PETITION FOR DESIGNATION OF THE

TROUTDALE AND UNCONSOLIDATED ALLUVIUM AQUIFER SYSTEM IN CLARK COUNTY, WASHINGTON AS A

SOLE SOURCE AQUIFER

Submitted to

U.S. Environmental Protection Agency
Region 10
1200 6th Avenue
Seattle, Washington 98101

Submitted by

Columbia Riverkeeper
Rosemere Neighborhood Association
Independent Clark County citizens

November 30, 2005

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1 Introduction

The Safe Drinking Water Act in Section 1424(e) provides for the designation of an aquifer or aquifer system that meets certain conditions as a Sole Source Aquifer (SSA). An SSA is an aquifer that is the sole or principal drinking water source for the area overlying it and if contaminated would create a significant hazard to public health. Any individual, corporation, company, association, partnership, State, municipality or Federal agency can petition the U.S. Environmental Protection Agency (EPA) to designate an SSA. The EPA has prepared the *Sole Source Aquifer Designation, Petitioners Guidance* (EPA, 1987) document to help petitioners prepare SSA designation petitions.

This petition has been prepared to request that the EPA designate the primary aquifer system in Clark County, Washington as an SSA. This aquifer system includes the portions of the Troutdale and unconsolidated alluvial aquifers that are in Clark County and hydraulically separated from other parts of these aquifers by the Columbia and Lewis Rivers and other hydraulic divides. The petition conforms with the provisions of the *Petitioners Guidance* and presents the information that demonstrates that this aquifer system qualifies as an SSA..

1.1 Organization of the Petition

The *Petitioners Guidance* describes four main sections for the petition as follows:

Section 1:	Petitioner Identifying Information
Section 2:	Narrative Description
Section 3:	Sole or Principal Source Data
Section 4:	Boundary Information

These are included in Section 2 of this Petition. A completed Initial Petition Review/Determination of Completeness Checklist is included in Appendix A. Documentation of the method used to estimate water usage is included in Appendix B.

2 Sole Source Aquifer Petition

2.1 Petitioner Identifying Information

Aquifer System	Name:	Troutdale and Unconsolidated Alluvium Aquifer System (TUAAS)
	Location:	Clark County, Washington
Petitioners	Names:	Columbia Riverkeeper Rosemere Neighborhood Association Dvija Michael Bertish Dennis Dykes Thom McConathy Nathan Reynolds Karen Kingston Coleen Broad Richard Dyrland Dean Swanson
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The petitioners are a group of independent citizens and organizations that are concerned about the quality and quantity of groundwater in Clark County.

2.2 Narrative Description

This petition addresses a portion of the Troutdale and Unconsolidated Alluvium Aquifer System (TUAAS) that is located in Clark County, Washington (Figure 1). The TUAAS extends through much of the Portland Basin. The portion of the aquifer system that is the subject of this petition is hydraulically separated from other parts of the system by the Columbia River on the south and west and a short part of the Lewis River on the northwest. The older rocks hydrogeologic unit typically bounds the TUAAS on the north and east except in a few areas. Parts of the boundary in the north are defined along topographic highs that separate surface water drainages rather than along geologic boundaries. These drainage divides define hydraulic divides within relatively thin areas of the Troutdale Gravel aquifer. In the southeast corner of the service area a short outcrop of the older rocks separates the petitioned part of the system from a small alluvial area located to the east in the vicinity of Camas and Washougal. This ridge in the bedrock extends under a relatively thin deposit of the Troutdale Sandstone and separates the proposed aquifer service area from the alluvial aquifer located to the east. These aquifers are described in detail in numerous United States Geological Survey (USGS) publications including *A Description of Hydrogeologic Units in the Portland Basin, Oregon and Washington* (USGS, 1993). Other publications are listed in the bibliography.

Over 97 per cent of the potable water used in the proposed SSA area is withdrawn from the TUAAS. This proportion was calculated from water usage data compiled using an alternative method to the one described in the Petitioners Guidance. Unfortunately accurate actual water usage data is not available from individual purveyors or other agencies because of security regulations and other concerns. These concerns were not at the forefront when the guidance document was written. However, alternative data is available that allows an accurate estimation of total water usage within the TUAAS area. The USGS compiled water usage data for the year 2000 for Clark County. Although the USGS does not make available a breakdown of this usage data, the amount of groundwater and surface water used in the TUAAS area can be estimated by subtracting the amount of water used in the county outside the TUAAS. This calculation shows that an average of 31.8 million gallons per day (Mg/d) of groundwater and 0.2 Mg/d of surface water were used in 2000. Therefore, 99.4 per cent of the potable water used in the proposed aquifer service area is obtained from groundwater, confirming that the TUAAS qualifies as a Sole Source Aquifer. A small amount of groundwater and all the surface water is imported to the southeast corner of the proposed aquifer service area. A spreadsheet detailing these calculations is included in Appendix B.

The cities of Vancouver, Battle Ground, Ridgefield, and La Center obtain all of their domestic water supplies from groundwater in the TUAAS. Only Camas, part of which overlies the TUAAS, obtains a portion of its water supply from surface water and groundwater from outside the proposed aquifer service area. The Clark Public Utility District (CPU) provides groundwater to more than 70,000 people primarily in unincorporated areas of the county. The CPU uses no surface water sources. Additionally, essentially all self-supplied dwellings and small Class B water systems use groundwater supplied by on the order of 20,000 private wells. The 2000 census counted 305,240 people in the TUAAS area.

The population of Clark County is projected to grow 2 per cent per year to approximately 585,000 people in 2024, about 240,000 more people than were counted by the 2000 Census. Most of this population growth will occur over the proposed Sole Source Aquifer. This rapid population growth will increase dramatically the demand for potable water. The risk to groundwater quality will also increase because the required infrastructure and business development will create additional potential sources of contamination.

The Lower Columbia Fish Recovery Board led the development of a regional watershed plan which was adopted in December 2004. This plan endorsed the development of the alluvial aquifer in the Vancouver Lakes lowland as a major water supply source. The plan directs water supply development away from surface water sources including the capture of surface water by groundwater pumping. The major purveyors in the proposed service area have incorporated these recommendations in their long term plans.

There currently are no significant alternative sources of drinking water in or near the TUAAS area. Interties to nearby large purveyors are not available because of the geographic isolation of the area by the Columbia River. Additionally, potential purveyors do not have excess capacity to supply the large population in Clark County, and there would be a substantial cost to develop and transport new water sources, if water rights could be obtained. Alternative aquifers that have not already been appropriated could only be expected to replace a portion of current water demand at a higher per unit cost. Additional surface water sources are not currently available to the service area and would require an intense effort and cost to develop if access could be acquired. Substantial surface water rights are generally not available in this region and the cost of developing and maintaining the withdrawal, treatment and transport systems would be high.

The petitioner's interest in SSA designation of the TUAAS is to protect our primary drinking water source, as well as to promote awareness and improve management of the aquifer system. We have been involved with various projects throughout the TUAAS and have come to understand that a wide range of activities have affected, or have the potential to affect, the primary source of our drinking water.

The aquifer system is vulnerable to contamination because recharge occurs essentially over the entire area and there are many anthropogenic activities that have or may release contaminants to the aquifers. The Washington Department of Ecology (Ecology) currently lists 216 active cleanup and 12 federal Superfund sites in the proposed aquifer service area. These sites are known to have been contaminated and are undergoing cleanup. Many of these sites include plumes of groundwater contamination. Ecology also lists over 620 hazardous waste generators and nearly 280 hazardous materials storage facilities in this area. These types of sites, which constitute significant threats to groundwater quality, are identified by Ecology in Clark County:

▪ Superfund sites	12
▪ Active state cleanup sites (MTCA, etc.)	87
▪ Active voluntary and independent cleanup sites	139
▪ LUST sites	185
▪ Hazardous waste sites	626
▪ Hazardous materials storage sites	277
▪ UST sites	609

Other sources of contamination include untreated or poorly treated stormwater and septic systems. There are on the order of 7,000 septic systems on small lots in the City of Vancouver, all more than 30 years old and likely to be failing. There are tens of thousands of additional septic systems outside the city discharging to the aquifer.

The county is experiencing rapid growth which increases the threat to the quality of the aquifer as well as increases the demand for potable water.

The quality of groundwater in the proposed aquifer service area is generally good with some exceptions. The quality of groundwater is described in *Quality Of Ground Water In Clark County, Washington,* (Turney, 1988). The following discussion is exerted from this publication and is based on data generated during the study. Dissolved-solids concentrations ranged from 12 to 245 milligrams per liter, with a median concentration of 132 milligrams per liter. Most waters can be characterized as soft to moderately hard. Concentrations of nitrate as nitrogen exceeded 1.0 milligram per liter throughout the Vancouver urban area, and were as large as 6.7 milligrams per liter. Potential nitrate sources are septic systems and fertilizers. An analysis of limited historical data indicates that nitrate concentrations may be decreasing in the southwestern part of the county around the Vancouver urban area. A slight increase in nitrate concentrations was noted in rural areas. Nitrate concentrations correlated with sulfate concentrations ($r = 0.61$), indicating similar sources for the two. Volatile organic compounds have been detected in wells in the Vancouver urban area. Compounds identified included tetrachloroethene, l,l,l-trichloroethane, and other solvents. Atrazine and 2,4-D have also been detected in well water. Trace elements and radiochemical constituents were present only at small levels, indicating natural sources for these constituents.

Many of the petitioners are end users of the purveyors that use the aquifer systems as their source of water. All of the petitioners at times use water provided by various purveyors. Some petitioners are self-supplied from the aquifers and are threatened by known or potential contamination and/or over pumping of the aquifers.

2.3 Sole or Principal Source Data

2.3.1 Aquifer Service Area

The proposed Aquifer Service Area is coincident with the main area of the TUAAS in Clark County as defined by hydraulic divides and geologic boundaries. The service area includes most of the population of Clark County and is shown on Figure 1. The Washington Department of Health (DOH) regulates water systems in the service area and does not document the export of water from this area, although the Camas water system imports some water to the area. The boundaries of the service area are the Columbia River on the south and west, a short part of the Lewis River on the northwest, and the hydrogeologic boundary across the north and east sides of the area. The hydrogeologic boundary is predominantly between the Troutdale aquifer and the older rocks hydrogeologic unit although a few sections are based on drainage divides. The Troutdale Formation was deposited in a basin in the older rocks unit (which is generally composed of basalt and andesite) therefore the boundary is in the uplands on the north and foothills on the east of the area.

2.3.2 Population

The 2000 census counted 305,240 people in the service area. Of these 297,380 (97.3 per cent) were served by the aquifer system. Water is imported to residents of the southeastern part of the service area in part of the City of Camas from groundwater and surface water sources located east of the aquifer service area. The population in the proposed aquifer service area is rapidly growing.

2.3.3 Sources of Drinking Water

There are 19 Class A water systems in the aquifer service area (Table 1). Only five of these systems serve more than 1,000 people and eight of them serve fewer than 100 people. Four of the five larger systems are municipal. The fifth is operated by the Clark Public Utility District, which is identified in DOH records as the second largest purveyor in the service area. The CPU system includes a number of small satellite systems as well as service to urban and unincorporated areas and the City of La Center.

A Current Drinking Water Sources matrix is presented as Table 2. This matrix shows that 97.3% of the domestic water used in the service area is supplied by the petitioned aquifer system and only 2.7% is imported. The imported water includes all of the surface water used in the service area (0.6% of total usage) and only 2.1% of the groundwater. All of the imported water is within the Camas water system service area. The surface water used by the Camas system is collected from two tributaries of the Washougal River, both of which are outside the proposed service and project review areas. The groundwater used by this system is pumped from an alluvial aquifer located east of the service area near the Washougal and Columbia Rivers.

