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Region 10
1200 Sixth Avenue
Seattle WA 98101

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Office of Ground Water

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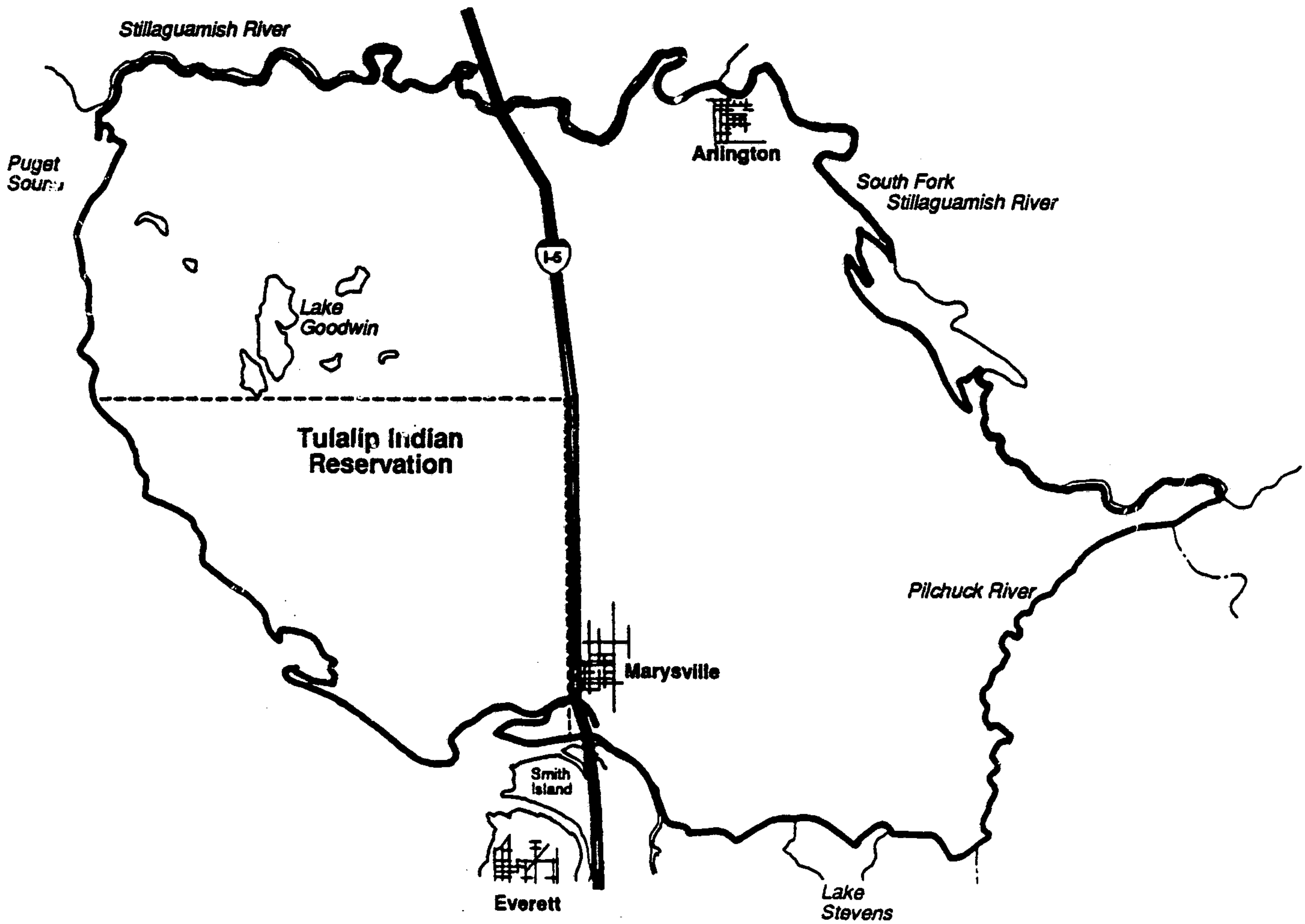
Resource Document

For Consideration of the Tulalip Aquifer as a Sole Source Aquifer



RESOURCE DOCUMENT

FOR THE CONSIDERATION OF THE TULALIP AQUIFER
AS A SOLE SOURCE AQUIFER

Office of Ground Water
U.S. Environmental Protection Agency
Region 10
Seattle, Washington 98101

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INTRODUCTION

In April of 1984 the U.S. Environmental Protection Agency (EPA) received a petition, from the Seven Lakes Water Association (SLWA), requesting sole source aquifer (SSA) designation for the Association's service area in west central Snohomish County, Washington. The SLWA intends to utilize sole source aquifer designation as one means of protecting their ground water resource. The petitioned aquifer was formerly unnamed. It is referred to, in this report, as the "Tulalip Aquifer."

The Administrator published a notice of receipt of the SLWA petition and a request for public comment in the Federal Register on July 17, 1984. At that time, EPA determined that the area proposed by the petitioners did not cover the entire aquifer and, therefore, had to be expanded. Preparation of this report was delayed until essential data were made available by the U.S. Geological Survey for use in defining the appropriate aquifer boundaries.

