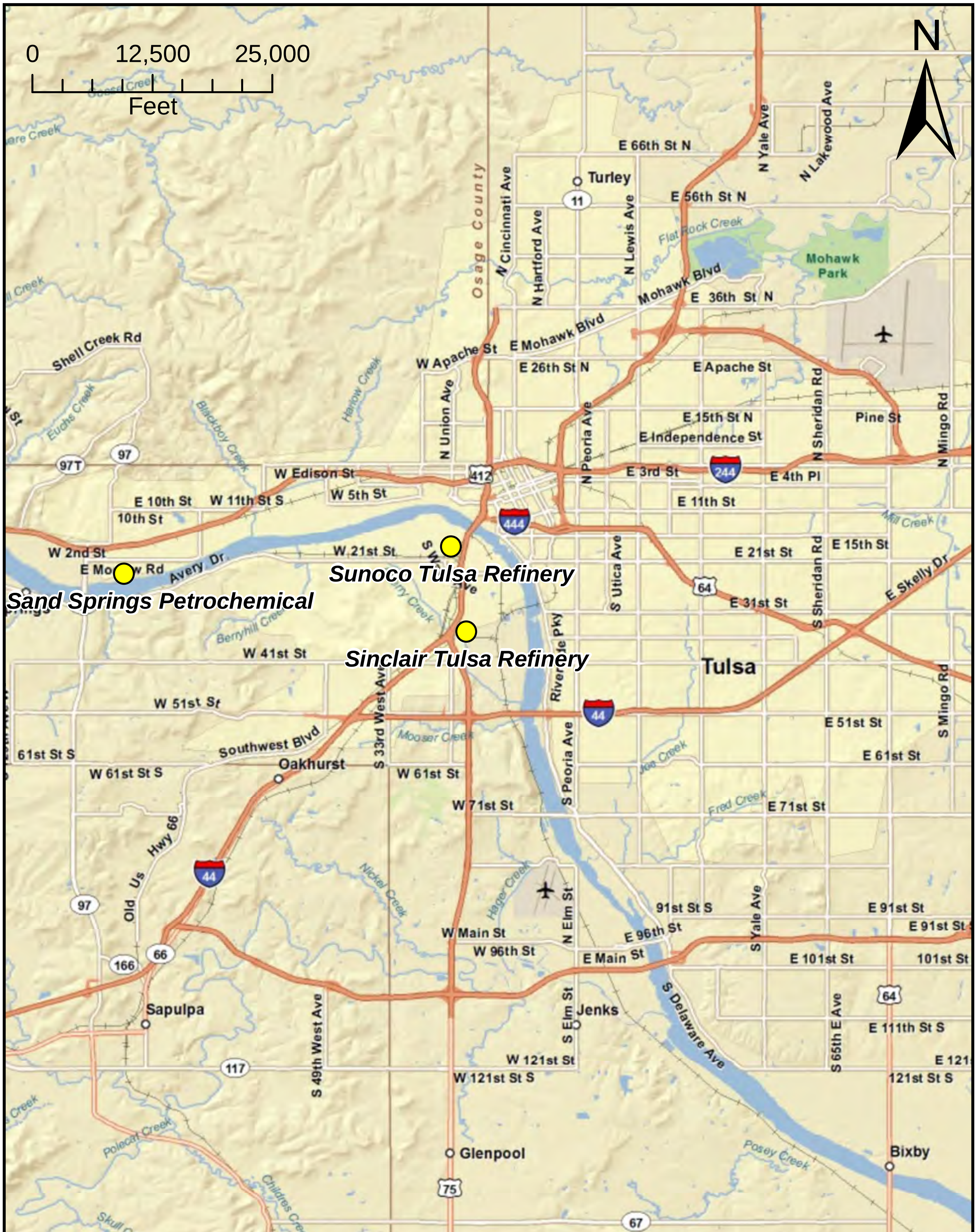
Known Existing Groundwater Quality Issues

At three sites along the project corridor in the Tulsa area, significant onsite groundwater contamination is known to be present and/or remediation activities may be ongoing. As shown in Figure 2, the proximity of these sites to the Arkansas River suggests there is potential that changing nearby surface water conditions as a result of project implementation could impact those systems and contaminant plumes. Identification of plumes and containment/extraction systems within the project corridor and evaluation of the potential for the project to affect them should be a component of subsequent environmental documentation. Three known sites in the Tulsa area are:

- Sunoco (aka Sun) refinery site, located on the south side of the Arkansas River in Tulsa, including at least two extraction wells and a large holding pond adjacent to the river just upstream of the I-244 bridge
- Sinclair refinery site, located on the west side of the Arkansas River, but downstream of the Sunoco refinery
- Sand Springs Petrochemical Complex, a Superfund site on the north side of the Arkansas River in Sand Springs currently undergoing post-closure maintenance