2.3.4 Method of Calculating Water Use Percentages

The USGS compiled water usage data for the year 2000 for Clark County. Although the USGS does not make available a breakdown of this usage data, the amount of groundwater and surface water used within the aquifer service area can be estimated by subtracting the amount of water used in the county outside the service area from the total usage for the county. A spreadsheet detailing these calculations is included in Appendix B. The amount of water used outside the aquifer service area was estimated by multiplying the population of this area by the USGS per capita water usage. This population includes those served by water systems and self-served water users. The USGS estimated per capita water usage for each of these population groups. The population was determined by overlaying the year 2000 Census maps at the block level on the aquifer boundary and totaling the number of people counted in the blocks that lie outside the proposed service area.

The petitioned aquifer service area includes a part of the City of Camas municipal water systems service area. The Camas systems water sources include surface water and groundwater. All of these sources, except one groundwater well, are located outside the proposed service area therefore most of the water delivered by the Camas water system within the proposed service area is imported. A proportional method was used to estimate the amount of water used in the service area from each source type. The population served by the Camas water system both within and outside the aquifer service area was estimated using 2000 Census data. These data and the USGS per capita water usage rate were used to calculate the water usage in the aquifer service area. The director of the water utility reported in a personal communication that 20% of the water used by the utility has a surface water source. This proportion was used to calculate the amounts of surface water and groundwater used in the aquifer service area. The water produced by the single well located within the aquifer service area was assumed to all be used within the service area. The amount of water produced by this well was estimated as the proportion of the total groundwater production capacity of the Camas system in 2000 as documented in the DOH Sentry database. The amount of water produced by this well was then subtracted from the amount of groundwater used in the Camas part of the aquifer service area to calculate the amount of groundwater imported. The amount of water produced by this well was also added to the total amount of groundwater produced within the aquifer service area.

This calculation shows that an average of 31.8 million gallons per day (Mg/d) of groundwater and 0.2 Mg/d of surface water were used in 2000 in the proposed aquifer service area. Therefore, 99.4 per cent of the potable water used in the TUAAS area is obtained from groundwater, confirming that the TUAAS qualifies as a Sole Source Aquifer.

2.3.5 Seasonal and Long Term Variations

Typical seasonal variations in water usage occur within the aquifer service area. Water usage increases in the dry summer months and decreases in the fall and winter. Water levels in the aquifer also fluctuate seasonally as well as show long term declining trends in many areas. The USGS describes water level changes in Clark County in *Description of the Groundwater*

Flow System in the Portland Basin, Oregon and Washington, USGS Water Supply Paper 2470-A (McFarland and Morgan, 1996A). In this report, the USGS describes water levels measured during a three year period as fluctuating 4 to 15 feet seasonally. The report also describes long term declines in water levels of 10 or more feet in wide areas of the county, particularly in areas with high groundwater pumpage. Additionally, the report describes substantial declines (42%) in spring discharges in the southern part of Clark County between measurement made in 1949 and 1988, which is likely the result of pumping induced water level declines. The Groundwater Management Plan (Groundwater Advisory Committee for Clark County, 1992) describes the long term decline as between 5 and 20 feet.

A computer simulation of the aquifer described in *Simulation Analysis of the Ground-Water Flow System in the Portland Basin, Oregon and Washington, US Geological Survey Water Supply Paper 2470-B* (Morgan and McFarland, 1996) estimates that water levels have declined as much as 50 feet from the predevelopment condition. The simulation indicates that this decline was caused by groundwater pumping and the creation of impervious surfaces which reduce recharge.

2.3.6 Actual Use and Potential Capacity

Groundwater within the proposed aquifer service area is currently the only source being considered to increase the supply of domestic water in Clark County. Unfortunately, neither a comprehensive management plan for, nor a detailed estimate of the potential capacity of the aquifer system have been adopted. Limits to the potential capacity of the system are suggested by published studies. A watershed management plan (Lower Columbia Fish Recovery Board, 2004) states that the currently exploited portions of the aquifers will be used to full capacity by 2020 because of growth. The plan identifies the unconsolidated alluvial aquifer in the Vancouver Lake lowlands as a major source area for future exploitation. The plan anticipates that the capacity of this source, which is acknowledged as recharged primarily from the Columbia River, will satisfy long term demand growth and will replace other water sources that interfere with instream flows within the watershed.

A USGS computer model of the aquifer system (Morgan and McFarland, 1996) was used to test an estimated 55% increase in demand from the base year of 1988 to the year 2010. This simulation estimated that equilibrium water levels would decline as much as 20 feet in the alluvial gravel aquifer and 20 to 40 feet in the Troutdale Gravel aquifer. Since most groundwater is withdrawn from the Troutdale Gravel, the USGS concluded that the decline in the alluvial aquifer resulted from seepage down to the Troutdale Gravel. Declines in groundwater levels such as this can reduce the discharge of groundwater to surface streams and ponds. The model showed that increased pumping will likely intercept groundwater flow that discharges to surface waters and will induce surface water to flow into the ground in some areas.

Another indication of the limits to the potential capacity of the aquifer system is the CPU management scheme for groundwater pumping in the Salmon Creek watershed. The CPU has developed a Water Resources Plan as part of an agreement with Ecology to manage existing supplies in this watershed. The plan includes curtailment of pumping to reduce impacts on low stream flows. Interties to other source areas are planned to make up for reduced pumping.

Pumping scenarios that affect stream flows will affect associated water rights and habitats. This information suggests a limit to the potential capacity of the TUAAS, particularly in the heavily used southern part of the proposed aquifer service area. Therefore, increases in the exploitation of the aquifer system are likely to be directed to less used areas. This is already occurring in the Ridgefield/Pioneer area where the CPU has recently installed several wells and applied for water rights and in the Vancouver Lake lowlands where a supper well field is planned.

2.3.7 Potential Alternative Sources

Potential alternative sources of water include surface water, groundwater from aquifers outside the service area, and interties to other water systems. Possible alternative sources include:

- The Columbia River
- The Lewis River system
- The Washougal River system
- The alluvial gravel aquifer in the Washougal River delta/Steigerwald Lake lowlands
- The alluvial gravel aquifer in the Woodland Bottoms
- Intertie to the Portland Water Bureau

The locations of these areas are shown on Figure 2. Each of these alternatives have limitations that constrain development or limit the development potential. Additionally, coordinated water supply planning in Clark County is limited at present. This raises obstacles to large scale development of alternative sources outside the aquifer service area.

Surface Water Alternatives

Columbia River. The Columbia River is a major river that flows along the southern and western sides of the proposed service area. The river is not directly used for domestic water supply in this region therefore, no intake structures or treatment systems exist. The flow in the river averages on the order of 200,000 cubic feet per second (cfs) but fluctuates from less than half this rate during the late summer and early fall to nearly than twice this rate during spring runoff. During droughts flow in the river has been as low as 70,000 cfs. The flow of the river is controlled by hydroelectric dams.

Lewis River. The Lewis River forms a short section of the boundary of the proposed aquifer service area. It flows from east to west and enters the Columbia River at the northwest corner of the proposed service area. Flow in the main stem of the Lewis River averages about 4,500 cfs and ranges from an average low flow of about 1,300 cfs in August to an average high flow of about 8,000 cfs in December. The Lewis River divides into two forks, the North Fork and the East Fork, near the City of La Center. The North Fork is larger and drains an area north and east of the service area. Three dams are located on this fork of the river and are used for power generation and limited flood control. The East Fork flows from east to west across the northern part of the proposed service area. Neither fork is currently used as a surface water source of supply although the City of Woodland uses a Ranney infiltration gallery located a short distance north of the service area.

Washougal River. The Washougal River drainage is located east of the proposed aquifer service area. It flows roughly north to south from the foothills of the Cascade Mountains and enters the Columbia River just east of the proposed service area. The Washougal River flow averages about 900 cfs and ranges from an average low flow of about 100 cfs in August to an average high flow of about 1,770 cfs in December. Water is currently collected from two tributaries of this river by the Camas water system.

Groundwater Alternative Sources

Washougal River delta/Steigerwald Lake lowlands. This area is located east of the proposed aquifer service area adjacent to the Columbia River. It is about six miles long and about a mile in the widest area. The eastern part of this area is in the Steigerwald Lake lowlands which is part of the floodplain of the Columbia River. The Steigerwald National Wildlife Refuge occupies most of this area although the Port of Camas/Washougal industrial area and the Washougal wastewater treatment plant occupy the western part of the lowlands. A dike protects this area from the Columbia River.

The Washougal River delta is located in the western part of the area and tends to be higher in elevation. The Cities of Camas and Washougal are in part located on the delta. The Washougal River takes a sharp west turn at the head of the delta and cuts through the delta before entering the Columbia River at Camas.

Woodland Bottoms. The Woodland bottom is an area about three miles wide and five miles long located north of the west side of the proposed service area. The Lewis River flows along the east and south sides and the Columbia River flows along the west side of the bottoms. The City of Woodland is located on the east central part of the area. The bottoms are part of the flood plain of the Columbia and Lewis Rivers and are primarily a productive agricultural area. They are protected from flooding by a dike system and drainage of this low lying area is conducted through a ditch and pump system.

Intertie

Portland Water Bureau. The Portland Water Bureau is a large purveyor of water located across the Columbia River south of the proposed aquifer service area. The water bureau serves nearly 800,000 people in an approximately 253 square mile service area. For 110 years the bureau's primary source of water has been the Bull Run Watershed located east of the city. In the 1980's the bureau installed a backup well field with a pumping capacity of 95 million gallons per day near the Columbia River east of Portland. The purpose of this well field is to provide water when the Bull Run system, which is not filtered, is not able to meet demand. It has been used primarily when the Bull Run water is turbid or in the summer when supplemental water is needed.

The Portland Water Bureau is part of a consortium of 27 water purveyors and the Metropolitan Regional Government (Metro). This consortium just completed a three year effort to update the *Regional Water Supply Plan* (Regional Water Providers Consortium, December 2004). This plan identifies how the consortium will address water supply in the Portland metropolitan area through the year 2050. Clark County is not included in this plan.

2.3.8 Evaluation of Potential Alternative Sources

The feasibility of each alternative source has serious unknown parameters, problematic limitations, and/or prohibitive costs for development. A brief discussion of each option follows.

Surface Water Sources

There are currently only two small surface water diversions near the proposed aquifer service area. Neither of these sources could be significantly expanded because they are located on small tributaries of the Washougal River. Therefore, any additional use of surface water would require a full planning and development process for new sources. Any development would require a water right, intake structure, possibly a dam, and water treatment, storage and distribution facilities. Planning, design and permitting of a new source would require a substantial effort and would extend over a considerable period of time most likely measured in decades.

The recently completed watershed management plan (Lower Columbia Fish Recovery Board, 2004), which encompasses the area of the potential surface water alternative sources (except the Columbia River), includes a policy that requests that Ecology adopt rules that restrict the issuance of new surface water rights. Additionally the plan sets net stream flow depletion allowances for subbasins in the primary watersheds. These allowances are not adequate to replace a significant portion of the service area demand. This does not include the Columbia River. The policy recommendations of the management plan have not yet been adopted as a Washington Administrative Code.

Columbia River. An analysis of the requirements for development of the Columbia River as a water source is described in the *Regional Water Supply Plan Update* (Regional Water Providers Consortium, 2004). This analysis is described in Chapter 4, Part 2 Section C of the plan. The Consortium is a group of water purveyors in the Portland metropolitan area. Clark County purveyors are not part of the consortium.