Sole Source Aquifer Program

The Safe Drinking Water Act, Public Law 93--523, was signed into law on December 16, 1974. This act provides the statutory basis for designation of sole source aquifers by the Environmental Protection Agency. Section 1424(e) of the Act states:

> "If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the Federal Register. After the publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal assistance may, if authorized underanother provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer."

To qualify as a sole source aquifer, an aquifer must supply at least 50 per cent of the area's drinking water, and there must be no physically, legally, or economically feasible alternative sources that can substitute for the total drinking water supplied by the aquifer (EPA, 1987).

Purpose and Scope

The purpose of this report is to describe the characteristics of the aquifer area and to evaluate the area against criteria for sole source aquifer designation. Specific topics discussed are: (1) the boundaries of the aquifer area as proposed by EPA; (2) hydrogeologic characteristics; (3) ground water and surface water consumption; (4) water quality, (5) potential for contamination, and (6) the availability of economically feasible alternative sources of drinking water. This report summarizes information available to EPA as of April, 1988; no additional field studies were conducted by EPA.

AQUIFER AREA DESCRIPTION AND PHYSICAL CHARACTERISTICS

Geographic Setting

The Tulalip aquifer, as proposed by EPA, covers approximately 180 square miles of west central Snohomish County (Fig. 1). It extends over most of the area between Puget Sound and Granite Falls, and between the South Fork Stillaguamish River and Lake Stevens. The Newberg Area sole source aquifer is also immediately east of the new proposed aquifer. These boundaries represent a considerable expansion of the area originally petitioned by the SLWA (Fig. 2).

The expansion of the boundaries of the sole source area beyond those petitioned is based on EPA's assessment of hydrogeologic characteristics of western Snohomish County, and on EPA guidelines for sole source aquifer designation. By definition, an aquifer is a geological formation, group of formations, or part of a formation capable of yielding a significant amount of water to a well or spring (EPA, 1987). A petitioner can petition for part of an aquifer if that portion is hydrogeologically separated from the rest of the aquifer; the petitioner might also petition an aquifer system to the extent that all aquifers in the system are hydrogeologically connected (EPA, 1987). EPA has determined that the area petitioned by SLWA is hydrogeologically connected to surrounding aquifer materials both laterally and vertically, and thus constitutes an aquifer system. These considerations are discussed in detail in the section of this report entitled "Aquifer Boundaries".

Climate

The climate of the Tulalip Aquifer area is characteristic of the Puget Sound lowland area, with heavy precipitation in winter and a dry period in summer. For example, the average annual precipitation is 46 inches, at Arlington, which occurs predominantly as rain, with occasional periods of light snowfall during the winter (Lee Krogh, National Weather Service, oral communication, February 1988). Temperatures range from an average high in July of 72.7 degrees to an average low in January of 32.6 degrees.

Population

Much of the proposed aquifer area is sparsely populated and predominantly rural, with the towns of Marysville and Arlington containing the highest population densities. EPA estimates that approximately 47,150 people live within the proposed sole source aquifer area. This estimate was arrived at by totaling 1986 U.S. Census Bureau tract population estimates (Table 2).

Fractions of census tracts 526 and 535.02 were used because only portions of the tracts are contained within the aquifer area. A 50 percent population increase is predicted through the year 2002, with an additional increase of 88 percent over the subsequent 35 year period (Rasmussen and Huse, 1987).

Geology

The availability and movement of ground water in western Snohomish County is governed largely by the nature and distribution of subsurface geologic materials. Therefore, understanding the geology of the Tulalip Aquifer is critical in determining the type and extent of aquifer materials that are capable of yielding significant amounts of water when saturated. The Tulalip Aquifer materials consist of accumulations of unconsolidated glacial and other surficial deposits overlying, at depth, consolidated sandstone and igneous and metamorphic bedrock (Fig. 3). Local alluvial deposits occur along rivers, streams, and Puget Sound. The sandstones and bedrock units outcrop along, and form part of, the eastern boundary of the proposed sole source aquifer area. The following detailed discussion of the varied geologic materials of the proposed area are based on recent geologic maps produced by Minard (1985a,b,c,d,e,f,g) and Booth (1985).

BEDROCK UNITS

Two types of bedrock units occur below unconsolidated deposits near the eastern boundary of the Tulalip Aquifer area. The older of these two types is a pre-Tertiary age (Paleozoic and Mesozoic) "melange" or group of metamorphic and igneous rocks. The other type of bedrock present is a Tertiary sedimentary rock, consisting of conglomerate, sandstone, siltstone, and shale (Minard, 1985c; Booth, 1985). Outcrops of these rock types constitute a portion of the eastern boundary of the proposed sole source aquifer area.