Information from several reports for these projects was reviewed to assess existing groundwater conditions and issues that may need to be evaluated for the project environmental documents. Additional reports will be reviewed as part of subsequent project activities to assess potential groundwater effects resulting from the development of the project. The most likely sources of such information appear to be environmental groundwater monitoring reports for facilities in the project corridor. Reports that have been reviewed thus far include:

- Five-Year Review Report for the Sand Springs Petrochemical Complex Superfund Site, Sand Springs, Tulsa County, Oklahoma (Tetra Tech EM, 2005).
- Summary of Remedial Alternative Selection - Main Site (Groundwater) Operable Unit, Sand Springs Petrochemical Complex (John Mathes and Associates, 1988).
- Sand Springs Petrochemical Complex Superfund Site, Tulsa Oklahoma, Main Site Operable Unit Remedial Investigation Report (Oklahoma State Department of Health Division of Solid Waste and John Mathes and Associates, 1988).
- Post Closure Permit Application for Hazardous Waste Land Treatment Unit at Sun Company, Inc. Tulsa Refinery (Sun, 1998).



Legend

Groundwater Contamination Sites

Arkansas River Corridor
Tulsa, OK
March 3, 2010

CH2MHILL

FIGURE 2
Major Sites Along the Arkansas River with Documented Groundwater Contamination

Semi-annual reports are currently prepared for the Sun and Sinclair refinery sites (now owned and operated by Holley Refining) and will be reviewed for subsequent assessment of current groundwater conditions, along with a November 2002 Current Conditions report prepared for the Sunoco refinery (Hensch, 2009). Review of these and subsequent reports will provide recent information on groundwater level conditions, groundwater changes over time, and ongoing remedial activities.

The 2005 Five-Year Review for the Sand Springs site (Tetra Tech EM, 2005) includes a discussion regarding seeps of black sludge observed along the northern bank of the Arkansas River during an inspection of the site in May 2001. The seeps were located near a former acid sludge disposal pit. According to the U. S. Environmental Protection Agency's (EPA's) current status sheet for the site (EPA, 2009), removal of sludge-contaminated soil occurred between October 2004 and January 2006.

Implementation of the Arkansas River Corridor Projects is not anticipated to affect long-term groundwater contaminant concentrations or transport at existing sites where groundwater contamination occurs. However, potential effects will be assessed to verify this assumption. Conditions to be considered include the following and are discussed further below:

- Impacts on Environmental Investigation/Remediation Systems
- Re-mobilization of vadose zone contaminants
- Change in plume migration speed/direction
- Increase of soil vapor intrusion risk

Impacts on Environmental Investigation/Remediation Systems

In addition to the three large Tulsa-area sites with known groundwater contamination, within the project corridor, there are additional contaminated sites, include leaking underground storage tank (LUST) sites (Environmental Data Resources [EDR], 2004). Changing groundwater conditions could affect ongoing investigations or remedial activities. In addition, review of information for these sites could also provide relevant groundwater information along the project corridor. In Oklahoma, requests to review the LUST database or case files must be submitted in writing to the Oklahoma Corporation Commission (OCC), Director of the Petroleum Storage Tank Division. This review would require additional lead time and could be performed during the preparation of the Environmental Impact Statement (EIS).

Re-mobilization of Vadose Zone Contaminants

Residual contamination and contaminants adsorbed to vadose zone soils can come in contact with groundwater as the groundwater level rises. Some of these contaminants partition into the dissolved phase, temporarily increasing the concentration of those constituents in an existing plume. Where a site has a remedial system in place that depends upon groundwater monitoring results, re-mobilization of contaminants can affect risk-based decision-making for the site and can cause environmental compliance issues.

Change in Plume Migration Speed/Direction

An overall rise in downgradient groundwater levels (adjacent to the river) could temporarily reduce the flow gradient across the site, slowing the movement of contaminant plumes. However, since recharge and pumping rates would not be affected by the proposed impoundments, pre-development flow velocities would soon be restored.

In the immediate vicinity of the dams, where local bypass of river water could dominate groundwater flow, re-direction of the flow gradient could cause an existing contaminant plume to migrate away from existing downgradient point-of-compliance monitoring wells. This could cause a false assessment of compliance, or could necessitate the installation of replacement compliance monitoring wells at the site. An in-place remedial system could also become less effective (or completely ineffective) if groundwater patterns are significantly affected. This effect would be limited to the immediate vicinity of the dams.