The Consortium's analysis discusses the potential difficulties of obtaining and maintaining water rights in the Columbia River because of Endangered Species Act (ESA) listings. Although they conclude that water rights are likely to be obtainable, they acknowledge that flow in the river can drop below recommended minimum flows which would likely cause the curtailment of water rights in some circumstances. They also acknowledge the potential complications that would result from reduced dry season flows caused by climate change. This is a significant issue because the water right would be dependent on the run of the river because it is not feasible to construct storage facilities in the river. Much of the analysis is predicated on obtaining and converting existing water rights which may be more secure. In Clark County, existing water rights to the river are primarily for industrial purposes and would present challenges, both to obtain and to convert to domestic water supply use.

Development of a Columbia River source would require installation of an intake structure. The environmental impacts of intake construction on ESA-listed species could complicate the permitting process and result in significant restrictions and limitations on design, construction and use.

A treatment system would also have to be designed and constructed. The Consortium used a pilot treatment study conducted by a member purveyor to evaluate treatment requirements and costs. The Columbia River presents special treatment requirements that would increase the complexity and costs of a system. Additionally, potential users of water from the Columbia River may perceive the water as contaminated and untreatable.

The estimated costs for the development and operation of a 50 million gallon per day water treatment system are provided in the plan. This volume is a little under half of the current peak water demand in the proposed aquifer service area. Development costs were estimated to be $123 million and the operation and maintenance costs were estimated to be $6 million per year in 2002 dollars. This does not include the costs associated with planning, water rights, the intake structure, and distribution system improvements. In Clark County these costs would be new with very little offset gained by the reduced use of groundwater.

The plan does not discuss the amount of time required to develop this source. It appears likely that it would take more than a decade to complete.

Lewis River. The Lewis River presents many of the same challenges for development as a water source as does the Columbia River. The substantially lower flow of the Lewis River would make obtaining water rights more difficult. New water rights are generally not available therefore water rights would have to be purchased. The watershed management plan includes policies intended to discourage the use of surface water as a water supply source.

The water quality in the Lewis River is likely to be higher than for the Columbia River therefore requiring less treatment although pilot studies do not appear to have been conducted. Although treatment costs for Lewis River water may be lower than for the Columbia River water, the overall development costs are likely to be higher because an intake at Lake Merwin would be more remote. A remote location would require more infrastructure development and a longer pipeline to transport the water. A long pipeline would have right-of-way issues and higher pumping costs.

The amount of time required to bring a Lewis River source on line could be longer than for a Columbia River source. This is because of the need to obtain water rights, develop more infrastructure and the potentially more difficult permitting and right-of-way issues.

Washougal River. The Washougal River also presents many of the same challenges for development as a water source and would require construction of a dam for diversion and storage. The substantially lower flow of the Washougal River would make obtaining water rights more difficult if not impossible. A storage reservoir constructed on the river might provide enough storage capacity to mitigate the impact on low flows but would have considerable environmental impacts. The feasibility of dam sites is not known. The water quality of the Washougal River is likely to be good, thereby requiring less treatment than for the Columbia River.

Although treatment costs for Washougal River water may be lower, the overall development costs likely will be higher because of the remote location and the need to construct a storage reservoir. A remote location would require more infrastructure development and a longer pipeline to transport the water. A long pipeline would have right-of-way issues and higher pumping costs.

The amount of time required to bring a Washougal River source on line would likely be longer than for a Columbia or Lewis River source. This is because of the permitting process and construction requirements for a dam as well as the need to develop more infrastructure and the other permitting and right-of-way issues.

Groundwater Sources

Washougal River delta/Steigerwald Lake lowlands. The potential for development of this area as a major source of water has not been formally studied. To replace about half of the current peak load of the proposed service area, a well field capable of continuously yielding 35,000 gallons per minute (gpm) would have to be developed. Currently the cities of Camas and Washougal obtain most of their water supply from wells located in the western part of this area. These wells typically yield over 1,000 gpm although the capacity of many is reported to be less. This suggests that more than 35 wells that do not substantially interfere with each other would be needed to replace just half of the current peak demand of the service area.

There are many factors that limit the potential for exploitation of the water resources of this area. First, there are already at least 13 municipal and an unknown number of industrial supply wells with water rights located in this area. These wells could not be interfered with. These wells are located on the western side of the area therefore most of the needed wells would have to be located to the east. The eastern area is occupied by the Steigerwald National Wildlife Refuge which is implementing a plan that restores in part the natural function of water to the floodplain. The refuge would limit access to potential well sites as well as put limitations on the amount that the shallow water table could be lowered in this aquifer.

It also appears likely that a large portion of the water produced from the aquifer in this area will have been induced to flow from the Columbia River through the ground. This is because of the limited extent of, and recharge to, the aquifer and the hydraulic connection between the aquifer and river. The needed water rights would therefore be complicated and require detailed analysis.

Quality of the water is likely to be good except in the vicinity of the industrial area where contamination has occurred. Development and operation costs would be substantial.

In summary, this area does not appear capable of replacing a substantial part of the current production capacity of the proposed aquifer service area. The limited extent of the aquifer, conflicting land uses, and existing wells place severe constraints on the potential of this aquifer.

Woodland Bottoms. The Woodland bottoms area has not been formally evaluated for water supply development. Currently there are a large number of irrigation and low yield domestic wells in this area. There are also a number of industrial supply wells in the City of Woodland in the eastern part of the area. No municipal water sources exploit this aquifer. Although this area is about three times the size of Steigerwald/Washougal River delta area, well yield and water right issues appear to severely limit the potential of this area for large scale water supply development.

A review of well logs shows that the aquifer in the Woodland bottoms typically consists of a surficial silt layer underlain by fine to coarse sand that is interbedded with silt layers. Most water wells are less than 50 feet deep and pump water from sand beds between 10 and 40 feet below the ground. Yield of these wells are reported to vary from tens of gallons per minute to 350 gpm or more. There are a few deeper wells up to 258 feet deep. These wells are typically reported to yield less water. Most wells, both shallow and deep, report high iron concentrations and the long agricultural history of the area suggest contamination with fertilizers and pesticides may have occurred. It is also likely that high yield wells will pump sand if not carefully designed and constructed.

The conceptual development of a high yield well field in this area raises a number of issues that undermine the feasibility of such a well field. The yield of individual wells would be low relative to the need. If wells providing 350 gpm could be installed over the entire area then over 100 wells would have to be installed to replace half of the current peak demand of the proposed service area. Conservative assumptions of recharge to and storage in this aquifer indicate that these wells could interfere with each other when evenly spaced throughout the area, even during non peak pumping. Additionally, the high iron concentrations of the groundwater would necessitate an intensive maintenance program and treatment of the water. These factors suggest that the required well field would have to be carefully planned and managed and would require detailed monitoring, management and maintenance to achieve and sustain the required production capacity.

Water rights in this aquifer are likely to have been appropriated by long established irrigation practices, the industrial users and the permitted domestic water users. Although water rights could be purchased and converted to municipal supply use, it does not seem likely that this could be accomplished on a voluntary basis at the scale necessary. The purchase of farms is also likely to be required to protect the aquifer and to compensate for the reduced viability of farming without water rights.

In summary, development of this aquifer on the scale required to replace a significant portion of the production capacity of the proposed aquifer service area appears to be problematic. The amount of time required to develop this resource, should it prove to be feasible, would be more than a decade and perhaps much longer if water right issues are challenged or significant aquifer contamination is identified. The cost of development of this source cannot be accurately estimated because of these unknown variables. However the large number of wells, the complexity of the project, and the need for water treatment indicate a high development and operation/maintenance cost.

Intertie

Portland Water Bureau. The feasibility of an intertie to the Portland Water Bureau has not been investigated. No Clark County purveyor is part of the Regional Water Providers Consortium and therefore not integrated into the long term supply planning of the Consortium. Therefore evaluation of the legal, polititcal and technical feasibility of an intertie is speculative and uncertain. Legal agreements that clarify participation in the Consortium, regionalization across the state border, and other issues would have to be developed, in part through public processes.

At present, the Portland Water Bureau does not appear to have sufficient excess capacity to supply a substantial portion of the service area demand without accessing capacity that is reserved for peak demand, a water emergency or planned growth in demand. A planning effort to prepare for a major new intertie would have to be undertaken and is likely to have to be acceptable to the 28 members of Regional Water Providers Consortium. The issues of regional governmental integration and trans-border transfer of water would have to be addressed. This would likely be a drawn out political process involving several levels of government.

Approval of an intertie to the Portland Water Bureau transfers responsibility for the source to the Bureau. The Bureau would have to develop an additional source or sources or expand existing sources. Both are provided for in the *Regional Water Supply Plan Update* (Regional Water Providers Consortium, December 2004) over the long term. It is conceivable that acceleration of planned increases in supply could be agreed to by the Consortium.

The most likely new source is the one closest to the service area. This is because of the lower transportation costs and that the development could focus on providing water to Clark County, rather than a general expansion of capacity with a commensurate increase in the distribution system. The nearest new source is the Columbia River. The requirements for this source have been studied by the Consortium and are discussed above. This raises the question of whether it would be more cost effective and politically expedient to build the necessary facilities on the Washington side of the river. Additional costs would be incurred to construct a backup connection to other sources because a water right to the Columbia River may be interruptible under certain conditions.

Other sources of supply for an intertie are likely to be more costly than the Columbia River. This is because of the capital and operating costs of the intertie infrastructure and the source expansion or development.

Summary of Potential Alternative Sources

Each of the potential alternative sources has limitations on quantity or quality of water and/or the feasibility of development. Table 3 summarizes the considerations for each potential source.

Of the six potential alternative sources two, the Columbia River and the Portland Water Bureau intertie, appear to offer adequate sources of supply although with significant potential limitations. Both would require extensive legal and political processes before implementation and could not be expected to come online for more than a decade, if at all. These sources would require substantially more treatment than the current groundwater sources. Development and operation/maintenance costs of these alternative sources would also be significantly higher than the costs of current sources. Therefore none of the potential alternative sources qualify as Alternative Drinking Water Sources as defined in the Petitioners Guidance.

2.4 Boundary Information

2.4.1 Description of Aquifer System Location

Topography

The topography of Clark County is described in *Evaluation of Factors that Influence Estimated Zones of Transport for Six Municipal Wells in Clark County, Washington* (Orzol and Truini, 1999) as being characterized by flat-lying alluvial lands along the Columbia River and its tributaries. The alluvial lands are broken by low, rolling hills or buttes with benches and hilly areas that rise to meet the foothills of the Cascade Range to the east and northeast. The altitude of the land surface ranges from about 10 feet along the Columbia River to about 3,000 ft in the foothills of the Cascade Range. The Columbia River flows westward out of the Columbia River Gorge until it passes the city of Vancouver, Washington, where it flows northward. The tributaries to the Columbia River that drain Clark County include the Lewis, East Fork Lewis, Lake, Little Washougal, and Washougal Rivers, and Cedar, Salmon, Burnt Bridge, and Lacamas Creeks.

Climate

The climate in the Portland Basin is described in *Estimated Average Annual Ground-water Pumpage in the Portland Basin, Oregon and Washington 1987-88* (Collins and Broad, 1993) as humid marine. The fall, winter and spring are generally cool and wet and summers are warm and dry. Average temperatures for the area range from about 39 °F (degrees Fahrenheit) in January to about 68 °F for July. Annual precipitation averages about 37 inches per year at the Portland International Airport. About 90 percent of this amount falls between October 1st and May 31st. Average annual rainfall in the hills near the east boundary of the area increases to up to 80 inches per year.

