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Technical Memorandum
Preliminary Critical Aquifer Recharge Area (CARA) Analysis
Lower Lake Roosevelt Watershed, Lincoln County, Washington

To: WRIA 53 Planning Unit and
Lincoln County Planning Department

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Subject: Preliminary CARA Designation – Lower Lake Roosevelt Watershed (WRIA 53), Ecology Grant G0800258

1.0 INTRODUCTION

WRIA 53 is primarily located in northern Lincoln County as shown in Figure 1. The watershed encompasses approximately 326,164 acres, or approximately 509.63 square miles. The Columbia River bisects the watershed with 118,730 acres (185.52 square-miles) located north of the Columbia River, primarily within the boundaries of the Colville Indian Reservation, and 207,432 acres (324.11 square miles) located south of the Columbia River, that area which was the primary focus of this assessment. Table 1 presents a summary of the area located within each County with lands located within the Lower Lake Roosevelt Watershed. In general, the watershed encompasses that portion of the Columbia River and it is tributaries between the confluence of the Spokane River to the east and the location of Grand Coulee Dam to the west.

TABLE 1: WRIA 53 AREA PER COUNTY			
County	***Acreage***	***Square-Miles***	***Percentage***
Lincoln	206,093	322.02	63.2
Ferry	74,542	116.47	22.8
Okanogan	44,274	69.18	13.6
Grant	1,255	1.96	0.4
TOTAL	***326,164***	***509.63***	***100***

The communities of Davenport, Lincoln, Seven Bays, and numerous smaller private housing developments are within the watershed. Major water bodies within the watershed include: Hawk Creek and Lower Lake Roosevelt. Residential areas utilizing public water supply systems include the development around Davenport, Seven Bays, and the town of Lincoln. Rural housing utilizing domestic exempt wells are also scattered throughout the watershed. After completion of the Phase 2 Level 1 analysis (St.Godard, 2009), the WRIA 53 Planning Unit and Lincoln County Planning Department decided to evaluate the watershed for CARA designation. This technical memo discusses the results of the preliminary CARA designation for this area.

1.1 Methodology

The Water & Natural Resource Group, Inc. (WNR Group, Inc.) utilized the methodologies and guidance set forth in the following documents for the preliminary CARA evaluation:

- Critical Aquifer Recharge Areas: Guidance Document, prepared by the Washington State Department of Ecology, Publication No. 05-10-028, January 2005.
- Critical Areas Assistance Handbook: Protecting Critical Areas within the Framework of the Washington Growth Management Act, prepared by Washington State Department of Community, Trade, and Economic Development, November 2003.
- Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands and Critical Areas, WAC 365-190-080.
- Guidance Document for the Establishment of Critical Aquifer Recharge Area Ordinances, prepared by Washington State Department of Ecology, Publication No. 97-30, Version 4.0, July 2000.

Hydrogeologic, geologic, and soil science utilized in this Preliminary CARA designation of the Lower Lake Roosevelt Watershed is summarized in the Phase 2 Level 1 Hydrogeology Technical Assessment (St.Godard, 2009) prepared for the WRIA 53 Planning Unit, and the Lincoln County Planning Department GIS Water Inventory Analysis (2010). This document compiled and summarized readily available data that had scientific data relevant to the aquifers within the Lower Lake Roosevelt Watershed.

2.0 LOCATION OF AQUIFERS IN LOWER LAKE ROOSEVELT WATERSHED

The surficial geology of WRIA 53 is summarized in Stoffel et al. (1991), Waggoner (1990), Hansen et al. (1994), Whiteman (1994) and St.Godard (2009). The WRIA 53 watershed lies within the northern extent of the Columbia Basin. This section presents a brief review of the geologic framework of the aquifers found within the WRIA 53 area. Potable groundwater in WRIA 53 is found predominantly in: 1) Pleistocene Cataclysmic Flood deposits and younger alluvial sediments (unconsolidated alluvial valley fill aquifers), 2) Miocene continental flood basalt and intercalated sedimentary units of the Columbia River Basalt Group (CRBG), and 3) pre-basalt basement rocks (predominantly crystalline intrusive granitic rocks and metamorphic rocks). Figure 2 presents a generalized map of where the three main aquifer types are located throughout the watershed. Figure 3 presents a map of the generalized depth to groundwater throughout the watershed.

Generally from youngest to oldest, the main geologic units found within WRIA 53 include the following:

- Holocene alluvial and colluvial deposits less than 10,000 years old.
- Pleistocene Cataclysmic Flood deposits ranging in age from approximately 12,000 years to more than 800,000 years.
- Pleistocene loess (the Palouse Formation) ranging in age from approximately 12,000 years to possibly over 1,000,000 years.
- Columbia River Basalt Group, which in WRIA 53 includes units ranging in age from approximately 14.5 million years to 16.5 million years.
- Pre-basalt basement rocks that probably include intrusive rocks over 40 million years old, and may include metasedimentary rocks greater than 600 million years old.

The CRBG is the most widespread and common of the rock types hosting potable groundwater currently being used in WRIA 53. Basalt flows of the CRBG underlie most of the WRIA except the northern and eastern edges where pre-basalt basement rocks crop out at the earth's surface. The following sections summarize the basic geologic setting of these rocks, and the folding and faulting that influences their distribution. Much of this discussion is based on regional characterization efforts on-going within the Columbia Basin Ground Water Management Area (GWMA) (GWMA, 2004, 2007a, 2007b, 2009a, 2009b, 2009c, 2009d).

The evaluation completed under this analysis was conducted as a generalized ranking over a large area within the Lower Lake Roosevelt watershed. Delineation of high, moderate, and low susceptibility aquifers is based on regional interpretations and analysis. Site specific conditions may alter the regional delineation (e.g. a site is located on an area where bedrock high exists and bedrock aquifers are located at depth, resulting in a low susceptibility ranking).

2.1 Unconsolidated Alluvial Aquifers

Within WRIA 53 the suprabasalt sediment, or alluvial, aquifer system comprises all saturated sediments that overlie the CRBG and pre-basalt basement. The base of the alluvial aquifer system is defined as the top of these underlying rocks, and it is hosted predominantly by Pleistocene Cataclysmic Flood deposits. The alluvial aquifer system is unconfined, although local semi-confined conditions may be encountered. The alluvial aquifer system water table can lie as shallow as 1 ft (0.3 m) near surface water bodies, including Lake Roosevelt to over 100 feet (30 m) on the high alluvial benches found along the shores of Lake Roosevelt (see Figure 3). Where the CRBG and pre-basalt basement is exposed at the Earth's surface and present above the unconfined water table, the alluvial aquifer system is absent.

The presence of bedrock highs acts to localize occurrences of the alluvial aquifer system. Consequently, the alluvial aquifer system generally consists of a number of small, isolated sub-systems that have no direct connection with each other. Existing geologic mapping for the WRIA (Waggoner, 1990) allows one to generally predict where these sub-systems may occur. However, a detailed evaluation of surface geology and well pumping records would be required to delineate the location, extent, and water resources associated with these local alluvial aquifer sub-systems.

Groundwater flow direction in the alluvial aquifer system is inferred to vary locally, depending on localized irrigation water application (if any), groundwater pumping, locations of surface-water bodies, suprabasalt sediment aquifer system and CRBG aquifer system hydrologic connection, and both buried and exposed bedrock highs. Natural recharge of the alluvial aquifer system is from rainfall and water infiltrating from streams along loosing reaches (Gephart and others, 1979; Drost and Whiteman, 1986; Gee, 1987; U.S. DOE, 1988), including bank storage from Lake Roosevelt. Discharge from the suprabasalt sediment aquifer system generally is down slope towards surface-water bodies and downward into the underlying CRBG aquifers and pre-basalt basement aquifer systems, if pathways through dense basalt flow interiors are available.

Generally, the Pleistocene Cataclysmic Flood deposits that host the most productive portions of the alluvial aquifer system consist of high permeability and high effective porosity sand facies and gravel facies. These strata typically are unconfined, and measured hydraulic conductivity for this unit ranges between 2,000 to 25,000 feet/day, with effective porosity greater than 10 percent (U.S. DOE, 1988). In many cases, water wells in these strata may sustain pumping rates in excess of 2000 gpm, especially where there is a significant degree of hydraulic continuity with surface water or the physical extent of the system great enough to store enough water. However, in areas where high permeability suprabasalt aquifer materials do not have a significant connection with surface water, or the surface water body is small, or the local sediment accumulations are small, it can be relatively easy to dewater the alluvial aquifer system.

<u>2.1.1 Alluvial Aquifer System Summary.</u> Some basic observations and inferences relative to the alluvial aquifer system are as follows:

1. The bulk of the system is hosted by coarse Pleistocene Cataclysmic Flood deposits and alluvial sediments.
2. The Flood deposits are found predominantly along Lake Roosevelt, probably display a fair amount of hydrologic connection with the Lake, and can be very productive. An alluvial aquifer system is also present throughout the extent of the Hawk Creek/Cottonwood Creek drainage basin. Welch Creek and Redwine Canyon also have smaller isolated alluvial aquifer systems.
3. Coarse strata not in connection with the Lake, or other surface water, may be productive, but limited recharge potential would limit potential pumping to recharge only available via limited infiltration from the small annual precipitation in this semi-arid climate.

Water well logs reviewed in the Hawk Creek Valley exhibit interbedded sand and gravel layers of varying thicknesses. Thickness of the valley fill are greater than 100-feet near Lake Roosevelt and appear to thin to the south. Wells are screened mostly in unconsolidated sand and gravel at depths of 10 to 50 feet below ground surface. One well is screened in a semi-confined aquifer below clay layers at a depth of 70 feet below grade. Typically, the water table can be encountered at a depth of 10 to 40 feet below grade within the Hawk Creek Valley. The approximate extent of the shallow outwash aquifer and inferred flow directions are discussed in the WRIA 53 Level 2 Phase 1 report. The estimated depth to the water table within the shallow unconfined outwash aquifer in Hawk Creek is:

T27N R36E Sections 29 and 32:	10-53 feet
T26N R36E Sections 4, 5, 9, 16, 17, 19, 30 and 32:	8 - 63 feet
T25N R36E Sections 5, 6, 7, and 8:	20 – 36 feet

Water well logs reviewed in the Welch Creek Valley exhibit interbedded sand and gravel layers of varying thicknesses. Thickness of the valley fill are greater than 200-feet near Lake Roosevelt and appear to thin to the south. Wells are screened mostly in unconsolidated sand and gravel at depths of 30 to 215 feet below ground surface. Typically, the water table can be encountered at a depth of 175 to 215 feet below grade near the town of Lincoln and 30 to 50 feet below grade in the upper portions of Welch Creek Valley. The approximate extent of the shallow outwash aquifer and inferred flow directions are discussed in the WRIA 53 Level 2 Phase 1 report. The estimated depth to the water table within the shallow unconfined outwash aquifer in Hawk Creek is:

T27N R35E Sections 20, 29, 32 and 33:	50-215 feet
T26N R35E Sections 4, 9, 17, and 18:	30 - 50 feet

Aquifer recharge in the alluvial valley fill aquifer is by direct precipitation in the form of rain and snow. Lake Roosevelt in Lincoln County is in direct hydraulic continuity with the alluvial aquifers along the main Columbia River Valley, and their water table levels likely rise and fall with the elevation of Lake Roosevelt. Additional recharge can be through irrigation or other land application. The average annual precipitation ranges from approximately 9-inches along the Columbia River to approximately 21–inches in the highlands in the northern part of the watershed on the Colville Indian Reservation. In the southern half of the watershed, precipitation is typically lowest along the Columbia River and increases as you move south in the watershed to an average annual precipitation of approximately 15-inches per year near Davenport, Washington.