Increase of Soil Vapor Intrusion Risk

Proximity of contaminated groundwater to the ground surface is a factor in assessing the risk for contaminant vapors to enter overlying structures. Therefore, rising groundwater levels due to impounding the river could increase the risk of soil vapor intrusion for structures at contaminated sites within the project corridor. The risk could be further increased if the rising groundwater levels were to mobilize contaminants adsorbed to vadose zone soils, thereby increasing contaminant concentrations in the groundwater.

Other Potential Groundwater-Related Issues

Several other potential issues caused by a rise in groundwater levels within the alluvial aquifer could develop as a result of project implementation. These include:

- Localized flooding of low areas and below-grade structures and sewers
- Increased stormwater runoff
- Stress on subsurface structures
- Root zone impacts

Because groundwater levels are not expected to increase above historical levels occurring during past flooding events, it is anticipated that the magnitude and extent of change will be comparable to previous conditions. However, because of the potential for average groundwater levels to increase because of a long-term rise in river stage, these situations could be exacerbated and/or more prolonged than in the past.

Localized Flooding

Groundwater levels could increase to an extent that the groundwater surface would impact basements or other subsurface structures, such as highway underpasses, parking garages, and tunnels (including utility tunnels). As a result, structures that do not have pumping systems to remove water could become flooded more frequently. At structures that are equipped with a pumping system, those systems may run for longer periods of time but should not require upgrade to accommodate increased volumes of water since the maximum groundwater levels would not be substantially increased. However, the volume of groundwater inflows to sanitary sewers, which are often located in river corridors, could be substantially increased, resulting in additional sewer rehabilitation to prevent additional inflow.

Groundwater could discharge into topographically low areas, if the groundwater level rises sufficiently to intersect the ground surface. Such groundwater discharge could aggravate existing drainage problems or create new drainage problems where no problem currently exists.

Increased Stormwater Runoff

Higher groundwater levels would result in a thinning of the vadose zone in soils. This could result in a decrease in the ability of the soil to absorb precipitation during storm events, possibly resulting in increased surface runoff. Reduction in available head would also reduce the capacity of existing conveyance systems which discharge into the impounded reach of the river. However, the effect would be similar to historical events when river levels were typically elevated during storm events.

Stress on Subsurface Structures

Basins (treatment plant underground structures, lift stations, etc.) and tanks (such as underground storage tanks) that extend below the groundwater surface would have increased buoyancy stresses, resulting from groundwater levels, that increase into the zone where the subsurface structures are located. These stresses would be greatest when the structures are emptied for cleaning.

Root Zone Impacts

There is the potential for the elevated groundwater levels to impact plants that are sensitive to root zone saturation. This could occur where these types of plants are present in areas where the water table rises to elevations within their root zones; over time, that would affect plant viability. Coordination with project biologists will be conducted to assess the potential for root zone impact.

Recommended Additional Evaluation and Investigation

Although average groundwater levels are not anticipated to exceed historical high levels, additional evaluation and investigation of groundwater conditions should be conducted in support of the project. It is anticipated that sufficient existing information is available to conduct the necessary analyses. This work would enable team members to evaluate potential groundwater impacts resulting from the project, identify the significance of such impacts, and select mitigation measures, if necessary. These additional actions would include:

1. More detailed review of groundwater conditions and remediation ongoing at the Sun, Sinclair, and Sand Springs facilities.
2. Identification and evaluation of other groundwater investigations in the project corridor, including those addressing LUSTs.
3. Inventory of potentially vulnerable subsurface structures, topographically low areas, underpasses, and areas where dewatering currently occurs.

4. Identification of areas where root zone impact could occur and where sensitive plant communities are also prevalent.
5. Review of existing groundwater and hydrogeologic reports and databases that were not readily accessible during preparation of this TM.

Depending on the findings of the preliminary review, development of analytical tools could be considered if detailed evaluation is warranted. Additionally, it has not been determined if analytical tools have been developed for any of the local groundwater investigations. If so, they may be useful in assessing potential project impacts.