Geology

Figure 3 is a geologic map of the proposed aquifer service area. The proposed aquifer service area can be described as the northern part of a basin in the older rocks that has been partially filled over several million years by fine and coarse grained sediments. The older rocks typically consist of basalt and andesite with consolidated marine sediments. Sediments overlying the older rocks are as much as 2,000 feet thick and are generally separated into the Troutdale Formation and unconsolidated recent alluvium. The Troutdale Formation consists of beds of gravel, sand and silt that have consolidated to varying degrees. Recent volcanic vents and flows are integrated in the Troutdale Formation in some areas. The overlying recent alluvium is up to several hundred feet thick and was deposited by a series of catastrophic floods that occurred near the end of last ice age. The alluvium generally becomes finer from east to west across the area because the high energy flood waters came out of the narrow gorge and lost energy as the water spread across the wide Portland Basin. Therefore, the alluvium consists of boulders, cobbles, and gravel in the southeast part of the proposed service area near the gorge and grades to silt in the northwestern part of the area.

Groundwater Use and Occurrence

Groundwater in the proposed service area is put to domestic, industrial and irrigation uses. Approximately 33% of the groundwater pumpage is for domestic use, 62% for industrial use, and 5% for irrigation, including golf courses. Most groundwater for domestic use is pumped from the upper part of the Troutdale Formation which is also known as the Troutdale Gravel aquifer. This pumpage is for the most part concentrated in the populated southern part of the proposed service area. Most of the industrial pumpage is from the unconsolidated recent alluvium aquifer and is concentrated in the Vancouver Lake lowlands where high yield wells have been installed. There are, however, significant industrial sources of groundwater in the Troutdale Gravel aquifer, and domestic sources in the unconsolidated alluvial aquifer.

2.4.2 Hydrogeologic Delineation and Description

The hydrogeology of the proposed aquifer service area is described in several USGS publications. The following descriptions are taken from the referenced publications. These publications are available online at addresses included in the bibliography. Reproductions of a hydrogeologic map and cross-section are presented in Figures 4 and 5.

Boundary Delineation

The boundary of the proposed aquifer service area is shown on Figure 1 and over a hydrogeologic map on Figure 4. Beginning in the southeast corner of the area the boundary follows the Columbia River as it flows to the west and turns to the north around the Vancouver Lake lowlands. The boundary continues along the river to the Lewis River where it turns to the west. It follows the Lewis River eastward along the East Fork of the Lewis River to the City of La Center. This portion of the boundary is generally a discharge zone except where groundwater pumping has induced a reversal of flow.

At La Center the boundary turns to the northwest following the contact between the older rocks and the Troutdale Gravel aquifer to a divide on the west side of the Jenny Creek drainage. The boundary follows this divide across the Troutdale formation to a divide between the drainages of the North and East Forks of the Lewis River. Here the boundary turns east and follows this divide to a contact between the older rocks and Troutdale aquifer units. This is a no flow portion of the boundary. The boundary follows these drainage divides because they are likely to express a hydraulic divide in the underlying aquifer. The boundary in this area overlies a relatively thin and less productive part of the aquifer and the excluded part of the aquifer is exploited by low yield self supplied water systems. The USGS discusses the isolation of the aquifer north of the boundary in the North Fork Lewis River drainage (McFarland and Morgan, 1996A).

The boundary continues to the east along the contact between the older rocks and Troutdale Gravel aquifer to a drainage divide between the East Fork of the Lewis River drainage and the Cedar Creek drainage. The boundary follows this drainage divide across the Troutdale aquifer to the contact between the Troutdale aquifer and the older rocks. Here the boundary turns to the south and follows this geologic contact in a slightly east of south direction to the Little Washougal River drainage. In this area the boundary turns to the east but at the drainage divide of the Little Washougal River it turns back to the south to a contact with the older rocks. The drainage divide between the Little Washougal River and Lacamas Creek drainages is likely to form hydraulic divide in the underlying aquifer in an area where the aquifer is thin and thickens to the southwest.

At the contact with the older rocks the boundary turns sharply to the west-northwest to exclude an area of older rocks that was displaced by the Lacamas fault. At the point where the boundary meets Lacamas Lake it turns sharply to the southeast and follows the lake and creek to the lower falls. The lower falls flow over an outcrop of older rocks that appear to be part of an east-northeast/west-southwest trending ridge in the older rocks that is exposed in the south facing slope located west of the falls. This older rocks ridge is covered by the Troutdale Sandstone just west of the falls. The aquifer boundary crosses the sandstone in an approximate alignment with the contact between the older rocks and Troutdale Gravel aquifer where this contact is exposed to the west. The boundary follows this contact to the west-southwest to the Columbia River.

Hydrogeologic Description

The hydrogeology of the proposed service area and the rest of the Portland Basin have been extensively studied by the USGS. The hydrogeologic units and the flow system are described in detail in numerous USGS publications including *A Description of Hydrogeologic Units in the Portland Basin, Oregon and Washington* (Swanson et al, 1993) and *Description of the Groundwater Flow System in the Portland Basin, Oregon and Washington, USGS Water Supply Paper 2470-A* (McFarland and Morgan, 1996A). These publications include detailed hydrogeologic maps and cross-sections of the Portland Basin. Reference is made to these publications for a comprehensive description of the hydrogeology of the service area. A reproduction of the relevant portion of the hydrogeologic map is presented in Figure 4 and a hydrogeologic cross-section is reproduced in Figure 5. The following discussion summarizes and exerts the USGS descriptions.

Swanson et al (1993) grouped the hydrogeologic units into three subsystems. The three subsystems, based on regionally continuous contacts between units with distinctly different lithologic and hydrogeologic characteristics, are: the upper sedimentary subsystem, the lower sedimentary subsystem, and older rocks.

The upper sedimentary subsystem consists of the unconsolidated sedimentary aquifer and the Troutdale Gravel aquifer. This subsystem is the primary source of drinking water in the proposed aquifer service area and is expected to supply most of the projected increases in demand. The unconsolidated sedimentary aquifer consists primarily of flood deposits of late Pleistocene age varying from bouldery gravel to silt. It includes flood plain and terrace deposits along major tributaries and glacial outwash in some areas. The top of the unit is land surface, and its thickness is mostly between 50 and 100 feet although deposits range up to 300 feet thick in some areas. Wells completed in these deposits have maximum yields between 1,000 and 6,000 gallons per minute near Washougal, Camas, and Vancouver, Washington, and up to 10,000 gallons per minute north of Blue Lake in Oregon.

The Troutdale Gravel consists of principally of sandy gravel, silty sand, sand, and clay. The altitude of the top of the unit ranges from about 700 feet in the Prune Hill area in Camas to minus 600 feet northwest of Gresham in Oregon. The maximum thickness of this unit is about 800 feet and well yields are as large as 3,000 gallons per minute in some areas.

The lower sedimentary subsystem consists of two confining units, the Troutdale Sandstone, and sand and gravel beds within the Sandy River Mudstone geologic unit. Swanson et al (1993) identify portions of this subsystem as the Undifferentiated Fine-Grained Unit where data were not available to differentiate the units. In the aquifer service area the confining units and the Troutdale Sandstone unit are mapped as overlying each other. They extend from Camas up to Meadow glade and west to the Orchards area.

The upper confining unit (identified as Confining Unit 1) is a grayish olive-green clay and silt with lenses of silt and fine-to-medium-grained sand. The altitude of the unit ranges from about 900 feet in the area south of the City of Sandy to about minus 300 feet near the center of the basin. The thickness is generally less than about 200 feet.

The lower confining unit (identified as Confining Unit 2) is lithologically similar to Confining Unit 1. The altitude of the top of the unit ranges from about 900 feet in the Tickle Creek area to about minus 500 feet toward the center of the basin. The thickness of the unit ranges from about 200 feet in the southeastern part of the basin to about 800 feet toward the center of the basin.

The Troutdale sandstone aquifer consists of coarse sandstone and conglomerate with lenses and beds of fine-to-medium sand and silt. The altitude of the top of the aquifer is about 1,000 feet in the area east of the Sandy River and dips westward to about minus 400 feet near downtown Portland. The thickness of the aquifer ranges from 100 to 200 feet but is about 400 feet in the southeastern part of the basin. Wells completed in this unit yield up to 2,500 gallons per minute.

The consolidated gravel aquifer is composed of a poorly- to moderately-cemented sandy conglomerate and includes local accumulations of lavas and a mantling soil horizon. This unit is mapped as only extending into the aquifer service area near Camas. However, it has recently been investigated as a groundwater source in the western part of the service area where Swanson et al (1993) were apparently not able to differentiate it from other units. Its elevation appears to be lower than in the southern part of the basin as described in the following sentences taken from McFarland and Morgan (1996B). The altitude of the top of the unit is about 1,400 feet east of the Sandy River; however, the top of the unit is between altitudes of 100 and 200 feet throughout most of the basin, and its thickness ranges from 100 to 400 feet in most of the area. Wells completed in this unit can yield about 1,000 gallons per minute.

The undifferentiated fine-grained sediments are lithologically similar to confining units 1 and 2. This unit includes all the sediments overlying the older rocks and underlying the consolidated gravel aquifer wherever individual units can not be discerned either because the individual units are not present or because information is insufficient to map them. Altitude of top of the unit ranges from about 1,200 feet east of Sandy, Oregon to minus 300 feet near the center of the basin, where its thickness is about 1,200. The unit is generally a poor water-bearing formation.

The older rocks unit includes generally low permeability, Miocene and older volcanic and marine sedimentary rock that underlie and bound the basin-filling sediments. The altitude of the top of the unit ranges from land surface in the exposed areas to minus 1,600 feet beneath Vancouver, Washington. This unit bounds the proposed aquifer service area on the east and much of the north.

The USGS summarizes storage coefficients that were determined from aquifer tests and published information for each of the hydrogeologic units. Average storage coefficients for each unit were as follows:

- unconsolidated sedimentary aquifer 0.003;
- Troutdale gravel aquifer 0.0008;
- confining unit 1 0.00005;
- Troutdale sandstone aquifer 0.00024;
- confining unit 2 0.00005;
- sand and gravel aquifer 0.0004;
- older rocks 0.0001.

Where these units are at the land surface, water in them can be under water-table conditions. Under water-table conditions, specific yield is commonly in the range of 0.05-0.20.

The USGS describes the hydraulic conductivities of the aquifers as follows: The four sedimentary aquifers in the basin have the highest median hydraulic conductivities. The unconsolidated sedimentary aquifer has the highest median value of hydraulic conductivity (200 feet per day) and also the greatest variation in values (0.03 to 70,000 feet per day). It is the most permeable aquifer, as well as the most heterogeneous unit. The Troutdale gravel aquifer, Troutdale sandstone aquifer, and the sand and gravel aquifer all have similar median values of about 7 to 16 feet per day. The Troutdale sandstone and the sand and gravel aquifer have low variation in hydraulic conductivity relative to some of the other units. The Troutdale gravel aquifer, however, has values of hydraulic conductivity ranging over six orders of magnitude.

The USGS describes groundwater movement in the aquifers as follows: In Clark County ground water in the unconsolidated sedimentary aquifer flows from more than 250 feet above sea level along the eastern extent of the aquifer toward the Columbia River and other major streams. Gradients are generally steepest beneath the break in slope between the terraces and the Columbia River flood plain. A mound in the water table occurs just west of Orchards, where water levels are more than 250 feet above sea level. This mound may be a result of slightly lower hydraulic conductivities in the unconsolidated sedimentary aquifer or could be due to greater recharge to the ground-water system from on-site waste-disposal systems or drywells, both of which are likely to introduce contaminants to groundwater.

North of Salmon Creek in Clark County the water table is relatively complex due to the complex surface water drainage in the area.