2.2 CRBG Aquifers

Numerous studies of CRBG aquifers have been conducted within the Columbia Basin to better understand their hydraulic characteristics and to develop a model of how various factors (e.g., physical characteristic/properties of CRBG flow, tectonic features/properties, erosional features, climate, etc.) interact to create and govern the CRBG groundwater system (e.g., Hogenson, 1964; Newcomb, 1961, 1969; Brown, 1978, 1979; Gephart et al., 1979; Oberlander and Miller, 1981; Livesay, 1986; Drost and Whiteman, 1986; Lite and Grondin, 1988; Davies-Smith et al., 1988; USDOE, 1988; Burt, 1989; Johnson et al., 1993; Hansen et al., 1994; Spane and Webber, 1995; Wozniak, 1995; Steinkampf and Hearn, 1996; Packard et al., 1996; Sabol and Downey, 1997). One of the most significant findings of these studies is the similarity of the hydrogeologic characteristics, properties, and behavior of the CRBG aquifers across the region. This similarity allows for the application of the knowledge of the general hydraulic characteristics and behavior of the CRBG aquifers to be applied to CRBG aquifers in other areas.

Groundwater in the CRBG generally occurs in a series of aquifers hosted by the interflow zones between the flow units comprising the upper three CRBG formations (Grande Ronde, Wanapum, and Saddle Mountains) and the interstratified Ellensburg Formation. CRBG aquifers have been characterized as generally semi-confined to confined. The major water-bearing and transmitting zones (aquifers) within the CRBG are variously identified as occurring in sedimentary interbeds of the Ellensburg Formation, between adjacent basalt flows (in the interflow zones), and in basalt flow tops (Gephart et al., 1979; Hansen et al., 1994; Packard et al., 1996; Sabol and Downey, 1997; USDOE, 1988). For the region it is generally accepted that lateral hydraulic gradients and groundwater flow directions in the CRBG aquifers are predominantly down structural dip (Drost and Whiteman, 1986; USDOE, 1988).

2.2.1 Hydraulic Characteristics of the CRBG

The physical characteristics and properties of individual CRBG flows affect their intrinsic hydraulic properties and influence potential distribution of groundwater within the CRBG. Interflow zones, in comparison to dense flow interiors, form the predominant water-transmitting zones (aquifers) within the CRBG (Newcomb, 1969; Oberlander and Miller, 1981; Lite and Grondin, 1988; USDOE, 1988; Davies-Smith et al., 1988; Wozniak, 1995; Bauer and Hansen, 2000; Tolan and Lindsey, 2000). Individual interflow zones are as laterally extensive as the sheet flows between which they occur. Given the extent and thickness (geometry) of individual interflow zones, this creates a series of relatively planar-tabular, stratiform layers that have the potential to host aquifers within the CRBG. Given the typical distribution and physical characteristics of CRBG intraflow structures, groundwater primarily resides within the interflow zones. The physical properties of undisturbed, laterally extensive, dense interiors of CRBG flows result in this portion of the flow having very low permeability (Newcomb, 1969; Oberlander and Miller, 1981; Lite and Grondin, 1988; USDOE, 1988; Davies-Smith et al., 1988; Lindberg, 1989; Wozniak, 1995). While the dense interior portion of a CRBG flow is replete with cooling joints, in their undisturbed state these joints have been found to be typically 77 to +99 percent filled with secondary minerals (clay, silica, zeolite). Void spaces that do occur are typically not interconnected (USDOE, 1988; Lindberg, 1989). The fact that CRBG dense flow interiors typically act as aquitards accounts for the confined behavior exhibited by most CRBG aquifers. In many areas around the Columbia Plateau artesian (flowing) conditions and low pressure zones within the CRBG aquifer system have been encountered.

Field data and inferences based on modeling studies suggest that the hydraulic properties of CRBG aquifers are laterally and vertically complex (e.g., Drost and Whiteman 1986; USDOE, 1988; Whiteman et al., 1994; Hansen et al., 1994). Vertically averaged lateral hydraulic conductivities were estimated in Whiteman et al. (1994) to range from 7×10^{-3} to 1,892 feet/day for the Saddle Mountains, 7×10^{-3} to 5,244 feet/day for the Wanapum, and 5 x 10^{-3} to 2,522 feet/day for the Grande Ronde aquifers. Hydraulic conductivity of dense basalt flow interiors, where they can even be measured, have been estimated to be 5 orders of magnitude, or less, than flow tops (USDOE, 1988). The available data on hydraulic properties of the various CRBG aquifers, including permeability, porosity, and storativity, indicate that a large variability in local flow characteristics is expected.

The distribution, physical properties, and discontinuities found within the intraflow structures that comprise each CRBG flow unit form the primary stratigraphic control on groundwater flow direction and rate and recharge and discharge within the CRBG aquifer system. Groundwater flow within an individual CRBG interflow zone (adjacent flow tops and bottom, and, if present, a sediment interbed) is directly influenced by the intrinsic physical properties of that interflow zone. For example, thick flow top breccias, sand interbeds, and/or pillow lava complexes will have higher permeability than typical simple vesicular flow tops, claystone interbeds, and/or simple flow bottoms. In addition, the lateral persistence of dominant lithologies, or facies, will impact the lateral hydrologic properties inherent to any interflow zone (Figure 33). The lateral distribution of intraflow structures, particularly dense interiors, also influences the degree of hydrologic connection between successive interflow zones. Although quite widespread, individual CRBG units (and their associated interflow structures) do pinch out (Figure 34). Where pinch outs occur, the dense flow interior that typically separates successive interflow zones will be absent and these interflow zones will merge. Under such conditions, the groundwater seen in these zones can display some, to a high, degree of hydraulic continuity. On a regional scale, such continuity could be important to understanding groundwater recharge and flow. In more laterally restricted CRBG units the potential for significant hydraulic continuity would be greater than in the more voluminous and widespread units. In addition, the geographic and structural distribution of pinch outs could influence groundwater conditions. Beneath WRIA 53, based on GWMA subsurface mapping (GWMA, 2009b), it is clear that a number of flow unit pinchouts occur, especially as CRBG units pinchout near and beneath the WRIA. Under such circumstances, the potential for hydraulic continuity will be greater than in those areas where flow units are laterally continuous (e.g., undisturbed).

Aquifers within the CRBG are typically found at depths of greater than 100-feet below grade. Recharge to the shallow basalt aquifers is most likely a result of direct precipitation and recharge from the unconsolidated valley fill aquifers. Recharge to the deeper CRBG aquifers, deeper than 200 feet, is not defined at this time, but is most likely recharged from distant recharge areas, and/or ancestral Glacial Lake Missoula flood waters, as defined from the age dating completed by the GWMA study showing many CRBG aquifers have water dated at greater than 10,000 years old.

2.2.2 CRBG Aquifer System Summary. The thick sequence of layered flood-basalt flows of the Columbia River basalt are prime sources of potable groundwater throughout the WRIA.

1. Aquifer horizons within the CRBG aquifer system generally are associated with intraflow structures at the top (e.g., vesicular flow-top, flow-top breccias) and

bottom (e.g., flow-foot breccias, pillow lava/hyaloclastite complexes) of sheet flows.

2. The interiors of thick sheet flows (in their undisturbed state) generally have extremely low permeability and act as aquitards, typically creating a series of “stacked” confined aquifers within the Columbia River basalt aquifer system.
3. The dominant groundwater flow pathway within this aquifer system generally is stratiform, that is it is horizontal to sub-horizontal along individual, laterally extensive, stratified interflow zones.
4. Given the physical properties of the Columbia River basalt, outcrop observations, and interpretations of well hydraulics vertical groundwater movement through undisturbed basalt flow interiors is greatly restricted. However, vertical groundwater movement between layered CRBG aquifers is possible, but occurs predominantly under specific geologic and anthropogenic conditions where basalt flow interiors are disturbed (such as by folds or faults), truncated (such as by flow pinchouts, erosional windows), or where they are cross-connected by wells.

2.3 Granitic Bedrock Aquifers

The granitic bedrock aquifers are primarily located in the northwestern part of the Lower Lake Roosevelt Watershed (west of Lincoln) and in several smaller areas in the east central portion of the watershed. Well logs reviewed determined that water supply wells withdraw water primarily from fractures within granites at depths greater than 100 feet. However, yields are generally low.

3.0 WATER USE

3.1 Domestic Wells

Many residences throughout the Lower Lake Roosevelt Watershed utilize private potable domestic drinking water wells for their source of drinking water. A review of Ecology’s well database for that portion of WRIA 53 in Lincoln County reveals approximately 600 well log records in the area. Lincoln County tax records indicate that there are 935 rural home addresses in the WRIA. Of the Ecology well records, approximately 344 were located (Figure 4) for use in this assessment. These located wells are deemed usable because: (1) they have a clear description of location, (2) they are legible, and (3) the descriptions of well geology and construction appear to be complete and interpreted to be representative of actual conditions. Well locations as reported on the well logs are assumed to be correct as most wells were not field located for this project.

Of the approximately 344 wells used in this assessment, all but 29 are listed as domestic wells. Basic well geology and construction for these wells is summarized on Table 2. Table 2 gives one an idea of the distribution these wells in the WRIA. Given that we used well records for approximately 311 wells compared to the 935 tax records we assume that the following discussion encompasses approximately one-third of the domestic wells in the WRIA.

The largest concentrations of domestic wells in the WRIA are located in and near the Hawk Creek drainage (63%) with smaller concentrations of wells occurring near Grand Coulee (26%) in the west end of the WRIA and above Lake Roosevelt near Sterling

Valley Road (11%) predominantly in T27N R34E in the Brody Creek subbasin. Reviewing geology, construction, and location information, approximately 17 percent of the domestic wells in the WRIA are pumping from the alluvial aquifer system, 19 percent from the pre-basalt basement aquifer system, and 64 percent from the basalt aquifer system.

TABLE 2: DISTRIBUTION OF WELLS IN WRIA 53				
TN/RE	**Area comments**	**Total wells**	**Non-domestic wells**	**Hydrogeology**
25/35		1	0	
25/36	Upper Hawk Creek	39	11	1 basement
25/37	Davenport	39	7	All bslt, 1 art.
25/38		2	0	Bslt
26/34	NE of Creston	4	0	Bslt
26/35	W of Hawk Creek	31	1	1 sed
26/36	Middle Hawk Creek	49	0	1 base, 1 sed, 3 sed/bslt
26/37		13	0	4 base, 1 bslt/sed
27/32-27/33	Above Lake R.	3	0	2 bslt, 1 base
27/34		27	1	Most basement
27/35	Lower Hawk Creek	48	4	5 base; 7 sed
27/36	East of Hawk Creek	22	1	6 base; 10 sed/bslt
27/37		17	0	9 base, rest mixed
28/31	Coulee City	33	1	Mix
28/33-28/36	Col R. highlands	16	3	Mix
	Totals	**344**	**29**	

The alluvial wells are predominantly located in Pleistocene Cataclysmic Flood gravel and sand bars near Lake Roosevelt and likely display a high degree of hydrologic continuity with the Lake. These wells appear to usually be capable of supporting single family domestic uses, and several of them seem to be capable of supporting larger pumping demands. A small number of these wells though may not be in direct connection with the Lake for a variety of local geologic reasons, including the presence of buried bedrock highs and the presence of landslide blocks truncating or restricting that connection. In such cases, wells in these settings may experience water level declines and decreased pumping capacity if the local use outpaces the local recharge. Further site specific assessment would be needed to better delineate areas such as these.