References

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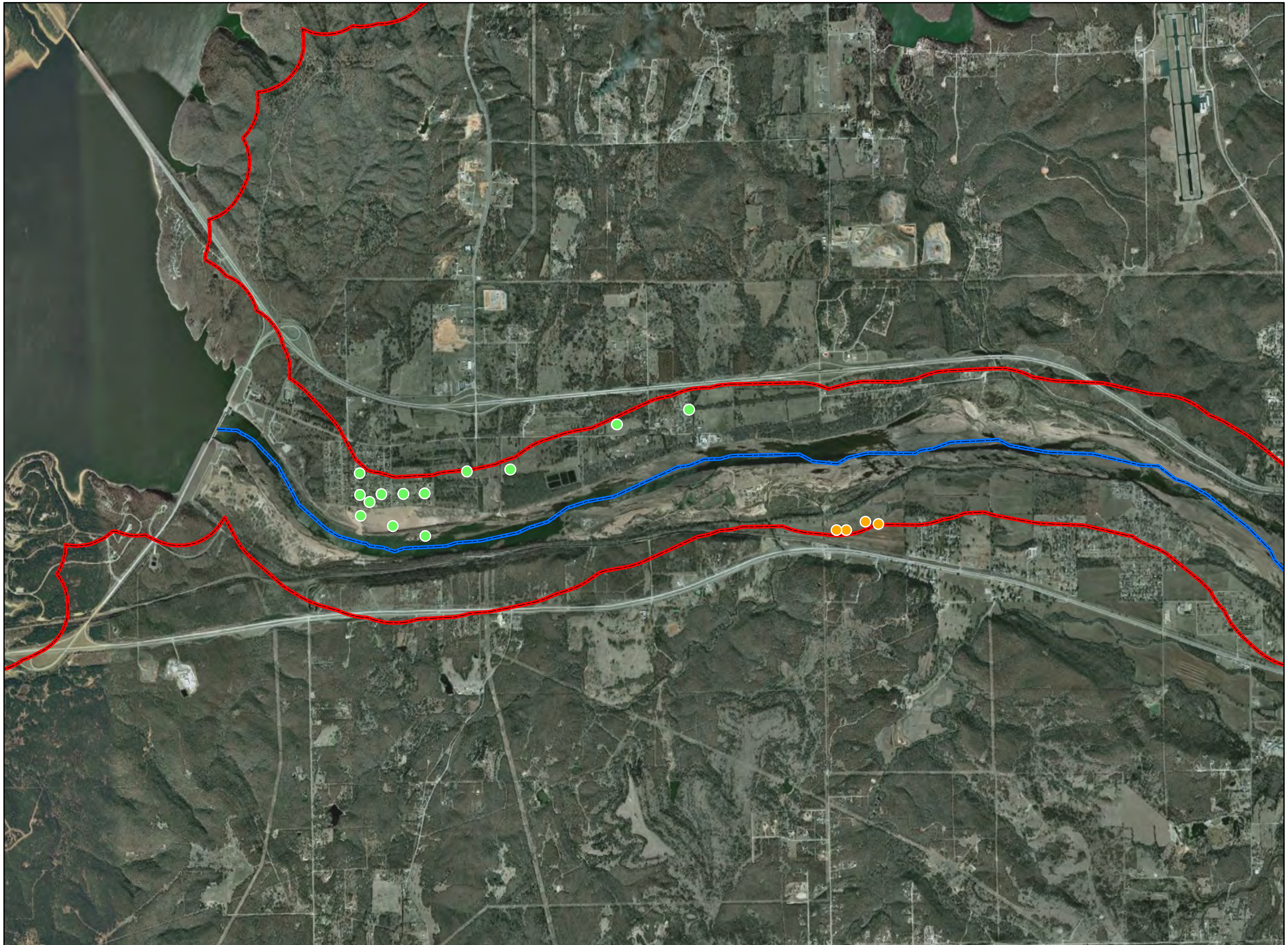
Appendix



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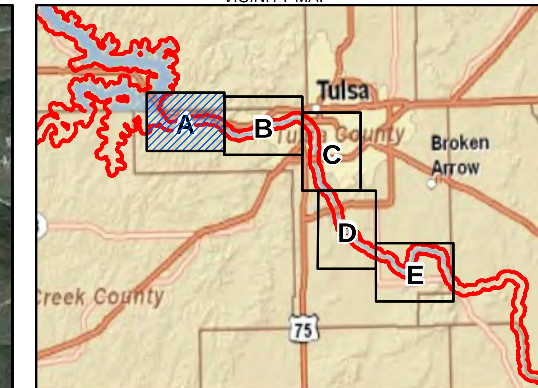

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OWRB Well Database

By Use

- Domestic
- Irrigation
- Site Assessment
- Soil Evaluation
- Water Quality
- Other
- Arkansas River Centerline
- Arkansas River Study Area

Note:
The classification "Other" consists of uses categorized by Commercial, Corrosion Protection, Dewatering, Industrial, Observation Well, Public Water Supply, Pump and Treat, and Water Location.