Water levels in the Troutdale gravel aquifer are highest in the Mount Norway area on the east side of the aquifer where they exceed 900 feet above sea level. Ground water in the Troutdale gravel aquifer moves southward toward the Columbia River. Throughout the rest of Clark County, water levels generally are highest in the eastern part of the county, along the western flank of the Cascades; ground water moves toward the Columbia River, East Fork Lewis River, and Salmon Creek. Mundorff's (1964) map of water levels in the upper member of the Troutdale Formation shows similar ground-water flow directions; however, some contours have shifted to the north in the past 40 years. This shift is most evident from the 150 foot contour just west of Prune Hill in Camas. Comparison water level contour maps show that this contour is positioned 1.5 to 2 miles to the northeast of the same contour for the 1949-50 map. This comparison would suggest that some stress to the aquifer system had caused the change in water levels, and that the decline possibly has been 10 feet or more. The 100 foot contour also has moved approximately 0.5 miles to the northeast.

The Troutdale sandstone aquifer has the highest water levels in the northeastern and eastern extent of the unit. Water levels are more than 200 feet above sea level and the primary ground-water movement direction is to the southwest toward the Columbia River.

The minimum groundwater age is less than 10 years throughout the extent of the unconsolidated sedimentary aquifer, with the exception of a few areas along the Columbia River at Vancouver (Snyder, Wilkinson and Orzol, 1998). The young minimum groundwater ages in these areas result from the occurrence of the aquifer at the surface and the presence of recharge areas for local and intermediate flow systems. The map of maximum groundwater ages for the unconsolidated sedimentary aquifer shows that most of the water has an age of less than 100 years, with the age of groundwater increasing downgradient to the west and south. Most of the groundwater within the Troutdale gravel aquifer has a minimum age of less than 100 years, with many areas having groundwater less than 10 years old

2.4.3 Groundwater Recharge and Discharge

Recharge occurs over the entire aquifer service area. Discharge occurs to streams, wetlands and other surface water bodies as well as to water wells. The Columbia River is the ultimate base level for the groundwater flow system. In some areas pumping of groundwater induces recharge from surface water. Groundwater recharge and discharge are described in *Description of the Groundwater Flow System in the Portland Basin, Oregon and Washington, USGS Water Supply Paper 2470-A* (McFarland and Morgan, 1996A). A summary of the description presented in this paper follows.

A detailed analysis of the distribution of recharge is presented in *Estimation of Ground-water Recharge from Precipitation, Runoff into Dry Wells, and On-site Waste-disposal Systems in the Portland Basin, Oregon and Washington, USGS Water-Resources Investigations Report 92-4010* (Snyder, Morgan and McGrath, 1994). Recharge to the ground-water system is described as from four sources: recharge from infiltration of precipitation, runoff to drywells, on-site waste-disposal systems, and streams flowing through the basin. Total average yearly recharge from sources other than streams is averages about 22 inches throughout the Portland Basin. The USGS estimated the average recharge in the Salmon Creek drainage within the proposed aquifer service area to average 27.1 inches per year, or 45 percent of the 60-inch average annual precipitation per year. This drainage extends up into the foothills where precipitation is higher than in the lower part of the drainage, where CPU production wells are located, therefore recharge where groundwater is exploited in this drainage is similar to the basin wide average rate. In general recharge from infiltration of precipitation at a particular location depends on the amount of precipitation and the type of soil and ground cover. Therefore urban areas will tend to have less recharge from this source than rural areas because of ground cover. However dry wells are more prevalent and on-site waste disposal systems are at a higher density in urban areas and more recharge will occur from these sources than in rural areas.

Ground water generally flows from upland areas to discharge in streams. Water levels in wells in the sedimentary aquifers and seepage measurements for streams indicate that many streams are significant discharge areas for the groundwater system. Discharge also occurs from springs. Spring discharge from the area north of the Columbia River between Vancouver and Camas was measured in 1988 to be about 6,000 gallons per minute. These measurements totaled about 42% less than the discharge measured in 1949, a decline attributed to groundwater pumping.

Withdrawals from wells in the basin also constitute a significant discharge from the groundwater system. In some areas pumping has induced recharge from surface water including the Columbia River, Salmon Creek, and Lacamas Creek (Orzol and Truini, 1999; McFarland and Morgan, 1996A and B).

Short and long term water level records from wells indicate that the groundwater system is not in equilibrium in some areas. Short and long term water level monitoring and computer simulations of the aquifer system indicate that declines have and continue to occur in southern Clark County at rates generally ranging from less than 1 to 4 feet per year. Declines in groundwater levels occur in areas with high groundwater exploitation and urbanization, where recharge has been reduced.

2.4.4 Streamflow Source Area

The proposed aquifer service area includes all or part of 13 drainages as defined by Clark County. Of these drainages, five extend outside of the proposed aquifer service area. These include the East Fork of the Lewis River, Lacamas Creek, Salmon Creek and two other areas on the southeast part of the boundary that do not include significant streams.

The USGS (McFarland and Morgan, 1996A) describes the East Fork of the Lewis River, Lacamas Creek, and Salmon Creek as generally receiving discharge from the aquifer system and are therefore gaining streams. Measurements on each of these streams have, however, shown periods at some locations when these streams were losing water to the aquifer. These conditions appear to be most significant for Salmon Creek and Lacamas Creek where groundwater pumping has lowered groundwater levels. The CPU monitors flow in Salmon

Creek and has voluntarily curtailed pumping during low flows in this drainage. The Lacamas Creek drainage occupies the area where the USGS (McFarland and Morgan, 1996A) describes a major shifting of water table contours due to pumping induced lowering of the water table.

The Salmon Creek and Lacamas Creek drainages are therefore proposed for inclusion in the project review area. The East Fork of the Lewis River is considered a gaining stream by the USGS, therefore the upper reaches of this drainage are not proposed for inclusion in the project review area. However, recently collected unpublished data suggest that sections of the lower East Fork are losing and the project review area may need to be reconsidered when this data is validated and published.

2.4.5 Project Review Area

The proposed project review area includes the proposed aquifer service area and the upper areas of the Salmon Creek and Lacamas Creek watersheds which are outside the service area. The proposed boundary of the project review area is shown on Figure 6.

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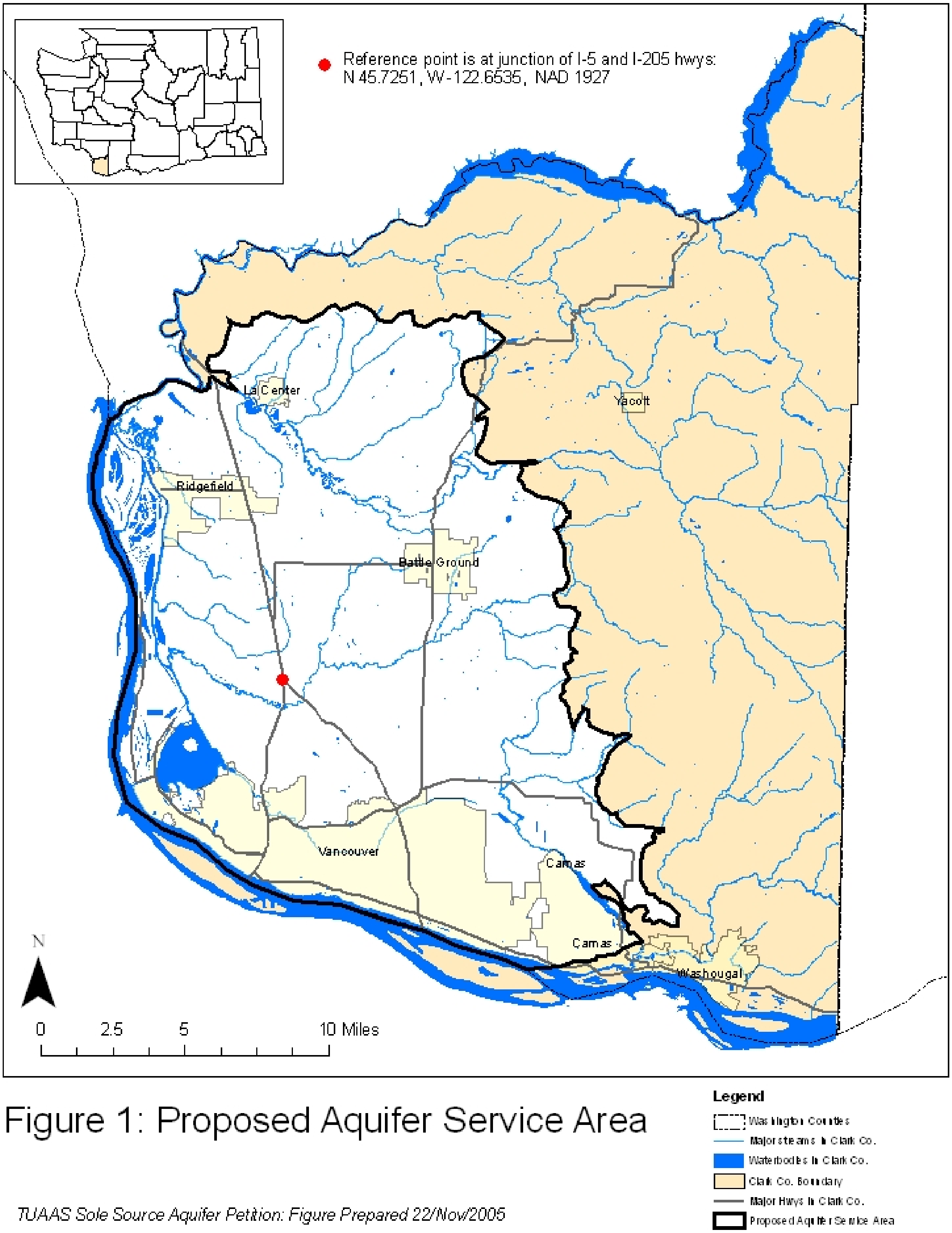