Basalt domestic wells generally fall into two basic groups. A small number of these wells located near the mouth of Hawk Creek appear to be in hydrologic connection with Lake Roosevelt. One would assume that pumping limitations on these wells will only be controlled by the capacity of these basalts to transmit water from the Lake to the well. Most basalt wells however are not in direct connection to the Lake. As discussed earlier, these wells are in a part of the aquifer system where modern recharge is derived solely from modern precipitation. In areas of low well density, it generally appears that such recharge is keeping pace with domestic demand and can be sustained (based on relatively stable water levels in the few regional monitoring wells available). However, in areas of greater well density this should not be assumed. Although we do not have any direct water level measurements to call upon, the anecdotal observations reported by WRIA participants suggest water level declines in the basalt aquifer system are occurring in

these areas. If such a situation is occurring, it would clearly indicate that pumping demand (whatever that is, and we do not know as there are no records) is exceeding the ability of that portion of the aquifer system to supply that water.

Domestic wells in pre-basalt basement are universally reported to be very low volume producers, commonly capable of only providing a few gallons, or less, per minute. It seems likely that few if any wells in the pre-basalt basement aquifer system produce more than a few gallons per minute.

Pumping demands on the domestic wells are very difficult to quantify as there are few pumping records available and it seems likely that not all domestic wells in the WRIA are represented in the records we reviewed (as suggested by our use of 311 well logs, but County record indicating 935 rural homes). Assuming we are looking at approximately one-third of the total domestic wells in the WRIA (311 well logs vs. 935 tax records) we estimate there are approximately 600 domestic wells in the Hawk Creek area, 250 in the Brody Creek subbasin, and 100 in the vicinity of Grand Coulee. If each well uses approximately 800 gallons per day (gpd) total estimated pumping, and pumping within the 3 subbasins is as follows:

- Total pumping, 760,000 gpd
- Hawk Creek, 480,000 gpd
- Brody Creek, 200,000 gpd
- Coulee Dam, 80,000 gpd

A more definite evaluation of actual pumping by area and aquifer system would require field verification of well use and location.

3.2 Public Water Supply Wells

Within the databases, we found 29 non-domestic wells with usable well records. Uses for these wells are reported to include a mix of irrigation, stock watering, municipal supply, small water systems, industrial applications, and recreational sites.

The greatest concentrations of non-domestic wells are found in the same basic areas as the domestic wells. Most of the non-domestic wells are located in the area around the lower reaches of Hawk Creek and around Davenport. The lower Hawk Creek wells consist predominantly of a mix of irrigation and small water system wells. Those near Davenport consist predominantly of municipal (City of Davenport) and irrigation wells. Location of the municipal and Group A water purveyors are identified in Figure 5.

Public drinking water supply systems are regulated by the Department of Health under the Safe Drinking Water Act. Group A systems consist of 15 or more connections. A search of public water supply records in the Department of Health and Ecology databases was conducted in May 2010 and is summarized in Table 3. This search revealed that twelve (12) Group A water supply systems are located in the Lower Lake Roosevelt watershed. However, nine systems are listed as transient non-community (TNC), which are campground and/or marina type systems. Location of Group A wells are shown on

Figure 4. It should be noted that although the City of Davenport service area is primarily within WRIA 53, its water systems (wells) are located immediately south of the watershed in WRIA 43. Therefore, it does not show up as a Group A water system in WRIA 53. Eighteen Group B wells were also identified in the watershed and are shown on Figure 5. The 10-year wellhead protection zone and associated susceptibility rating for the three Group A water systems is presented on Figure 6. Information on the Group A susceptability ratings can be found at Washington State Department of Ecology's web site: http://www.ecy.wa.gov/services/as/iss/fsweb/fshome.html.

4.0 SUSCEPTIBILITY ANALYSIS OF THE LOWER LAKE ROOSEVELT WATERSHED

A susceptibility analysis characterizes how fast deleterious materials can travel to the groundwater supply. The susceptibility analysis is dependant on the natural setting of the watershed, both the soil column above the aquifer (vadose zone), and the characteristics of the aquifer itself. The susceptibility of the Lower Lake Roosevelt Aquifer was analyzed on a regional basis. Conditions of susceptibility may vary with a site specific evaluation. Susceptibility rankings were determined in accordance with Ecology guidelines (Cook, 2000 and Morgan, 2005).

4.1 Vadose Zone

The characterization of the vadose zone encompasses the overall permeability of the soil and the thickness of the unsaturated soil. In addition, the amount of recharge (natural precipitation and artificial irrigation) available is evaluated. Figure 7 presents a map of the surficial soil classifications throughout Lincoln County (Donaldson and others, 1982). Review of the Lincoln County Soil Survey (Donaldson and others, 1982) determined that the soil permeability throughout the Lower Lake Roosevelt watershed are classified as moderate (0.60 – 6.0 in/hr) or rapid (6.0 - >20.0 in/hr). Soils classified with rapid permeability are primarily located in the valley near the confluence of Indian Creek and Hawk Creek, along the southern bank of Lake Roosevelt between the Spokane River and Sevens Bays, and along the southern bank of Lake Roosevelt between Keller Ferry and Grand Coulee Dam (Figure 8). Utilizing the Ecology guidance document (Cook, 2000), a susceptibility rating of 2 is assigned for moderate permeable soils and a rating of 3 is assigned for rapid permeable soils.

4.2 Geologic Matrix

Well logs and the WRIA 53 Planning Unit Phase 2 Level 1 hydrogeologic report (St.Godard, 2009) were utilized to determine the permeability of the geologic matrix below the soil horizon. The soils at depth primarily consist of sand and gravel with varying amounts of silt and clay in the valleys. Within the Ecology guidance document, a sand and gravel geologic matrix is estimated to have a permeability of 0.1 to 10 cm/sec, and classified as rapid permeability. Utilizing the Ecology guidance document (Cook, 2000), a susceptibility rating of 3 (rapid) is assigned for the sand and gravel geologic matrix. For basalt and granitic aquifers, which are under confined systems at depth, a susceptibility rating of 0 to 1 was assigned.

4.3 Infiltration

Infiltration is the degree to which water moves through the vadose zone into the uppermost aquifer. Infiltration is determined by taking into account all available moisture (rainfall, snowfall, irrigation, etc.) and subtracting the moisture lost due to potential evapotranspiration (PET). Ecology has provided representative numbers for areas in Washington State in their guidance document. For the Lower Lake Roosevelt watershed, values presented for the Davenport area were utilized for the southern extent of the watershed: precipitation=16.7 inches, PET=23.6, resulting in a negative infiltration rate of 6.9 inches. For the area in the western extent of the watershed, values for the Wilbur area were utilized: precipitation = 12.8 inches, PET=23.9, resulting in a negative infiltration rate of 11.1 inches. For areas with infiltration rate at or below zero, the Ecology guidance document assigns a rating value of zero (0). Therefore, for the Lower Lake Roosevelt watershed, a value of zero is assigned for the entire watershed.

4.4 Depth to Water

Water well logs reviewed in the Hawk Creek Valley exhibit interbedded sand and gravel layers of varying thicknesses. Thickness of the valley fill are greater than 100-feet near Lake Roosevelt and appear to thin to the south. Wells are screened mostly in unconsolidated sand and gravel at depths of 10 to 50 feet below ground surface. One well is screened in a semi-confined aquifer below clay layers at a depth of 70 feet below grade. Typically, the water table can be encountered at a depth of 10 to 40 feet below grade within the Hawk Creek Valley. The approximate extent of the shallow outwash aquifer and inferred flow directions are discussed in the WRIA 53 Level 2 Phase 1 report. The depth to the shallow alluvial aquifer and associated rating per Ecology guidance document (presented in parentheses) is presented below. The estimated depth to the water table within the shallow unconfined outwash aquifer in Hawk Creek is:

T27N R36E Sections 29 and 32:	10-53 feet (1-2)
T26N R36E Sections 4, 5, 9, 16, 17, 19, 30 and 32:	8 - 63 feet (0-2)
T25N R36E Sections 5, 6, 7, and 8:	20 – 36 feet (1-2)

Water well logs reviewed in the Welch Creek Valley exhibit interbedded sand and gravel layers of varying thicknesses. Thickness of the valley fill are greater than 200-feet near Lake Roosevelt and appear to thin to the south. Wells are screened mostly in unconsolidated sand and gravel at depths of 30 to 215 feet below ground surface. Typically, the water table can be encountered at a depth of 175 to 215 feet below grade near the town of Lincoln and 30 to 50 feet below grade in the upper portions of Welch Creek Valley. The approximate extent of the shallow outwash aquifer and inferred flow directions are discussed in the WRIA 53 Level 2 Phase 1 report. The estimated depth to the water table within the shallow unconfined outwash aquifer in Hawk Creek is:

T27N R35E Sections 20, 29, 32 and 33:	50-215 feet (0)
T26N R35E Sections 4, 9, 17, and 18:	30 - 50 feet (1)

4.5 Topography and Surficial Geology

Topographic maps show landscape changes that are often associated with aquifer boundaries. This is consistent with what is observed within the Lower Lake Roosevelt watershed. Reviews of the USGS topographic maps for the Lower Lake Roosevelt area were compared to the hydrogeologic information known for the watershed. The valley floor is typically underlain by the unconsolidated alluvial aquifer which is located at depths from 10 to 70 feet below the ground surface in Hawk Creek and 30 to 215 feet below ground surface in Welch Creek. The shallow unconfined aquifer boundary is determined to be located where the valley floor meets the base of the surrounding hills. These aquifers are typically more susceptible to impacts.

Geologic maps and well logs indicate that bedrock is near surface in the areas out of the main stream valleys. Well logs reviewed in these areas determined that the unconfined aquifer is absent in these areas and domestic supply wells are located within basalt interflows or granitic bedrock fractures. Therefore, due to the existing geologic conditions, a low susceptibility rating will be assigned.

4.6 Source Water Protection

The Department of Health evaluates and assigns a susceptibility rating for each public water supply well, based on a number of factors, including whether or not there is a protective confining layer above the aquifer. The rating system for well head protection is determined under different criteria than that for a CARA; however, this information is useful in support of the CARA susceptibility assessment, along with wellhead protection plans. A goal of Lincoln County is to consider these source water protection areas in its determination of CARA designations. A review of Washington Department of Health, and Ecology records and Wellhead Protection Plans, revealed the following susceptibility ratings for the Group A public water supply systems in the Lower Lake Roosevelt watershed. Source water protection areas are presented for the 10-year well head protection radius. Ten year source water protection radii are also presented on Figure 6. It should be noted that the susceptibility ratings assigned to water supply wells utilize different criteria than the susceptibility criteria used in designating aquifers under the CARA process. As shown in Figure 6, the well head protection zones as defined by the criteria set forth by the Washington Department of Health are moderate to high.