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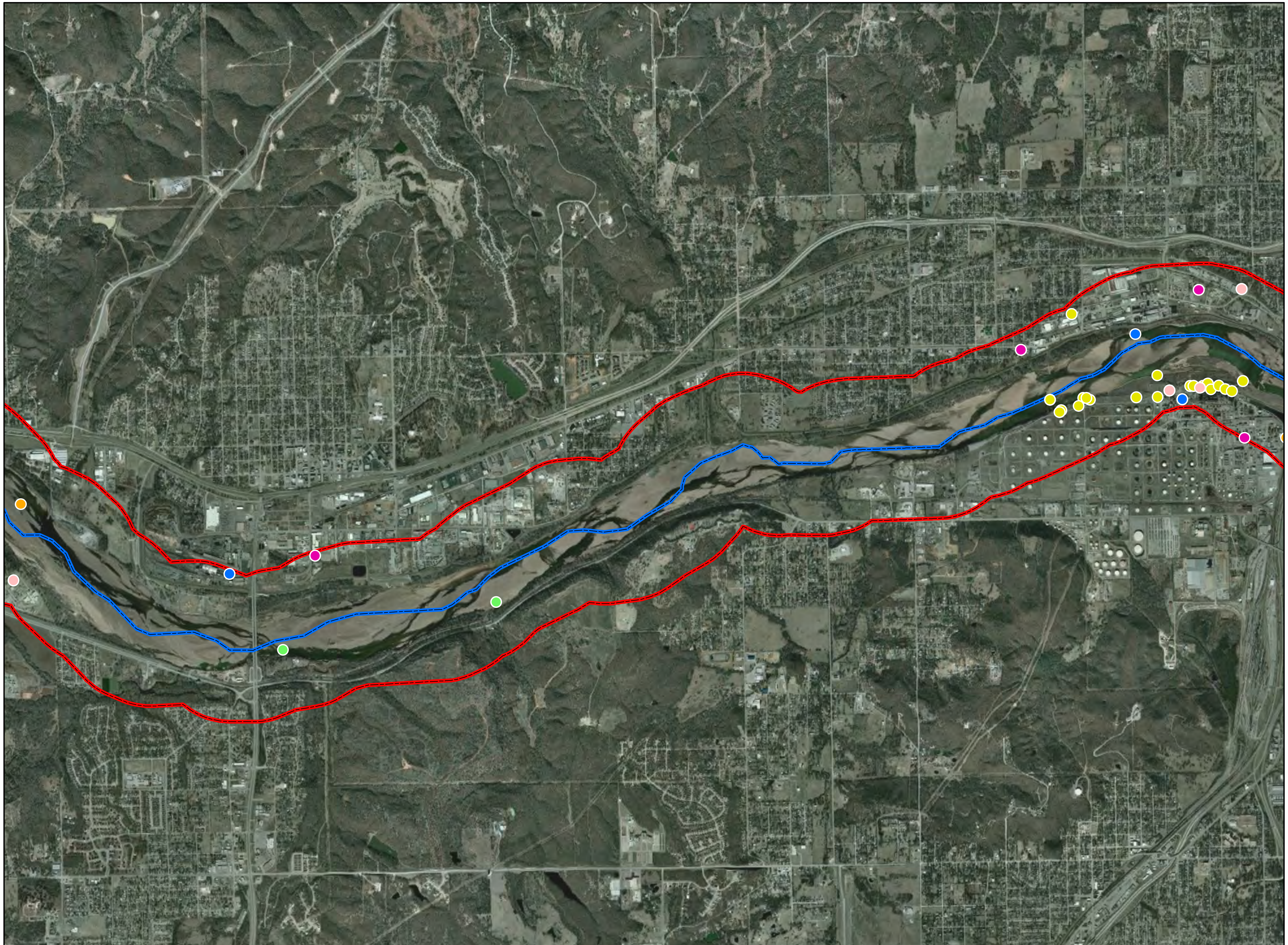
OWRB Well Database **Map A**

Arkansas River Corridor

Tulsa, OK



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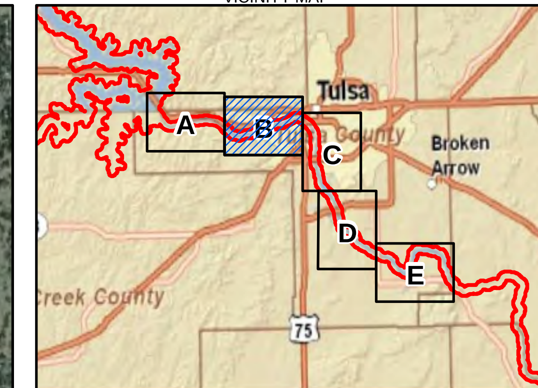

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OWRB Well Database **Map B**