Figure 1: Proposed Aquifer Service Area

TUAAS Sole Source Aquifer Petition: Figure Prepared 22/Nov/2005

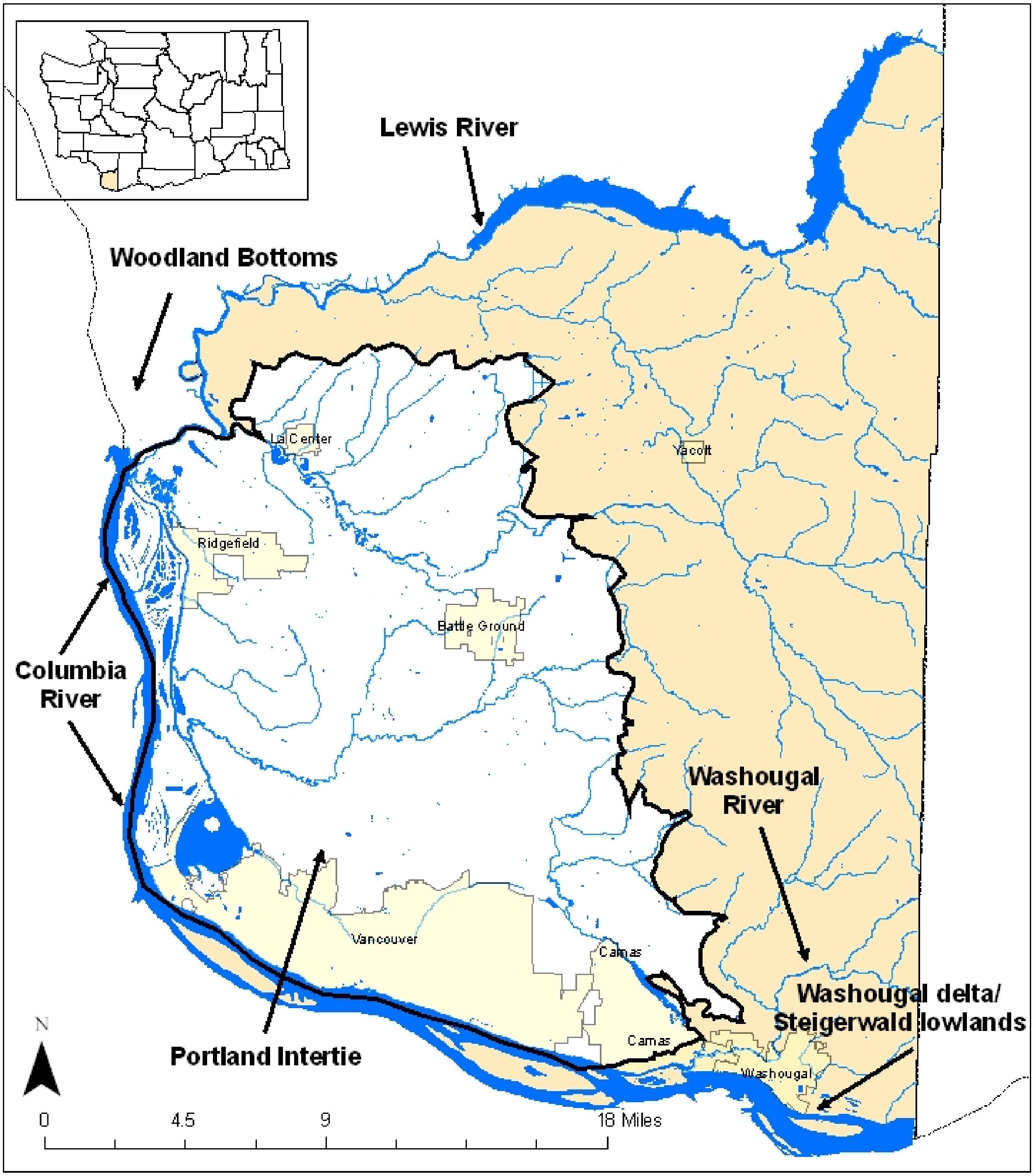


Figure 2: Potential Alternative Sources of Water

Legend
Waterbodies in Clark Co.
Major streams in Clark Co.
Clark Co. Boundary
Proposed Aquifer Service Area
Washington County Boundaries

TUAAS Sole Source Aquifer Petition: Figure Prepared 22/Nov/2005

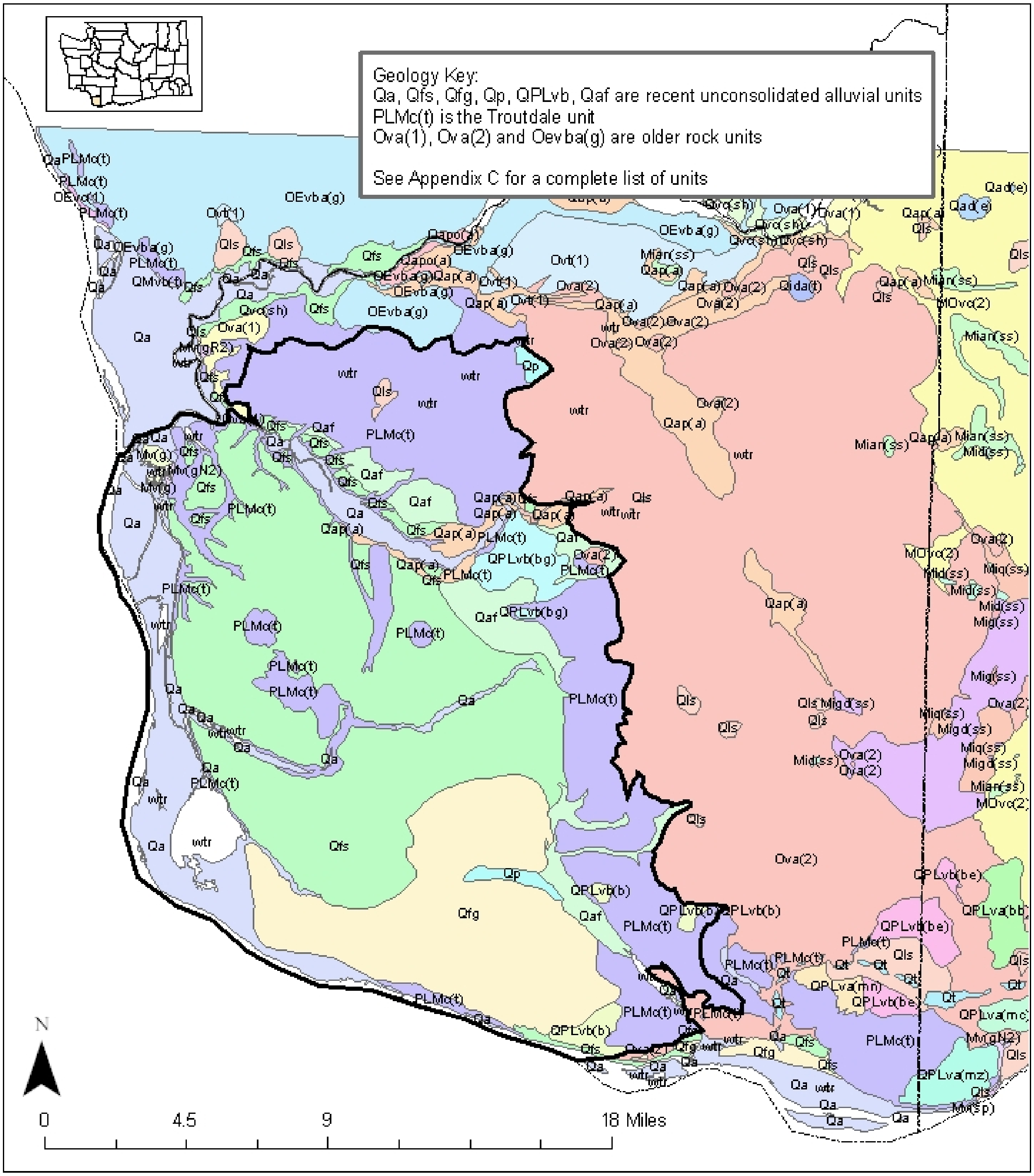


Figure 3: Surface Geology of the Proposed Aquifer Service Area

Surface Geology coverage provided by WA DNR Department of Geology and Earth Resourecs

Legend

Washington Counties

Proposed Aquifer Service Area

TUAAS Sole Source Aquifer Petition: Figure Prepared 22/Nov/2005

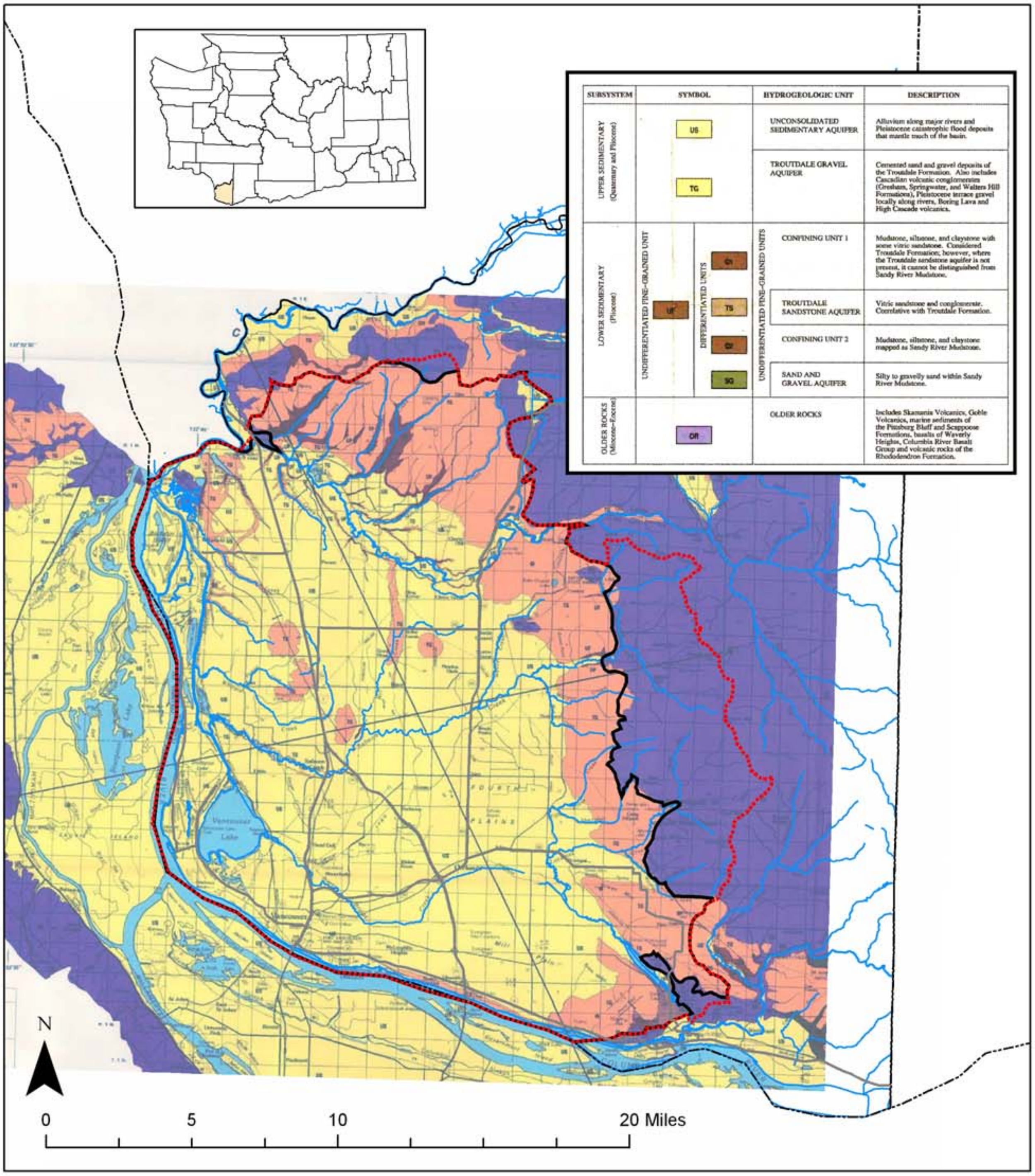
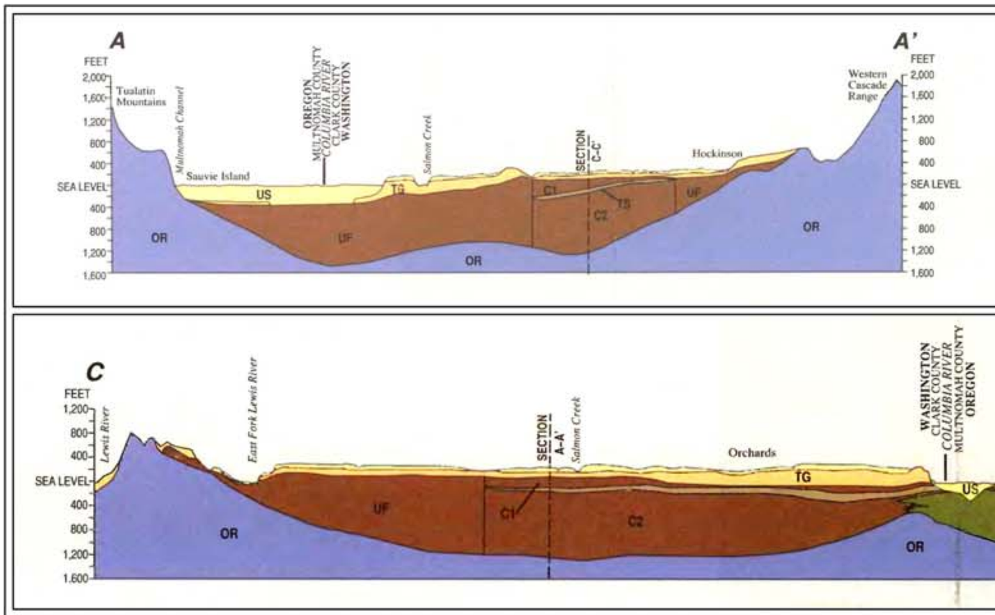


Figure 4: Hydrogeologic Map of Area
(map image and key taken from Swanson, et al. 1993)

Legend

- Proposed Aquifer Service Area
- Washington County Boundaries
- Proposed Project Review Area
- Major streams in Clark Co.
- Major Hwys of Clark Co.