4.7 Vulnerability

As a general statement, all groundwater is vulnerable to varying levels; some areas where strategic public groundwater resources are located are more vulnerable than others (Morgan, 2005). Susceptibility refers to natural conditions, and vulnerability refers to the total contamination risk from both the natural conditions and potential contaminant sources. For the CARA designation in Lower Lake Roosevelt, the vulnerability of the aquifer was considered in the susceptibility rating of the aquifers. This was completed by reviewing known contaminant sources within the watershed and determining their relative location to the known water source in the watershed. This allows a relative conclusion to be made of which strategic groundwater supplies may be most at risk under current land use conditions. Ecology maintains a database of known facilities. A review of their records indicated there are 68 identified facilities in the Lower Lake Roosevelt watershed (listed in Table 4). Figure 9 shows the location of facilities which may have potential contamination sources. As shown on the map, most facilities are located in or near the town of Davenport.

5.0 SUSCEPTIBILITY DETERMINATION

A review of Best Available Science was conducted in order to assist with the determination of CARA designations in the Lower Lake Roosevelt Watershed. The susceptibility determination was conducted in accordance with the criteria set forth in Ecology Guidance documents (Morgan, 2005 and Cook, 2000). Due to the two unique physical settings in the watershed, an analysis was conducted for those areas within the stream channels where the unconsolidated aquifers are located, and the second throughout the remaining portion of the watershed. Utilizing the above outlined determinations from the susceptibility rating system from the Ecology guidance document, the Lower Lake Roosevelt watershed would be characterized as:

TABLE 5: CREEK DRAINAGES AND LAKE ROOSEVELT AREA	
Parameter	***Rating***
Soil Permeability	3
Geologic Matrix	3
Infiltration	0
Depth to Water	0 to 2
Overall Rating for Creek Drainages in the Lower Lake Roosevelt Watershed	**6 to 8**

TABLE 6: WRIA 53 OUTSIDE CREEK DRAINAGES	
Parameter	***Rating***
Soil Permeability	2
Geologic Matrix	0-1
Infiltration	0
Depth to Water	0
Overall Rating for Non-Creek Drainages in the Lower Lake Roosevelt Watershed	**2 to 3**

Ecology rating for susceptibility:

Low Susceptibility	Moderate Susceptibility	High Susceptibility
0-3	4-7	8-12

For the Lower Lake Roosevelt watershed, the general susceptibility rating in the Hawk Creek and Welch Creek drainages are moderate to high, as determined from the Ecology guidance documents. This is based on best available science which is primarily located in and along the valley floors of the watershed. Those areas outside the valley floors where the shallow basalt and granitic bedrock are present and where unconsolidated aquifers are not present were assigned a low susceptibility designation. Review of more localized hydrogeologic data and reports from the watershed will allow for a refinement of susceptibility areas within the Lower Lake Roosevelt watershed in the future. The delineation of the susceptibility designations are provided on the attached Figure 10. Higher susceptibility is designated in the main valley floors in which the unconfined alluvial aquifer is located near surface, typically less than 25 feet below the ground surface. The moderate susceptibility is assigned to those areas in the lower parts of the drainages and along the Columbia River gravel aquifers where the alluvial aquifer water table is found deeper than 50 feet below the ground surface. Protection to these areas should be conducted. Low susceptibility was assigned to the area in which shallow bedrock is present and domestic water wells are founded in deep granitic fractures and/or basalt interflows at depth. For designation of susceptibility, the vulnerability of the aquifer was also evaluated. Within the Lower Lake Roosevelt watershed, existing development which may have deleterious materials that may affect the aquifers water quality are primarily located in the area of Davenport.

CRBG aquifers host the primary domestic drinking water supplies in the Lower Lake Roosevelt watershed. This aquifer also serves as the source of potable water for the most Group A water purveyors in the watershed. Older consolidated sedimentary, metamorphic and igneous rocks can supply adequate amounts of water to domestic wells, but these bedrock fracture aquifers generally yield lower quantities of water and are far less susceptible to contamination than the shallow unconsolidated aquifer.

Because of the complex geologic history in Lincoln County, a large degree of variability in the hydrogeologic conditions and aquifer characteristics may exist. Hydrogeologic studies conducted within the watershed suggest that an unconfined upper outwash aquifer is only present in the creek drainages within the watershed. This unconfined aquifer system is highly susceptible to contamination. A review of water well logs in the watershed reveal a large number of domestic wells withdraw water from the CRBG aquifer at a depths of greater than 100 feet. Artesian aquifers and/or groundwater tables under large hydraulic heads, are confined by an impermeable or semi-permeable geologic material, and have an upward hydraulic gradient. Under these conditions, the water bearing aquifer is less susceptible to contamination. The designation of CARA susceptibility boundaries identified on Figure 10 are based on regional characteristics. Site specific information within a larger CARA designation may be applicable and should be evaluated.

TABLE 3: LIST OF GROUP A AND B WATER PURVEYORS IN WRIA 53												
System Name	Group	SystemType	Full Time Residential Population	Residential Connections	Total Connections	Service Name	Service Type	Well Depth	Township	Range	Section	QtrQtrSect
DEER MEADOWS WATER COMPANY INC	A	Comm	48	334	351	WF/S01,S02	WF	185	28	35E	36	NESE
COLUMBIA SPRINGS ESTATES	A	Comm	36	22	22	WELLFIELD / S01, S02, S03	WF	235	00	00E		
LAKEVIEW HEIGHTS WATER SYSTEM	B	GRPB	15	10	10	WELL 1	W	290	27	36E	06	NESE
LAKE ROOSEVELT HIDEAWAY	B	GRPB	4	2	2	WELL #1	W	120	28	31E	07	SESE
BROUGHER RANCH II	B	GRPB	4	3	3	WELL #1 - AAK364	W	35	28	34E	20	NENE
TRANQUIL ESTATES	B	GRPB	1	4	4	WELL 1 / AEB860	W	225	28	31E	11	NENE
LIVINGSTON, GEORGE WATER SYSTEM	B	GRPB	2	1	2	WELL 1	W	650	28	36E	31	SWSE
FDR ESTATES #5	B	GRPB	2	2	2	AFB116 FDR 5	W	142	28	31E	08	SWSW
BROUGHER RANCH III	B	GRPB	2	1	1	WELL #1 - AGK453	W	32	28	34E	20	NENE
CAMPBELL BAY FARMS	B	GRPB	10	7	7	WELL #1 - ABQ390	W	310	28	33E	30	NWNW
HANSON HARBOR HOMEOWNERS ASSN	A	Comm	27	43	43	WELL #3 - UNAPPROVED	W	0	00	00E		
RANTZ MARINE PARK	A	TNC	2	18	18	WELL #2 - AGK452 - UNAPPROVED	W	158	28	34E	20	NENE
RIVER RUE WATER SYSTEM	A	TNC	2	1	96	WELL #1	W	420	28	33E	20	SWNW
SUNNY HILLS WATER SYSTEM	A	TNC	20	27	27	WELL 1	W	156	28	31E	11	NWNE
BROUGHER RANCH INC	B	GRPB	0	3	3	SPRING	SP	0	28	34E	20	NENE
ROCKY TOP ESTATES	B	GRPB	7	6	14	WELL #1	W	183	27	36E	18	NENW
CHAR-DONNIE	B	GRPB	16	3	3	WELL #1 - ACS225	W	118	28	31E	17	NENW
WIND WALKER	B	GRPB	20	4	4	WELL #1 - AEC568	W	187	28	31E	17	NENE
ROOSEVELT VIEWS SUBDIVISION	B	GRPB	6	2	2	WELL #1 - AFW484	W	418	28	33E	20	NWNW
ROOSEVELT VIEWS SUBDIVISION	B	GRPB	6	2	2	WELL #2	W	419	28	33	20	NWNW
Lakeview Catering	B	GRPB	4	1	1	WELL #1 - ABZ974	W	260	27	36E	07	NENW
Starkenburg Water System	A	TNC	2	1	17	WELL #1 - ALR606	W	200	28	33E	17	NESW
Ridgeview Water System	B	GRPB	1	1	1	WELL #1 - BAC981	WW	417	27	35E	13	SWNE
Ridgeview Water System	B	GRPB	1	1	1	WELL #2 - BAC967	WW	412	27	35E	13	SWNE
Cattle Drive #1	B	GRPB	1	9	9	WELL #1 - BAB575	W	188	28	31E	12	NENW
KELLER FERRY LANDING	A	TNC	5	2	3	ABR559 WELL, KELLER FERRY	W	238	28	33E	17	SWNE
HAWK CREEK CAMPGROUND	A	TNC	0	0	1	HAWK CREEK WELL - AFA205	W	30	27	36E	30	NENW
KELLER FERRY MARINA	A	TNC	0	0	5	WELL #1 - AFA213	W	160	28	33E	17	SENW
KELLER FERRY CAMPGROUND	A	TNC	0	1	7	KELLER FERRY WELL - AFA238	W	131	28	33E	17	NENW
SPRING CANYON CAMPGROUND	A	TNC	0	1	25	SPRING CANYON WELL - AFA218	W	183	28	31E	16	NENW