Arkansas River Corridor
Tulsa, OK

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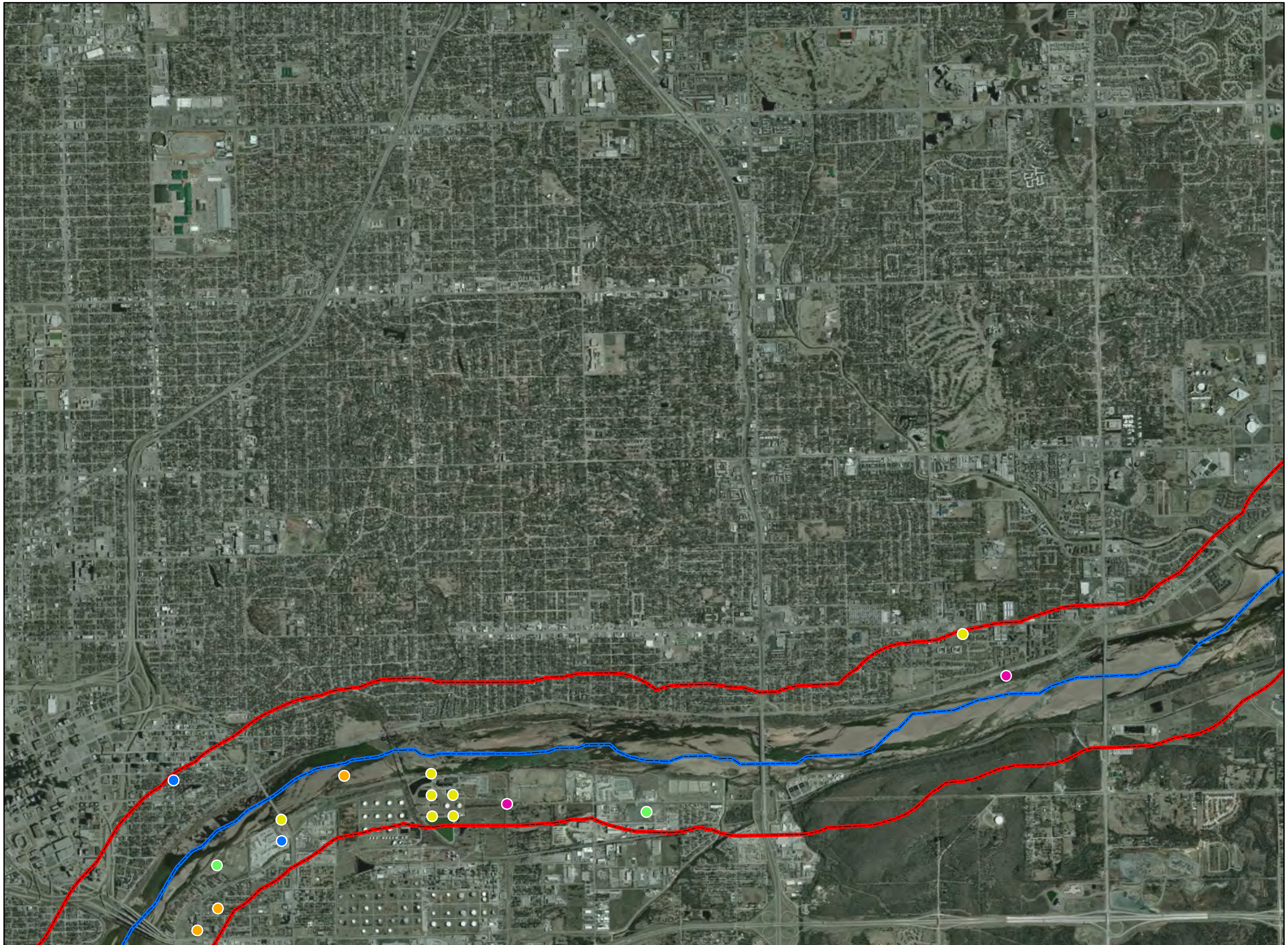

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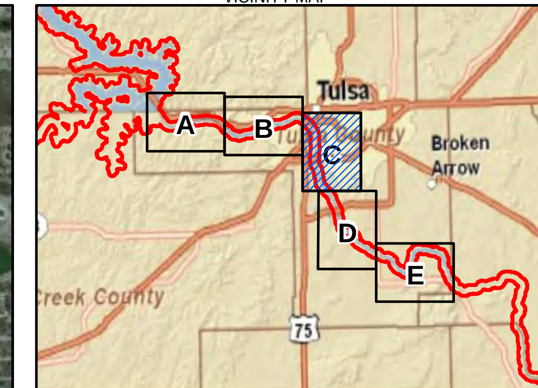

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OWRB Well Database **Map C**