TUAAS Sole Source Aquifer Petition: Figure Prepared 2/Dec/2005



SUBSYSTEM	SYMBOL		HYDROGEOLOGIC UNIT		DESCRIPTION
UPPER SEDIMENTARY (Quaternary and Pliocene)	US		UNCONSOLIDATED SEDIMENTARY AQUIFER		Alluvium along major rivers and Pleistocene catastrophic flood deposits that mantle much of the basin.
	TG		TROUTDALE GRAVEL AQUIFER		Cemented sand and gravel deposits of the Troutdale Formation. Also includes Cascadian volcanic conglomerates (Gresham, Springwater, and Walters Hill Formations), Pleistocene terrace gravel locally along rivers, Boring Lava and High Cascade volcanics.
LOWER SEDIMENTARY (Pliocene)	UNDIFFERENTIATED FINE-GRAINED UNIT: UF	DIFFERENTIATED UNITS: C1	UNDIFFERENTIATED FINE-GRAINED UNITS	CONFINING UNIT 1	Mudstone, siltstone, and claystone with some vitric sandstone. Considered Troutdale Formation; however, where the Troutdale sandstone aquifer is not present, it cannot be distinguished from Sandy River Mudstone.
		TS		TROUTDALE SANDSTONE AQUIFER	Vitric sandstone and conglomerate. Correlative with Troutdale Formation.
		C2		CONFINING UNIT 2	Mudstone, siltstone, and claystone mapped as Sandy River Mudstone.
		SG		SAND AND GRAVEL AQUIFER	Silty to gravelly sand within Sandy River Mudstone.
OLDER ROCKS (Miocene–Eocene)	OR		OLDER ROCKS		Includes Skamania Volcanics, Goble Volcanics, marine sediments of the Pittsburg Bluff and Scappoose Formations, basalts of Waverly Heights, Columbia River Basalt Group and volcanic rocks of the Rhododendron Formation.

Figure 5: Hydrogeologic Cross-section of Area (taken from McFarland and Morgan, 1996A)

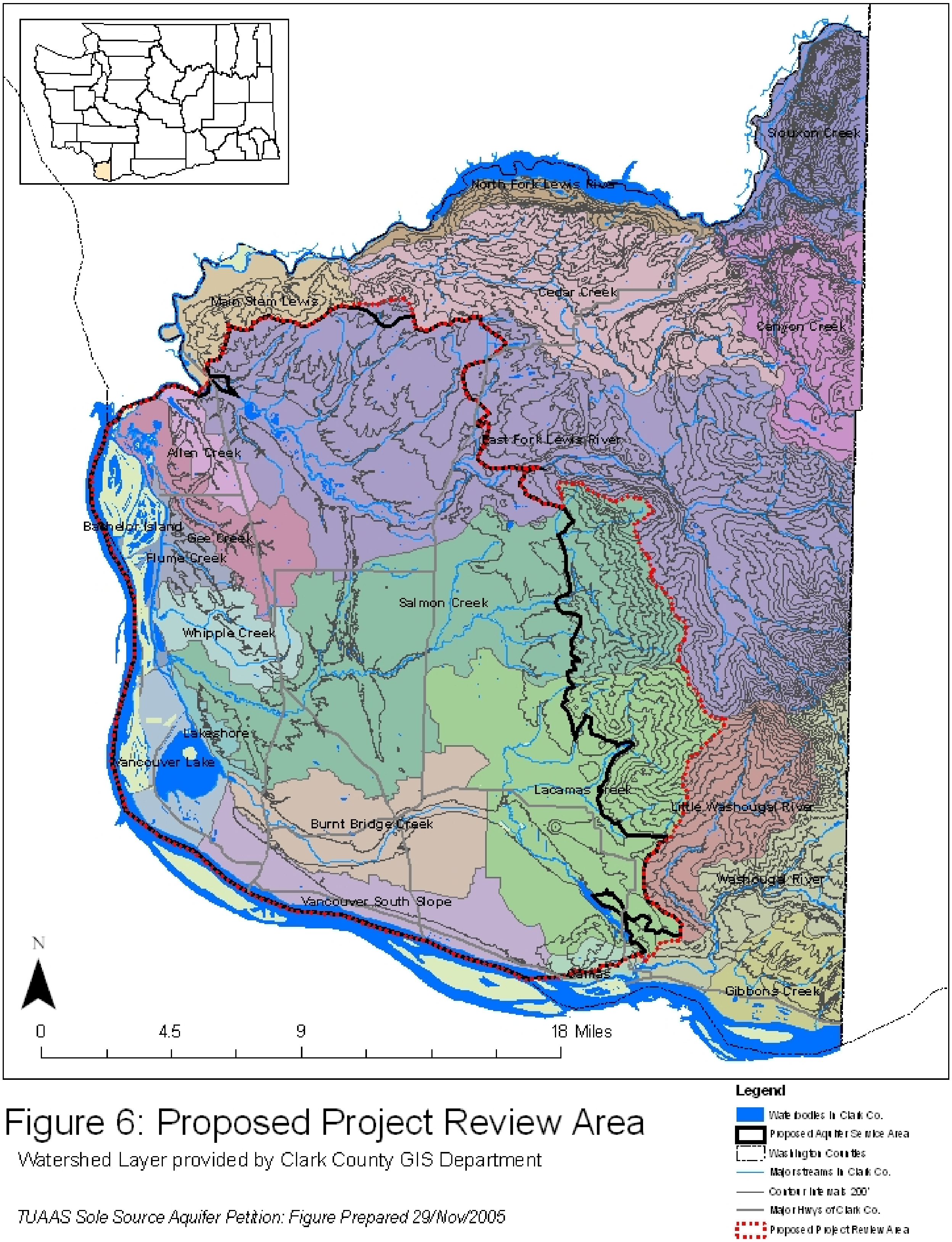


Figure 6: Proposed Project Review Area

Watershed Layer provided by Clark County GIS Department

TUAAS Sole Source Aquifer Petition: Figure Prepared 29/Nov/2005

Table 1
Community Water Systems
in the
Proposed Aquifer Service Area

DOH Number	Water System Name	Water System Type	Active Sources	Population Served
283400	TUKES MOUNTAIN HOMEOWNERS	Community	2	38
5078	CASCADE ESTATES SATELLITE	Community	3	40
AA308K	REGENCY PLACE	Community	3	50
17267W	HILLCREST MOBILE MANOR	Community	1	52
26879X	PARKSIDE AIRPARK OWNERS	Community	1	66
00950E	MORNING MEADOWS	Community	3	75
53991B	GREEN MOUNTAIN MOBILE RANCH	Community	4	80
123666	SINGLE TREE ACRES	Community	1	90
15637H	VANRIDGE MOBILE HOME PARK	Community	2	120
251011	OAK MEADOWS MOBILE HOME PARK	Community	2	216
67724	GREAT WESTERN MOBILE HOME PARK	Community	1	250
157997	GOLDEN WEST MOBILE MANOR	Community	4	300
06044F	VISTA DEL RIO MOBILE HOME PARK	Community	3	352
155211	COUNTRY MANOR MOBILE HOME PARK	Community	1	450
72400V	RIDGEFIELD PUBLIC WORKS	Community	9	2,097
47005	BATTLE GROUND WATER DEPT, CITY OF	Community	11	10,458
108002	CAMAS MUNICIPAL WATER SEWER SYSTEM	Community	11	14,200
13333X	CLARK PUBLIC UTILITIES	Community	36	78,721
91200L	VANCOUVER, CITY OF	Community	48	170,056
			Total Population Served	277,711

Note: Information taken from the Washington Depatment of Health SENTRY database in November 2005.

Table 2

Current Drinking Water Sources for the Proposed Aquifer Service Area (per cent)

Source	Public Community Water Supply	Self Supplied	Total
Petitioned Aquifer	79.25%	18.03%	97.28%
Other Aquifer	2.12%	0.00%	2.12%
Surface Water	0.60%	0.00%	0.60%
Total	81.97%	18.03%	100.00%

Note: Other aquifer and surface water are transported to the service area by the City of Camas water system.

Current Drinking Water Sources for the Proposed Aquifer Service Area (million gallons per day)

Source	Public Community Water Supply	Self Supplied	Total
Petitioned Aquifer	25.38	5.78	31.16
Other Aquifer	0.68	0.00	0.68
Surface Water	0.19	0.00	0.19
Total	26.25	5.78	32.03

Note: Other aquifer and surface water are transported to the service area by the City of Camas water system.

Table 3

Summary of Potential Alternative Sources of Water

Alternative Source	Quantity Available	Quality	Water Rights	Environmental Impacts	Technical Feasibility	Relative Costs	Political Complications
Columbia River	Adequate although may be interruptable	Substantial Treatment Required	Likely available, possible curtailment at low flow	Possible ESA, Shoreline and wetlands impacts	Feasible	Substantially higher than current	Environmental, Water quality concerns, Shoreline access, Water Rights
Lewis River	May be adequate	Treatment required	Availability not certain	Possible ESA, Shoreline and wetlands impacts	Feasible	Substantially higher than current	Environmental, Shoreline access, Pipeline route, Water Rights
Washougal River	May not be adequate	Treatment required	Availability not certain	Possible ESA, Shoreline and wetlands impacts, dam and reservoir impacts	Feasibility not certain	Substantially higher than current	Environmental, Shoreline access, Pipeline route, Water Rights
Washougal River delta/Steigerwald Lake lowlands	Limited	Limited treatment required	Availability not certain	Possible ESA, Shoreline and wetlands	Feasibility not certain	Substantially higher than current	Environmental, Shoreline access, Pipeline route, Water Right conflicts
Woodland Bottom	Limited	Treatment required	Availability not certain	Possible ESA, Shoreline and wetlands	Feasibility not certain	Substantially higher than current	Environmental, Shoreline access, Pipeline route, Water Right conflicts
Portland Water Bureau Intertie	Adequate	Treatment by purveyor	Likely available	Possible ESA, Shoreline and wetlands	Feasible	Substantially higher than current	Integration with regional system, Source expansion/development

Appendix A

Initial Petition Review/Determination of Completeness Checklist

CHECKLIST

INITIAL PETITION REVIEW/DETERMINATION OF COMPLETENESS

Purpose

Phase II, conducted by EPA Regional Office staff, is designed to ensure that petition information is adequate to perform the technical verification in Phase III.

EPA Acknowledgment

Upon receipt of a petition, EPA should notify the petitioner in writing.

Initial Review / Determination of Completeness

The EPA reviewer should determine if the petition includes a plausible and up-to-date response to each of the petition requirements as outlined in Section 3.3. The reviewer should use a Completeness Determination Checklist to conduct this review.