TABLE 4: LIST OF POTENTIAL FACILITIES WITH CONTAMINANTS

MAP ID	FS_ID	FACILITY NAME	GIS_CALC_L	GIS_CALC_1	COORD_XTNT	COORD_GEOG	HORZ_ACCU_	HOR_DTM_CD	HORZ_COLL_	LOC_VERIFI
1	8120021	AT&T WIRELESS DAVENPORT	47.65114603110	-118.15426559500	99	99	99	99	99	N
2	421	BRETT PIT	47.97006800000	-118.96391600000	99	99	99	2	9	Y
3	56117369	Cavenham Forest Industries Lin	47.82821000000	-118.41574000000	99	99	99	2	99	N
4	64776914	CENTURYTEL DAVENPORT	47.65361000000	-118.15222100000	99	99	99	2	99	N
5	69134211	CLARK DISTRIBUTORS DAVENPORT	47.70999900000	-118.19999600000	99	99	99	2	99	N
6	33252212	CONNELL OIL INCORPORATED	47.64727777780	-118.15777777800	4	8	4	2	18	
7	88644843	CONSOLIDATED GRANGE SUPPLY LIND	47.97130600000	-118.62019400000	4	5	6	2	4	N
8	4323408	Copenhaver Construction Inc	47.64626317950	-118.28592712700	99	99	99	99	99	N
9	5157	COPENHAVER CONSTRUCTION LLC	47.75030000000	-118.48200000000	0	0	99	4	99	
10	2157714	COULEE EXPRESS	47.96558374540	-118.97698427200	99	99	99	1	99	N
11	4345215	Crop Production Services Davenport	47.64741062000	-118.15749160000	99	8	4	2	29	Y
12	5654259	Dan Anderson	47.84820000000	-118.33940000000	99	99	99	2	99	F
13	57217753	DAVENPORT CITY	47.65390800000	-118.15620400000	4	5	6	2	4	N
14	85214652	DAVENPORT FOOD MART	47.65390835000	-118.15712040000	4	5	4	2	29	Y
15	42397527	DAVENPORT PRINT95 5TH SUB LSO378	47.69535100000	-118.19775400000	4	5	13	2	4	N
16	54838793	Davenport School Dist	47.65699000000	-118.15275000000	99	99	99	2	99	N
17	43618323	DAVENPORT SCHOOL DISTRICT 207	47.64901800000	-118.15206400000	4	5	13	2	4	N
18	41926531	Davenport Sewage Lagoon No 1	47.66654500000	-118.14441700000	2	5	9	2	19	N
19	17658246	Davenport Sewage Lagoon No 2	47.66657800000	-118.14677300000	2	5	8	2	19	N
20	53919137	Davenport Sewage Lagoon No 3	47.66754700000	-118.14171900000	2	5	8	2	19	N
21	69672493	Davenport Sewage Lagoon No 4	47.66765100000	-118.14896700000	2	5	8	2	19	N
22	23736	DAVENPORT STP	47.66670000000	-118.14900000000	0	0	99	4	99	
23	22369	DAVENPORT WWTP	47.65644900000	-118.15489600000	0	0	99	4	99	
24	7128897	David & Roxanna Macheel	47.97026436980	-118.66248341200	99	8	99	99	99	N
25	33361859	DON JANTZ	47.69535100000	-118.19775400000	4	5	13	2	4	N
26	2301212	EDWALL CHEMICAL CORP DAVENPORT	47.66044651580	-118.13103454000	99	99	99	99	99	N
27	51696171	EDWARD ENSOR	47.69535100000	-118.19775400000	4	5	13	2	4	N
28	91354484	FT SPOKANE GOVERNMENT BOAT DOCK	47.73349000000	-118.17219800000	4	5	13	2	4	N
29	42845475	FT SPOKANE MAINTENANCE SHOP	47.73349000000	-118.17219800000	4	5	13	2	4	N
30	72286338	FUDS FAIRCHILD ATLAS S8	47.83902290000	-118.21269240000	1	8	4	2	29	Y
31	48512859	FUDS RRA 7 DAVENPORT	47.80766000000	-118.17217000000	1	5	99	2	99	N
32	3261744	George Scharff	47.64840000000	-118.14390000000	99	99	99	2	99	F
33	85841965	GRAND COULEE DAM SCHOOL DIST 301 J	47.97440200000	-118.97082600000	4	5	7	2	4	N
34	72242142	Hwy 2 Davenport	47.65482000000	-118.14108000000	99	99	99	2	99	N
35	31825237	JAMES MANN FARM	47.69535100000	-118.19775400000	4	5	13	2	4	N
36	6837	Joyce Metzger Property	47.93711111110	-118.86211111100	0	8	6	3	13	
37	2589479	K & J PONTIAC INC	47.65390800000	-118.15253400000	4	5	6	2	4	N
38	4100	LAKEVIEW TERRACE MOBILE HOME PARK	47.92330000000	-118.93700000000	0	0	99	4	99	
39	15446529	Lincoln Cnty Courthouse	47.65491000000	-118.15019000000	99	99	99	2	99	N
40	972	LINCOLN COUNTY DEPT OF PUBLIC WORKS	47.66220000000	-118.14100000000	0	0	99	4	99	
41	74367953	LINCOLN COUNTY FIRE PROTECTION 5	47.65390800000	-118.15212400000	4	5	7	2	4	N
42	83677165	LINCOLN COUNTY HIGHWAY UST 11020	47.65645046000	-118.14700600000	4	5	4	2	29	Y

43	9332298	Lincoln County Public Works	47.65864637470	-118.14157504500	99	99	99	99	99	
44	24987	Lincoln County Transfer Station	47.64330319490	-118.21527706400	0	8	6	3	13	
45	1751178	LINCOLN ELECTRIC COOP INC	47.65417877000	-118.15734300000	4	5	4	2	29	Y
46	2618192	LINCOLN MUTUAL SVC 2 DAVENPORT	47.65391618190	-118.14684525200	99	99	99	99	99	N
47	82582612	MCGREGOR CO DAVENPORT	47.65416700090	-118.14250100000	99	99	99	4	99	N
48	72681479	Meadow View Greenhouses	47.65148000000	-118.17289000000	99	99	99	2	99	N
49	25469754	MICHAEL HARDIN FARMS INC	47.69535100000	-118.19775400000	4	5	13	2	4	N
50	43338877	MILES TARESKI	47.65399200000	-118.16238700000	4	5	6	2	4	N
51	52492472	MILTON R HARDY	47.73349000000	-118.17219800000	4	5	13	2	4	N
52	35713363	NORTHWEST AVIATION INC	47.65287800000	-118.16927900000	4	5	13	2	4	N
53	41828428	ODESSA UNION WAREHOUSE UST 2128	47.64704200000	-118.14959400000	4	5	6	2	4	N
54	36318758	Priceless Gas	47.65410027000	-118.15694690000	4	5	4	2	29	Y
55	7596159	Reyes Automotive Repair	47.97497794980	-118.96813608600	99	99	99	99	99	
56	6064892	Roger P Johnson	47.89468700000	-118.71405600000	99	99	99	2	99	F
57	21701	S & W ROCK PRODUCTS	47.65420000000	-118.15800000000	0	0	99	4	99	
58	20264	SEVEN BAYS ESTATES STP	47.84695476770	-118.33820648500	0	0	99	4	99	
59	22468	SEVEN BAYS ESTATES UNLIMITED	47.84280000000	-118.33800000000	0	0	99	4	99	
60	77359128	Siemens Pwr Corp Gr Coulee Dam 3rd Pwrhs	47.96537000000	-118.98016000000	99	99	99	2	99	N
61	74242975	SPRING CANYON CAMPGROUND & BOAT	47.93481817000	-118.94009090000	4	5	4	2	29	Y
62	2672738	TRADERS EXPRESS	47.65432300000	-118.14775000000	4	5	6	2	4	N
63	5016	TURNER DAVID DDS	47.65479800000	-118.15117000000	0	8	99	4	4	
64	8195572	WA AGR Pesticide Turn in	47.65821336560	-118.14177304400	99	99	99	99	99	
65	32689842	WA DOT KELLER FERRY MAINTENANCE SITE	47.92837710250	-118.68937488200	4	8	6	3	13	
66	83877553	WA DOT Morgan Davenport	47.65357136000	-118.16132210000	4	5	4	2	29	Y
67	16726621	WESTERN FARM SERVICE INC UST 8857	47.64843700000	-118.15858900000	4	5	13	2	4	N
68	9307856	WSP Missile Silos	47.65137608430	-118.15428555800	99	99	99	99	99	

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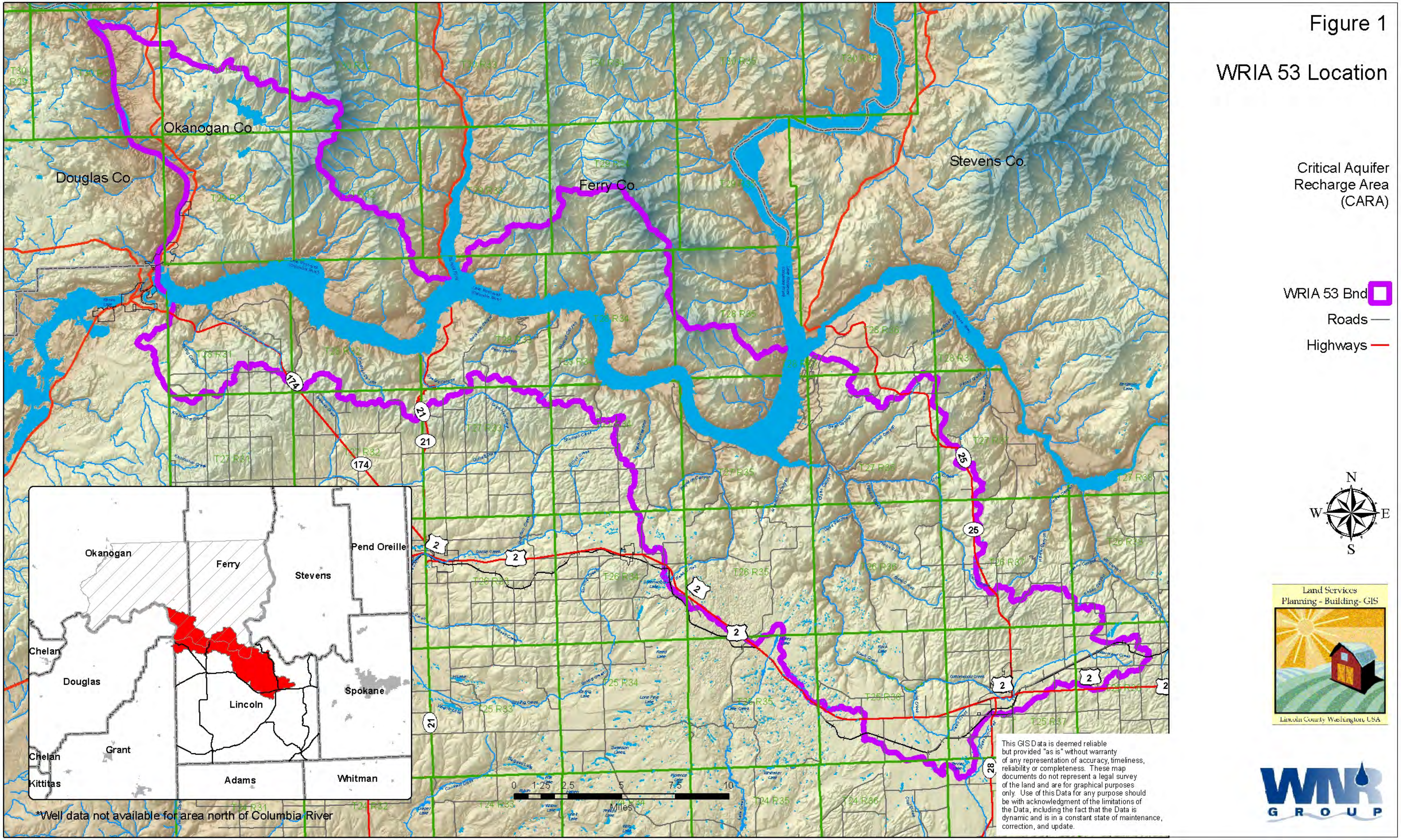
Figure 1