Arkansas River Corridor

Tulsa, OK

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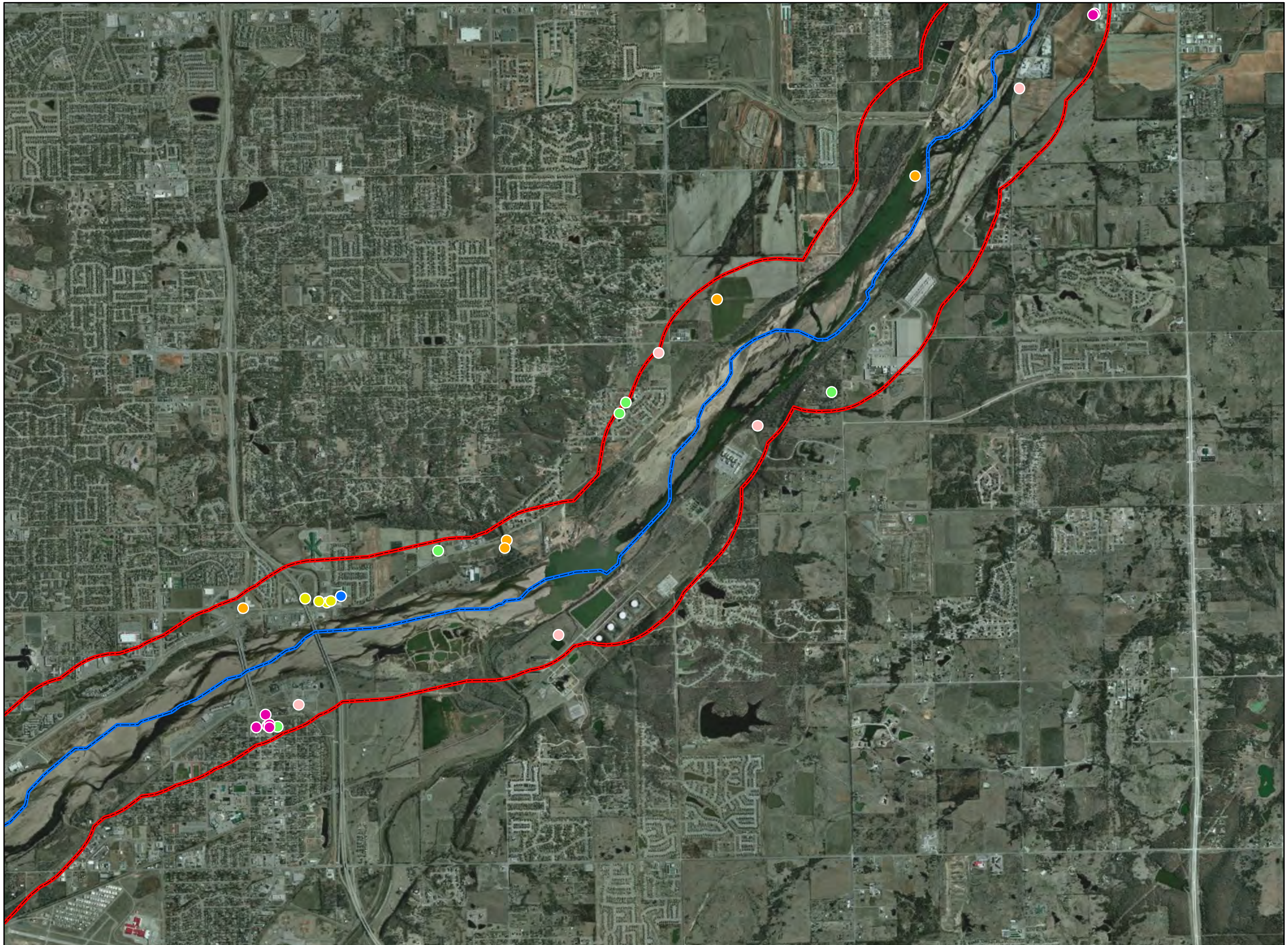

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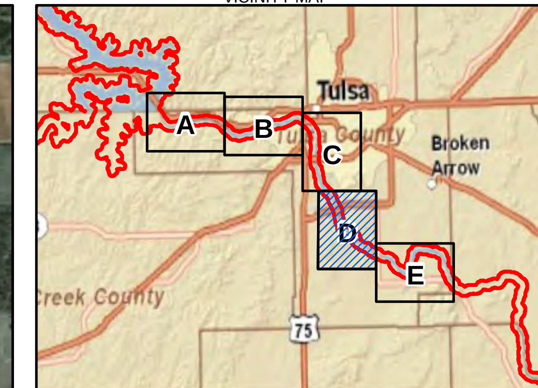

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OWRB Well Database **Map D**