Complete Petition

If the EPA reviewer determines that the petitioner's responses are plausible and up-to-date, EPA intends to notify the petitioner of the initiation of technical verification. Acceptance at this point does not necessarily mean that EPA will not request additional data from the petitioner at a later point; it also does not guarantee that designation is forthcoming.

Incomplete Petition

If EPA determines that the petition is incomplete, the petition should be returned to the petitioner with a Notice of Deficiencies outlining the information that should be provided before EPA can perform the technical verification. The petitioner should correct the deficiencies and resubmit the petition for another completeness determination review. This process should be repeated until the petitioner submits a petition deemed complete by EPA.

Public Participation Announcement

After EPA has determined that the petition is complete, it should announce an opportunity for public hearing concerning the potential designation. Information about the hearing and the opportunity for comment will appear in the local media, and EPA should notify the petitioner directly.

COMPLETENESS DETERMINATION CHECKLIST

I. Petitioner Identifying Information	INCLUDED
All items on the suggested petitioner identifying information format should be completed (see Exhibit 3-6). Attach a completed copy of the format to this checklist.	YES
II. Narrative	**INCLUDED**
A reasonable response for each of the following topics should be included. Each topic should be described in approximately one paragraph:	YES
General location of the aquifer	YES
Ground water dependency in the area and on the particular aquifer for which designation is requested	YES
Availability of other public water supplies	YES
Reasons for interest in SSA designation	YES
Quality of the water from the aquifer	YES
Relationship of the petitioner to the purveyor(s) of the water supply.	YES
III. Sole or Principal Determination	
Information should be sufficient to determine whether the aquifer is the sole or principal drinking water source for the aquifer service area.	
A. Aquifer Service Area	**INCLUDED**
1. Description of the aquifer service area	YES
2. Map delineating the boundaries of the aquifer service area	YES
B. Population	**INCLUDED**
1. Total population within the aquifer service area	YES
2. Population served by the aquifer	YES
C. Current Sources of Drinking Water	**INCLUDED**
1. Information similar to that requested on the “Current Drinking Water Sources” matrix	YES
2. A brief narrative description of each current source, with the method(s) used for calculating the percentage used in the matrix	YES
3. Explanation of seasonal variations	YES
4. Explanation of actual use versus potential capacity	YES
5. Explanation of why the source is not used currently to its full capacity	YES
D. Alternative Sources of Drinking Water	**INCLUDED**
1. Information similar to that requested on the first version of the “Alternative Drinking Water Sources” matrix	YES
2. Information similar to that requested on the second version of the “Alternative Drinking Water Sources” matrix	**YES**

Requested Item	SOURCE 1 INCLUDED	SOURCE 2 INCLUDED	SOURCE 3 INCLUDED	SOURCE 4 INCLUDED	SOURCE 5 INCLUDED	SOURCE 6 INCLUDED
3. Narrative Description	Yes	Yes	Yes	Yes	Yes	Yes
4. Why source not currently in use	Yes	Yes	Yes	Yes	Yes	Yes
5. Legal or institutional constraints	Yes	Yes	Yes	Yes	Yes	Yes
6. How estimated daily supply was calculated	Yes	Yes	Yes	Yes	Yes	Yes
7. What is necessary to transfer to this source	Yes	Yes	Yes	Yes	Yes	Yes
8. Estimated cost to provide water of comparable quality	Yes	Yes	Yes	Yes	Yes	Yes
9. Determination of economic feasibility	Yes	Yes	Yes	Yes	Yes	Yes

IV. Hydrogeological Data

Information should be sufficient for EPA to verify the boundaries of the areas in question and to give EPA a general understanding of the system.

A. Aquifer and its location	**INCLUDED**
1. Narrative description of the locale, including topography, climate, geology, ground water use and occurrence.	YES
2. Delineation (plane view) of aquifer's boundaries on USGS 7.5- or 15-minute quadrangle topographic maps; delineation of very large aquifer areas (greater than 1,000 square miles) on 1:100,000 scale maps.	YES
3. Detailed (as necessary) descriptions and diagrams of the aquifer's hydrology and hydrogeology including:	YES
- Delineation of the aquifer and non-aquifer units	YES
- Longitudinal and transverse geologic cross sections depicting the aquifer	YES
- Data or estimates concerning aquifer characteristics such as porosity, hydraulic conductivity, direction of ground water flow, and well yields	YES
4. Description of discharge or ground water withdrawal from the aquifer, for example:	YES
- Wells (drinking, irrigation, industrial);	
- Springs;	
- Stream baseflow; and	
- Maps showing water table contours or potentiometric surfaces, springs and surface water pathways.	

B. Recharge Area(s)	**INCLUDED**
1. Delineation of recharge area(s) on topographic maps.	YES
2. A description of methods used to determine recharge area(s), for example:	YES
- Assessment of topographic, geologic or hydrogeologic maps;	
- Review and assessment of regional and Sub-regional ground water flow system(s) data;	
- Data obtained from field studies based on isotopic dating techniques, observation well networks, tracer tests, etc.; and/or	
- Numerical simulation, i.e., regional flow modeling.	
3. Description and location of natural and man-induced aquifer recharge such as precipitation, snow melt, unlined surface impoundments, irrigation, injection of fluids and injection wells.	YES

NOTE: If the streamflow source area is not included in the project review area, there should be a statement as to why it has not been included. If the streamflow source area has been included in the project review area, the following information is requested:

C. Streamflow Source Area	**INCLUDED**	
1. Delineation of the streamflow source area on detailed topographic maps including location of losing streams, if such streamflow demonstrably contributes to the aquifer through these areas.	YES	NO
2. Explanation of methods used in determining streamflow contributions.	YES	NO
3. Streamflow characteristics including delineation of gaining and losing portions of streams.	YES	NO

D. Designated Area	**INCLUDED**
Delineation of the proposed designated area on a topographic map.	Figure 6
E. Project Review Area	**INCLUDED**
Delineation of the proposed project review area on a topographic map.	Figure 6
F. Reference Map	**INCLUDED**
An 8.5 x 11 inch or 8.5 x 14 inch reproducible reference map indicating:	YES

1. The Sole Source Aquifer area;
2. County/parish boundaries;
3. Major streams and lakes;
4. Cities and towns;
5. Latitude and Longitude of a reference point within the petitioned aquifer service area;
6. Other information that contributes to a clear under standing of the

location of the area and its relation to other major political and physical features; and
7. An inset map showing the aquifer location with the State.

G. (At the option of the Petitioner)	**INCLUDED**
Minimum Set of Data Elements for Public and/or Private Water Wells and Springs producing from the petitioned aquifer for drinking water that is supplied within the aquifer service area.	
General Descriptor	YES
1. Data Sources	
Geographic Descriptors	NO
2. Latitude 3. Longitude 4. Method used to determine Lat/Long 5. Description of Entity 6. Accuracy of Lat/Long Measurement 7. Altitude 8. Method used to Determine Altitude 9. State FIPS Code 10. County FIPS Code	
Well Descriptors	NO
11. Well Identifier 12. Well Used 13. Type of Log 14. Depth of Well at Completion 15. Screened / Open Interval	
Sample Descriptors	NO
16. Sample Identifier 17. Depth to Water 18. Constituent or Parameter Measured 19. Concentration / Value 20. Analytical Results Qualifier 21. Quality Assurance Indicator	

Appendix B

Water Usage Estimation Method Documentation

Sole Source Aquifer Petition - Water Use Calculation Spreadsheet

for Troutdale and Unconsolidated Alluvium Aquifer System

in Clark County, Washington

Clark County, Washington Water Usage in million gallons per day, average (domestic only, from USGS)

	Population	Groundwater	Surface Water	Total	Per Capita (gpd/person)
Public System	253250	27.83	0.28	28.11	111.00
Self Supplied	91990	7.73		7.73	84.03
Total	345240	35.56	0.28	35.84	103.81

USGS water usage breakdown

Domestic	Industrial	Losses/Other	Self Supplied
28.11	1.76	9.7	7.73

Note: Surface water calculated as 20% of Camas total usage. Camas usage calculated as population x per capita rate.

Portion of water usage in Clark County outside SSA

	Population	Groundwater	Surface Water	Total	Per Capita (gpd/person)
Public System	16,736	1.77	0.085	1.86	111.00
Self Supplied	23,264	1.95	0.000	1.95	84.03
Total	40000	3.73	0.085	3.81	95.31

Systems excluded: Woodland Mobile HP, Yacolt, Larch Corrections, Amboy, Brookside, Magna Vista, Washougal and part of Camas

Population determined using 2000 Census blocks for area. Excluded system populations listed below.

Water usage in SSA area (Clark Co total minus portion outside SSA area)

	Population	Groundwater (MGal/day)	Surface Water (MGal/day)	Total	Per Capita (gpd/person)
Public System	**236514**	**26.06**	**0.19**	**26.25**	**111.00**
Self Supplied	**68726**	**5.78**	**0.00**	**5.78**	**84.03**
Total	**305240**	**31.83**	**0.19**	**32.03**	**104.93**

Data sources: USGS: Lane, R.C., 2004, Estimated domestic, irrigation, and industrial water use in Washington, 2000: U.S. Geological Survey Scientific Investigations Report 2004–5015, 16 p.

Washington Dept of Health SENTRY system

US Census Bureau

Note: A slight error is introduced by using system populations from the DOH SENTRY database to subtract the excluded area because the system populations have been updated from the 2000 census data used by the USGS.

Excluded water systems

DOH Number	Water System Name	Water System Type	Active Sources	Population Served	2000 Census	Owner	Source Loc	
50240E	MAGNA VISTA WATER CORP	Community	1	56		MVWC	1/4E-9	
	Amboy	Community	1	152		PUD		
	Yacolt	Community	5	1230				
	Brookside	Community	1	100				
	Larch Correctional Facility	Community	3	400				
20469R	WOODLAND MOBILE HOME PARK	Community	4	209		TH Properties	5/1E-19	
934000	WASHOUGAL, CITY OF	Community	7	10,770	8595	Washougal	1/4E- 8,16	1/3E-12
108002	CAMAS MUNICIPAL WATER SEWER SYSTEM	Community	11	3,819	12534	Camas	SW 2/4E-4,2	
				16,736			GW 1/3E-12,4	

Camas Source/Usage Estimation (Estimated for 2000)

Population Served (2000 Census)

In SSA	Out SSA	Total
8715	3819	12534

Camas water usage in SSA

Gndwtr	0.77
Surf Wtr	0.19
Total	0.97

Total Camas water usage (pop x per capita rate)

1.39 Mg/d

Water used from SSA (system capacity % x total usage)

0.10 Mg/d

Number of people served:

From in SSA	858
From out SSA	7857

Source capacity (gpm) by location (one of 9 sources active in 2000 was in SSA) (DOH SENTRY database)

In SSA	Out SSA			Total	Pumping capacity of sources					
Gndwtr	Gndwtr	Surf Wtr	Total Out		Surf Wtr	Source #	Gndwtr	Act. Date	Inact. Date	Source #
650	8500	1000	9500	10150	500	1	950	1970	2003	3
					500	2	950	1970	2003	4
	% of capacity in SSA		6.84%				1100	1970		5
							600	1970		6
		% of usage Surf Wtr	20.0%		(reported by City of Camas)		1400	1970		7
							40		1994	12
							1300	2003		14
							1300	2003		15

Additional Data

Total population outside SSA	40000	(from 2000 Census Clark Co block map overlain on SSA)
Total Water from TUAAS in the SSA	30.96	
Population served by TUAAS water	297383	97.43%