WRIA 53 Location



*Well data not available for area north of Columbia River

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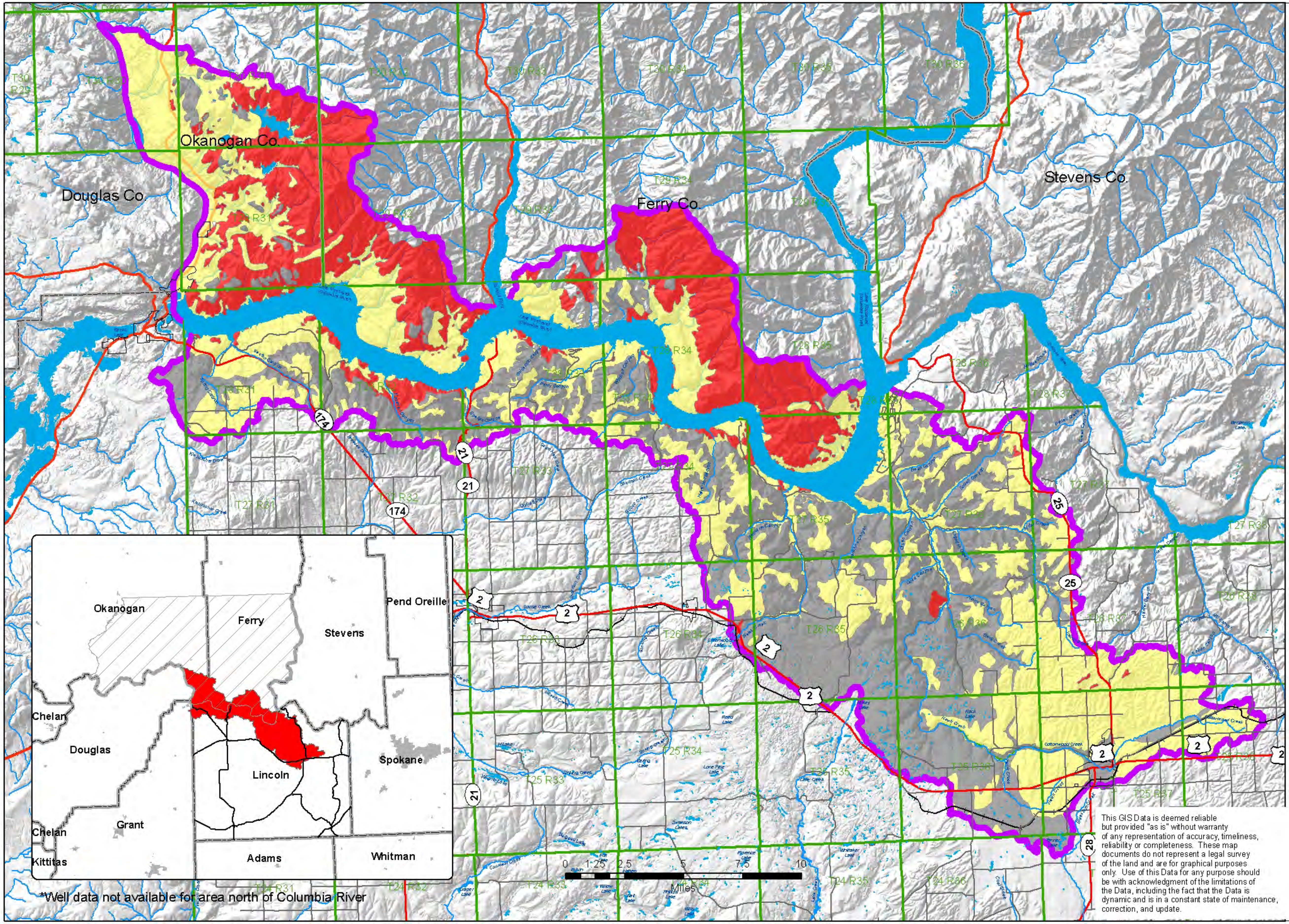
Figure 2

Aquifers



Critical Aquifer Recharge Area (CARA)

WRIA 53 Bnd

Roads

Highways

Aquifers

Basalt

Granite & other bedrock

Unconfined sand/gravel

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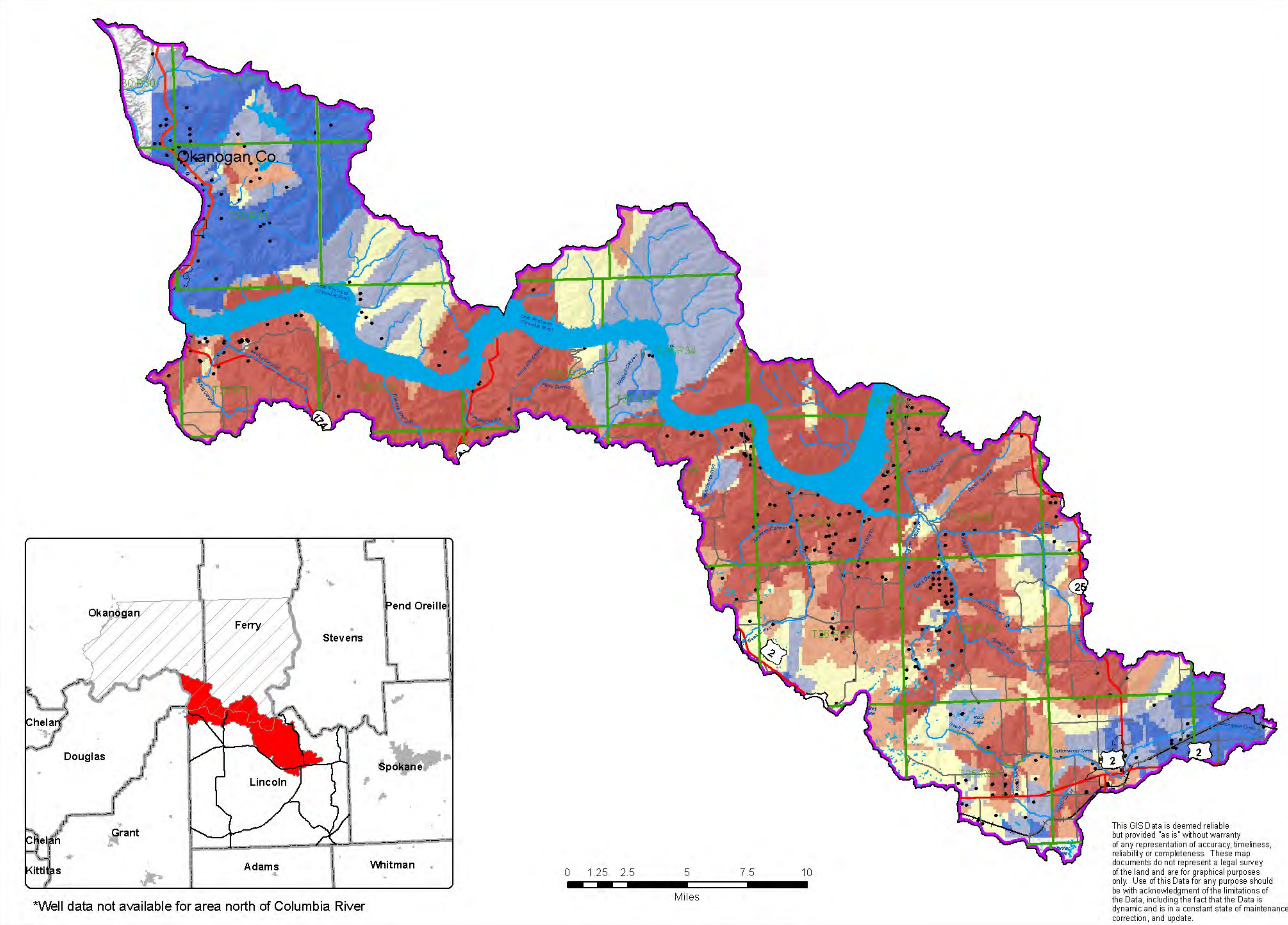
Figure 3

Depth to Groundwater (ft)



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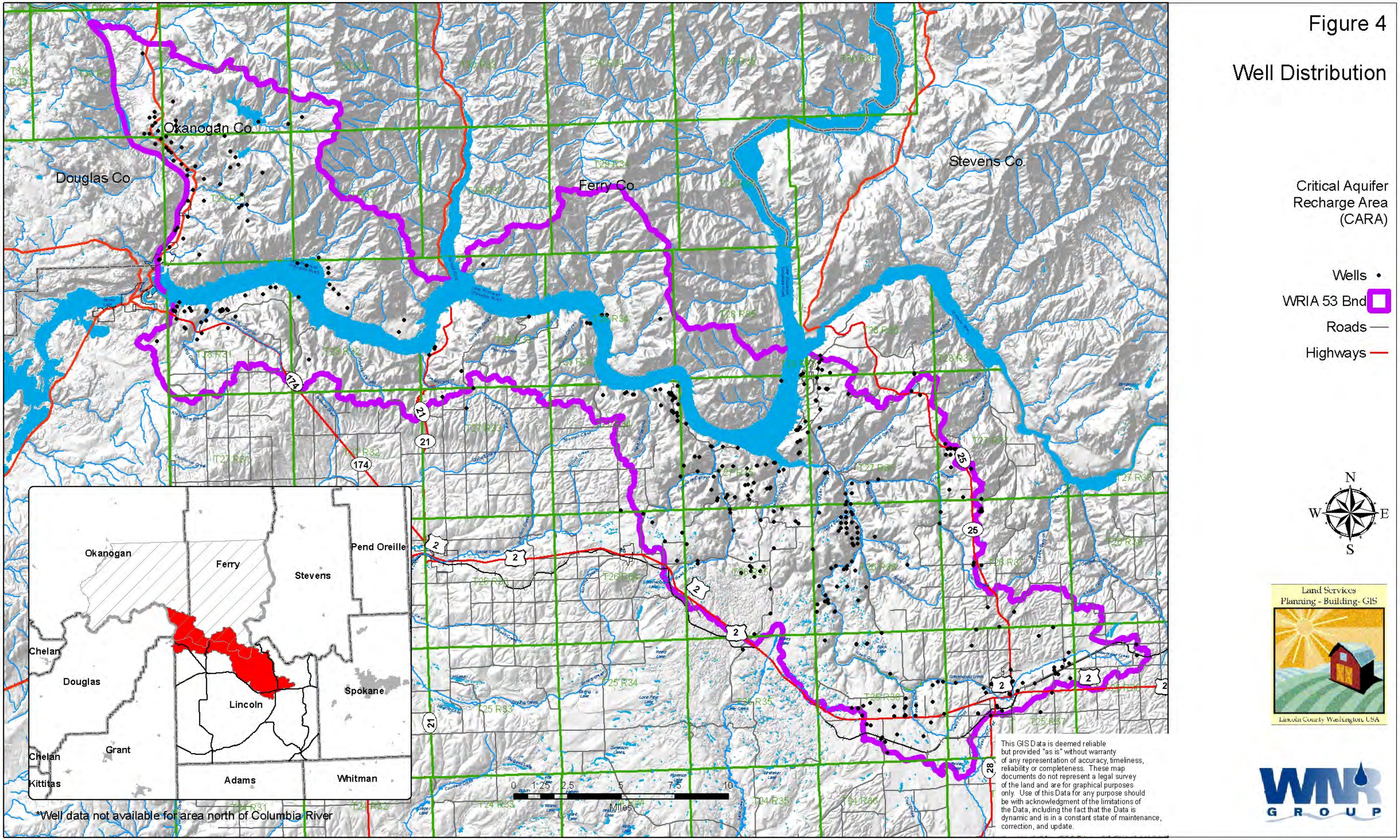
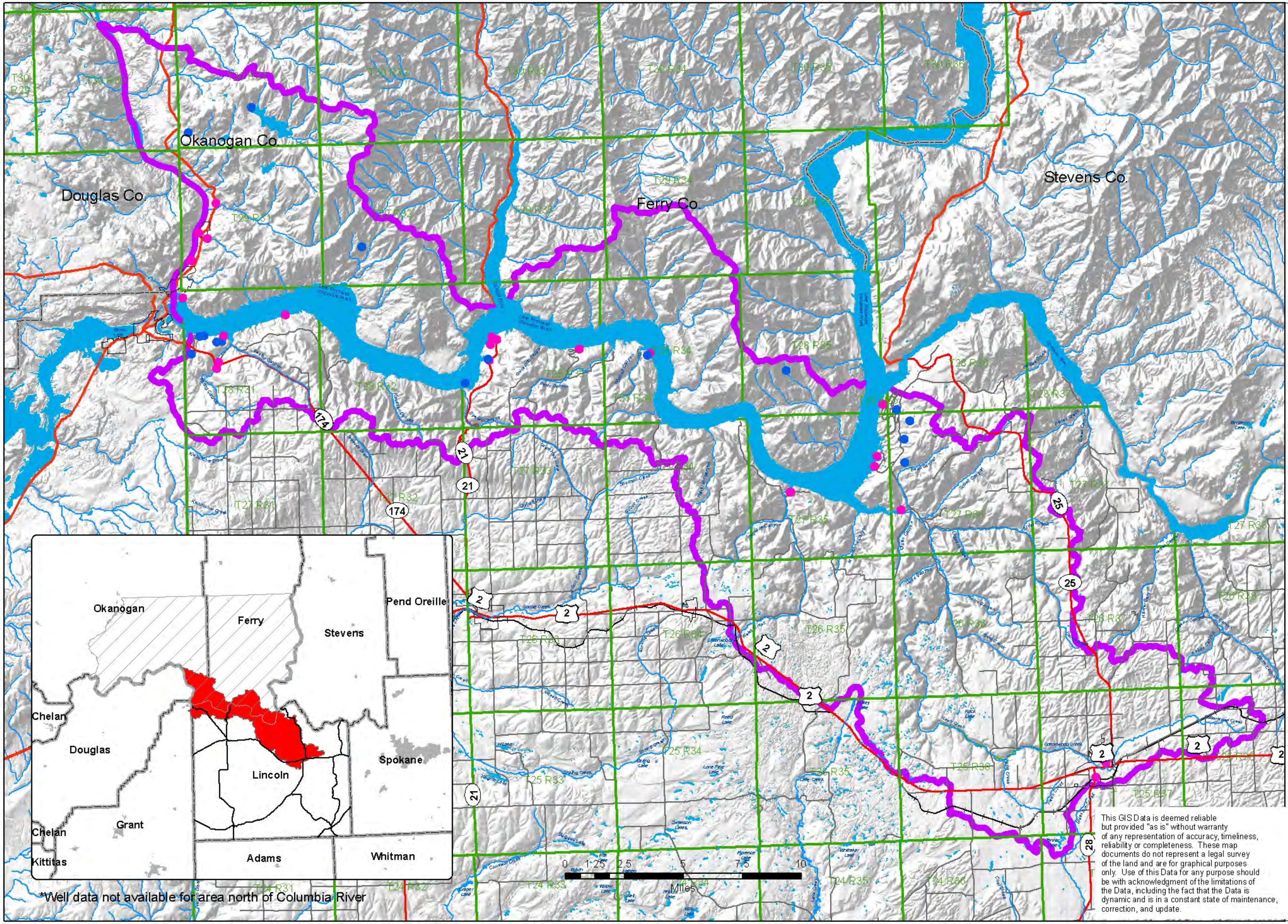