Arkansas River Corridor
Tulsa, OK

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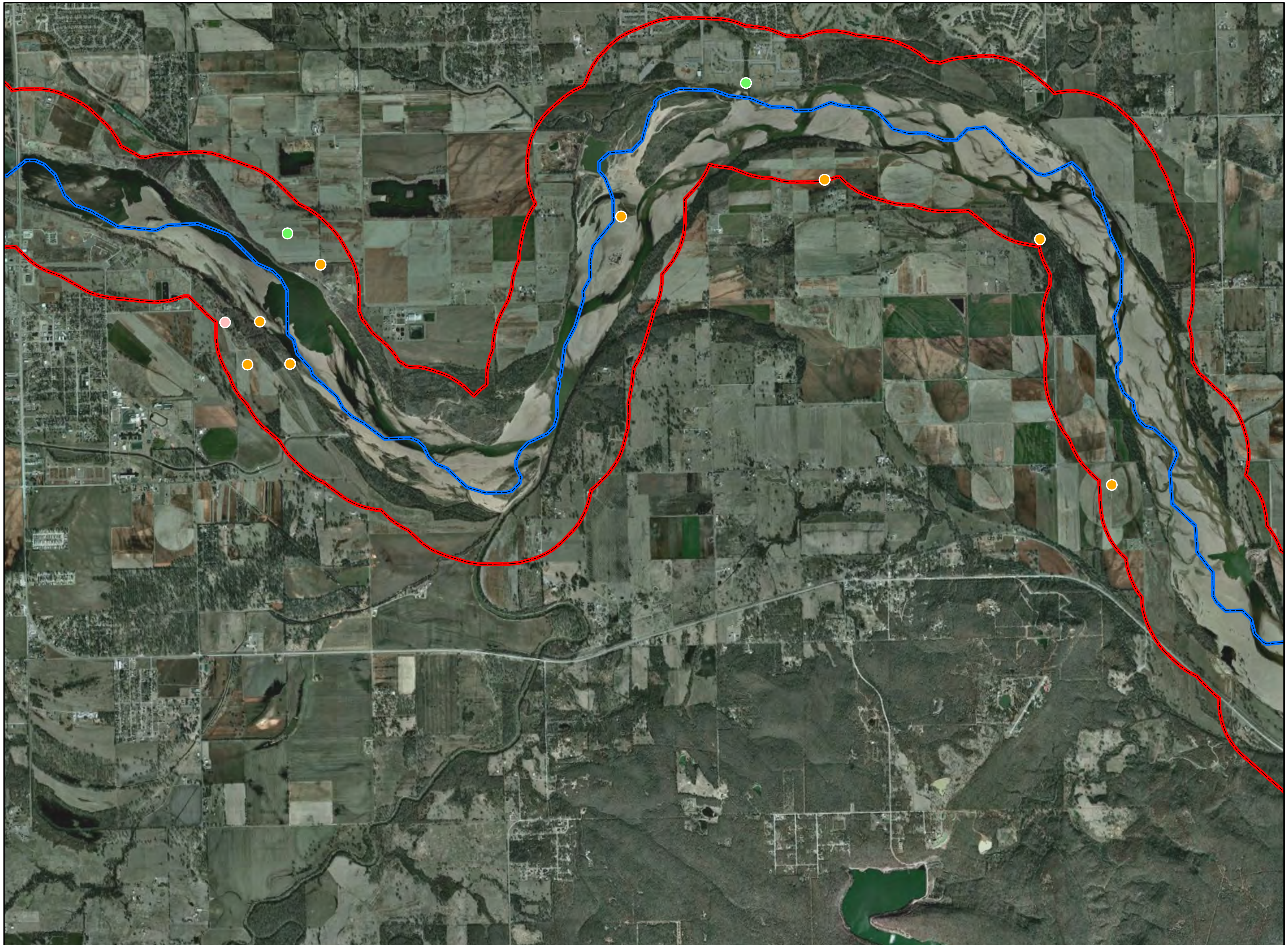

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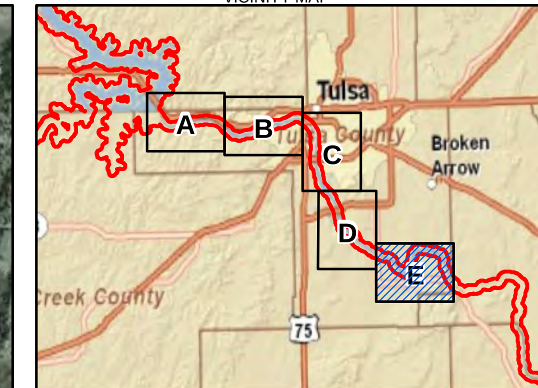

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OWRB Well Database **Map E**

Arkansas River Corridor
Tulsa, OK

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