Figure 4

Well Distribution

Figure 5

Group A & B Locations



Critical Aquifer Recharge Area (CARA)

- Group A Wells
- Group B Wells
- WRIA 53 Bnd
- Roads
- Highways

N
W E
S

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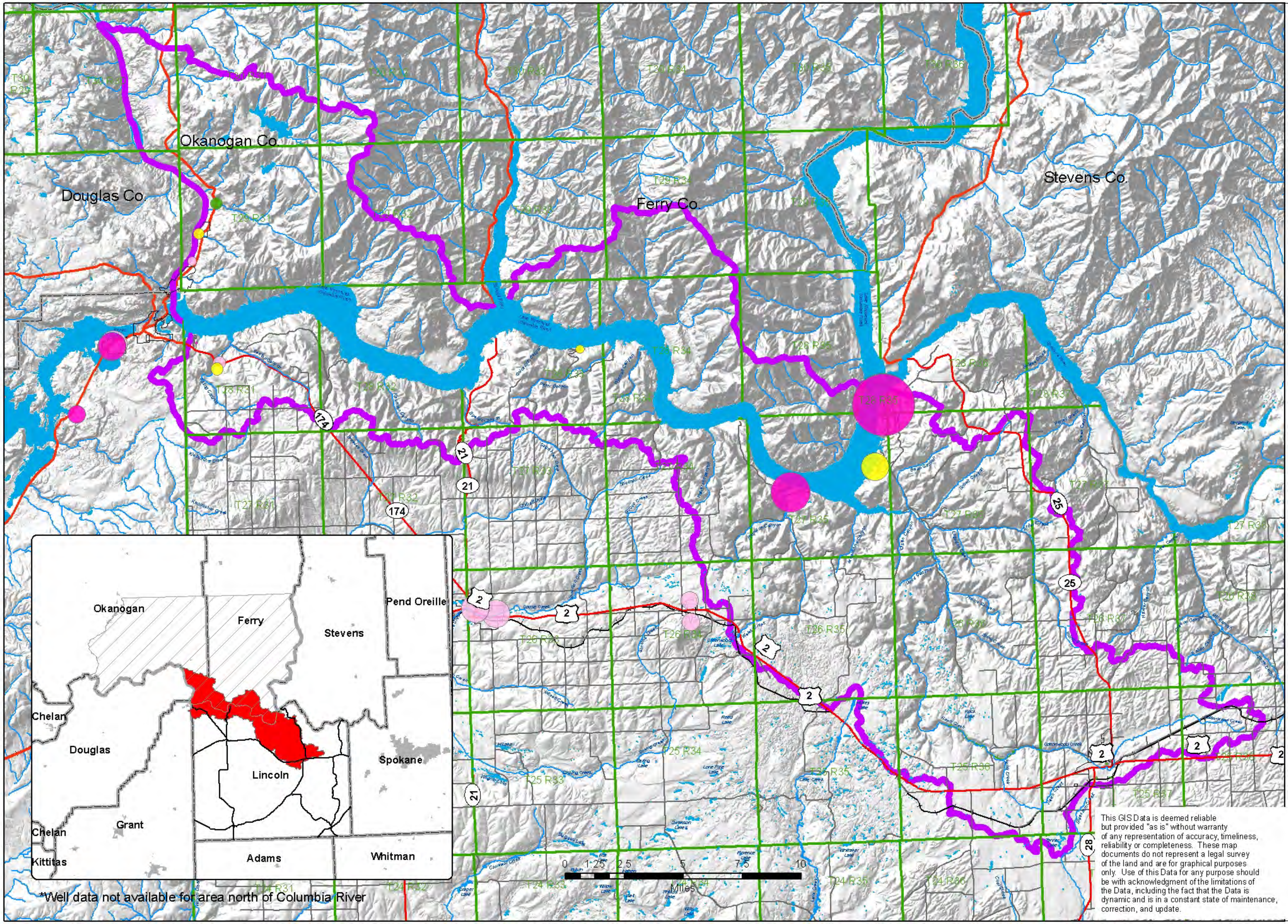
Figure 6

Wellhead Protection Areas 10 Year Time of Travel (TOT)



Critical Aquifer Recharge Area (CARA)

Source Susceptability

- Low
- Moderate
- High
- Unknown
- WRIA 53 Bnd
- Roads
- Highways

N W E S

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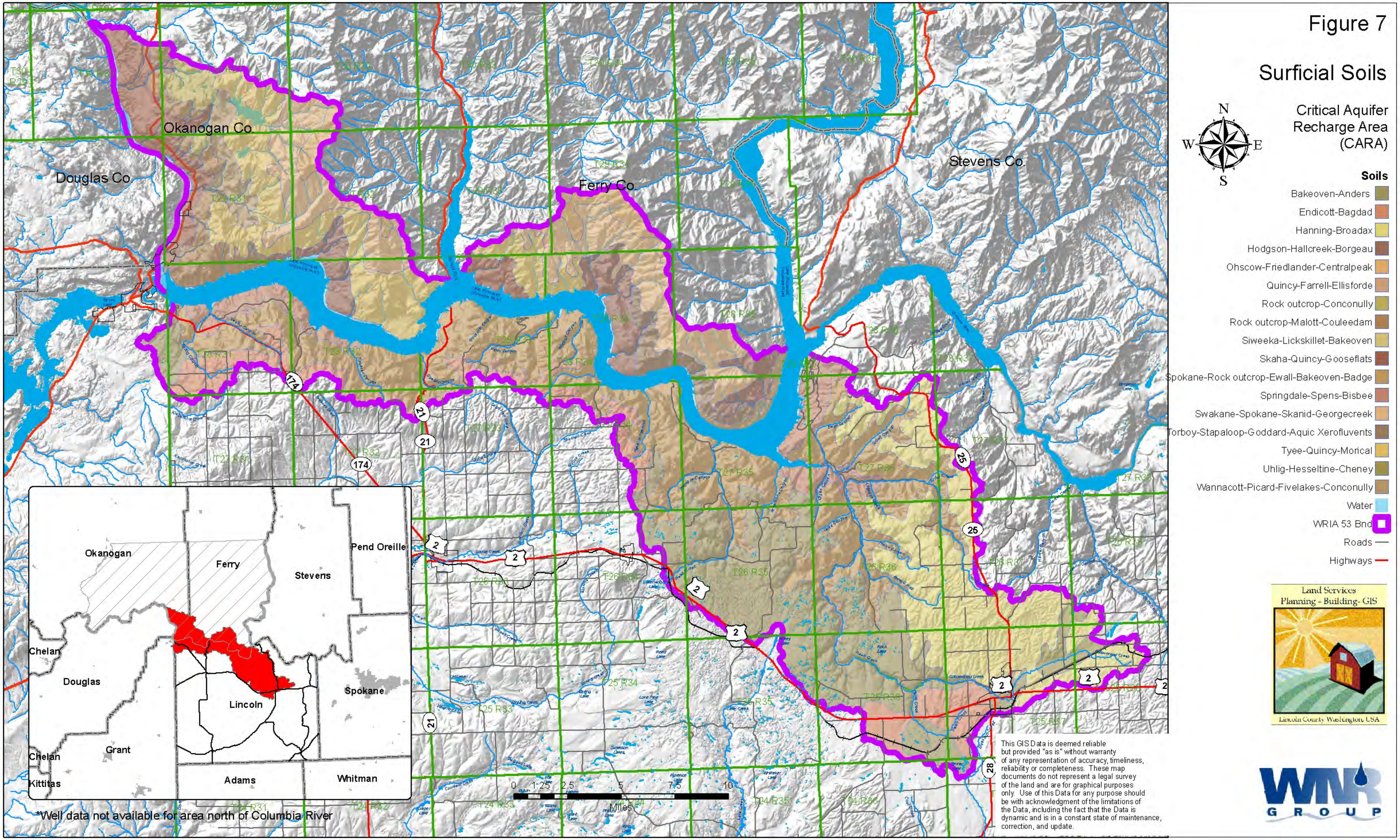

Figure 7

Surficial Soils

Figure 8

Surficial Soil Permeability

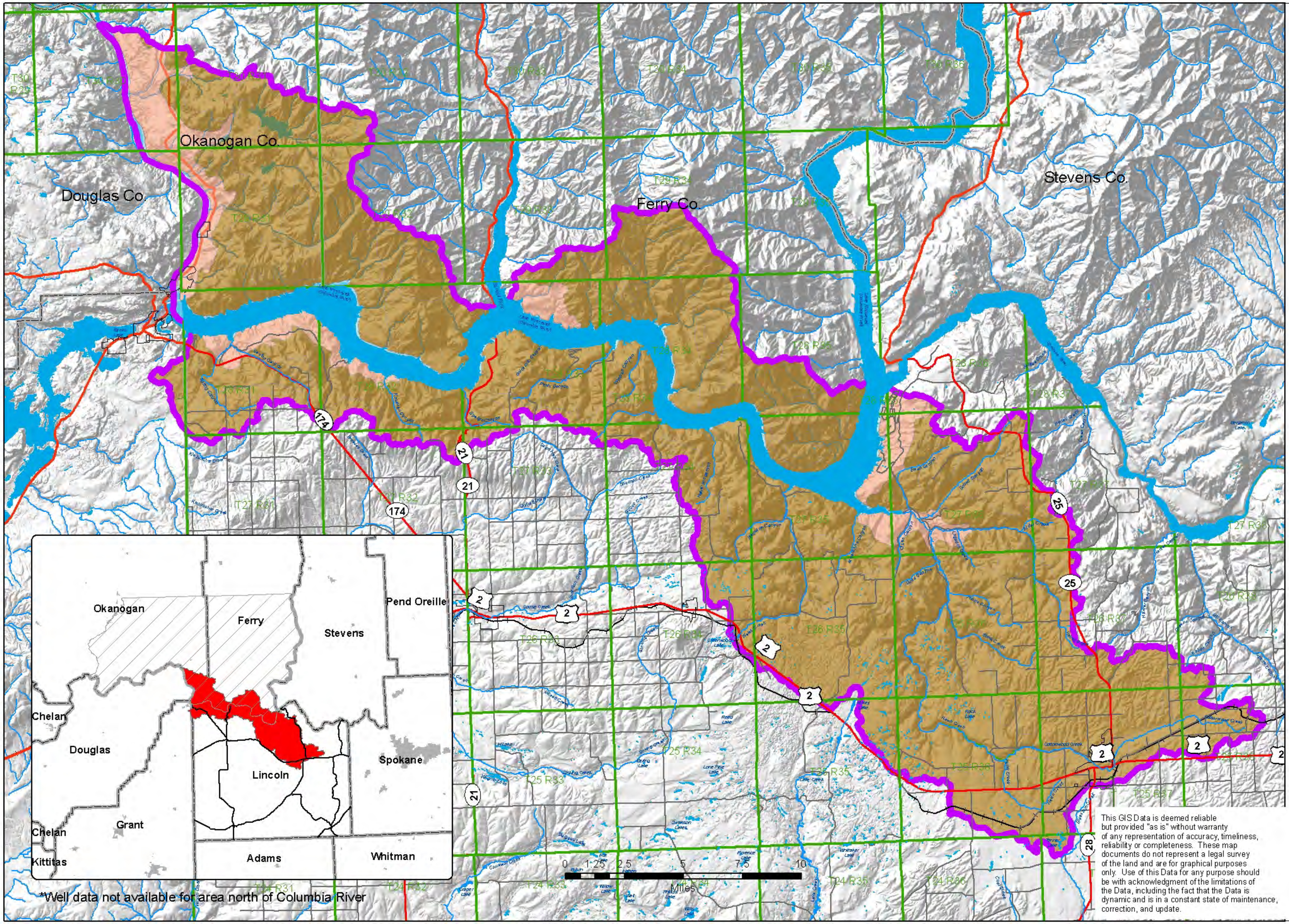

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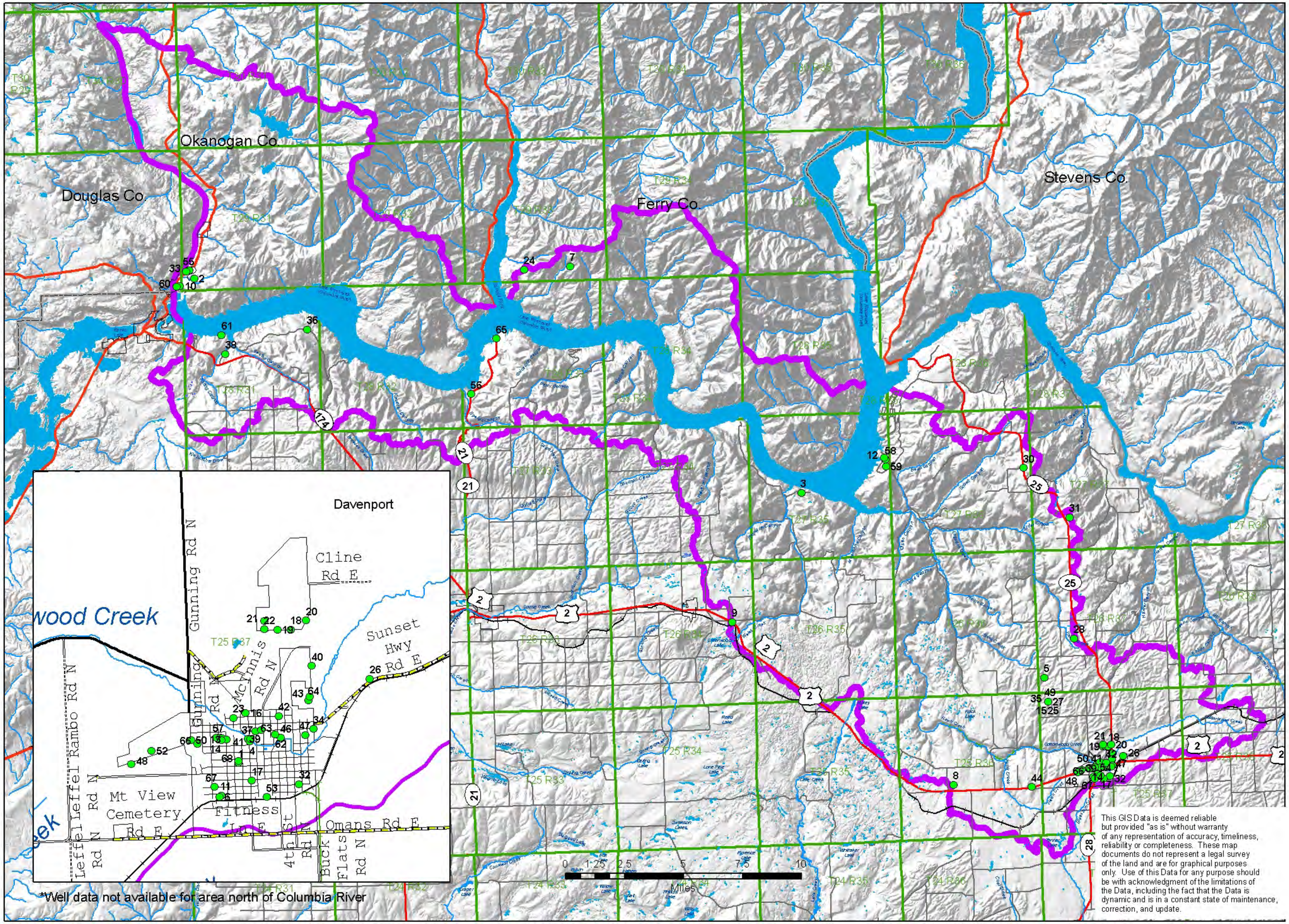
Figure 9

Facilities



Critical Aquifer Recharge Area (CARA)

Known Facility (DOE)

WRIA 53 Bnd

Roads

Highways

N W E S

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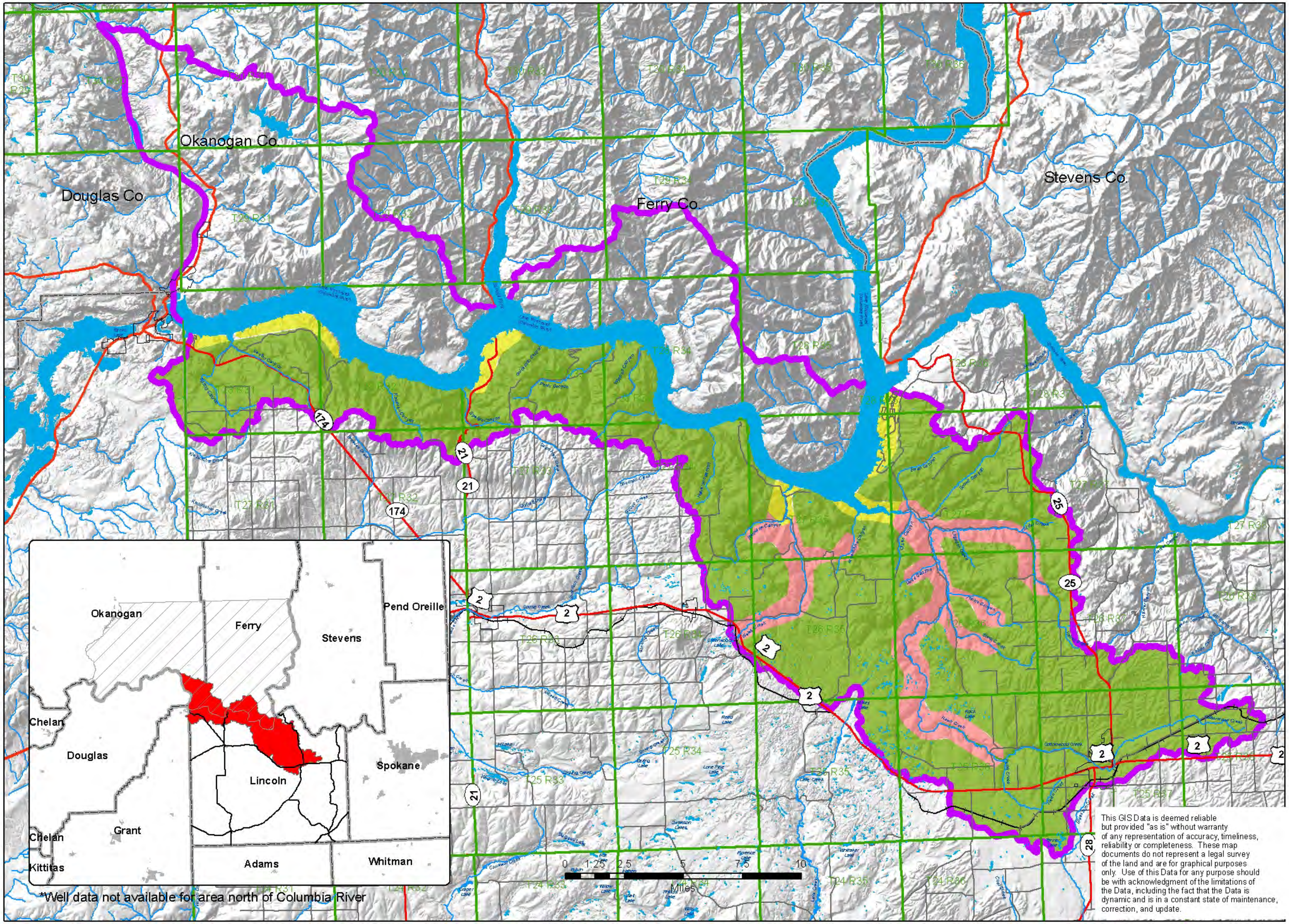

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Figure 10

Susceptibility Ranking for Aquifers

Critical Aquifer Recharge Area (CARA)

Aquifer Susceptibility

- High
- Moderate
- Low
- WRIA 53 Bnd
- Roads
- Highways

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