Metamorphic and igneous rocks outcrop in much of the area east of the South Fork Stillaguamish River valley, beyond the Tulalip Aquifer boundary (Minard, 1985c; Booth, 1985). Only a very small outcrop actually occurs within the aquifer area, near the community of Hyland, located along the west bank of the Pilchuck River (Minard, 1985f). These rocks consist largely of low grade metamorphic rocks, including metamorphosed pillow basalt, argillite, recrystallized limestone, and sections of meta-basalt (greenstone). Clasts from this rock unit are common in much of the glacial deposits of the region. Outcrops of the igneous sections of this rock unit do not occur within the proposed area.

The sedimentary rocks outcrop along the South Fork of the Stillaguamish River. They consist of sections of conglomerate, sandstone, siltstone, and shale, with lenses of coal interbedded within the different sections. The rocks range in color from dark gray and olive gray to reddish brown and tan. Bedding ranges from thick and massive to thin and shaly, and induration from well indurated to loose and crumbly (Minard, 1985b,c,f; Booth, 1985).

UNCONSOLIDATED DEPOSITS

Several different types of unconsolidated units exist within the Tulalip Aquifer area. Non-glacial units include younger alluvial and estuarine deposits, and beach deposits. Unconsolidated glacial and other surficial deposits occur in thicknesses of up to approximately 600 feet within the proposed sole source area (Minard, 1985a,c). Most glacial units were deposited approximately 15,000 years ago during what has been termed the Vashon Stade of the Fraser Glaciation. They consist of recessional outwash, till, and advance outwash, which are all units of the Vashon drift, and separate, older units known as transitional beds, Olympia gravels, marine glacial drift, undivided till, and sedimentary deposits. The glacial deposits provide the primary drinking water source for the area.

The younger alluvial and estuarine deposits lie in and along present streams. These sediments consist mostly of stream-deposited stratified sand and gravel, with silt, clay, and organic matter present in the floodplain. These deposits may be at least 30 meters thick near the mouth of the Stillaguamish River.

The beach deposit sediments form beaches along Puget Sound and consist mainly of sand, but locally contain abundant gravel. Thickness of the deposits vary according to tidal action.

Recessional outwash of the Vashon drift is the youngest glacial unit of the proposed area. It occurs in terraces and upland valleys, and on hilltops and slopes, throughout the proposed area. It consists mostly of stratified sand and gravel with silt and clay layers common locally. The thickness of the deposit ranges from 1 to 7 meters.

Till occurs at the surface in much of the proposed area. It underlies the recessional outwash, where that unit is present. This till is mostly a non-sorted mixture of clay and silt, sand, pebbles, cobbles, and boulders, but includes some lenses of stratified material. It is generally compact and often referred to as hardpan. Till thickness ranges from 1 to 30 meters.

Advance outwash sediments underlie the till throughout the proposed area. They consist of mostly gray, pebbly sand with increasing amounts of gravel higher in the section. Fine-grained sand and silt are common in the lower section. The advance outwash can be as much as 90 meters thick, and is known as being capable of yielding some of the largest amounts of water in the region.

The transitional beds outcrop in places beneath the advance outwash deposits, and consist mostly of thick beds of gray clay, silt, and very fine to fine sand. It outcrops near the bases of the bluffs bordering the Stillaguamish River Valley and along Puget Sound. Thickness usually ranges from 10 to 12 meters.

The Olympia gravel underlies the advance outwash and transitional beds, and outcrops at the bases of bluffs along the south side of the Stillaguamish River near its mouth and at Kayak Point on Puget Sound. They consist of massive sandy, pebbly gravel, alternating with beds and lenses of coarse sand and gravel. Thicknesses between 6 and 8 meters are exposed at the surface, but the total thickness of the deposit is unknown.

The marine glacial drift underlies the recessional outwash and crops out in the bluff along the Stillaguamish River near Silvana Terraces. It consists of 1 to 2 meters of fossiliferous gray clay, silt, and sand with sparse to abundant pebbles.

A pre-Vashon age till unit, referred to as "till--undivided" by Minard (1985a). lies beneath the marine glacial drift at the eastern end of that drift's outcrop area. It consists of hard clay material similar to the Vashon till.

The unit termed "sedimentary deposits-undivided" lies beneath the marine glacial drift at the western end of that drift's outcrop area. They consist of 8 to 10 meters of firm, medium gray, very fine sand, silt, and clay.

AQUIFER AREA BOUNDARIES

The proposed sole source aquifer area is considerably larger than the area originally petitioned for designation by the Seven Lakes Water Association. This expansion was based on review by EPA of available information on ground-water resources of western Snohomish County, and on regional ground-water flow modeling of the Tulalip Plateau area, conducted by the U.S. Geological Survey (Lum and Alvord, in press).

The originally petitioned area consisted of only a portion of the Tulalip Plateau area (Fig. 1). The Tulalip Plateau is a upland area bounded by the Stillaguamish River Valley on the north, the Marysville Trough on the east, and Possession Sound and Ebey Slough on the south. Previous investigations have indicated that aquifer materials of the Tulalip Plateau area are largely continuous, through the plateau, and therefore constitute a single aquifer system, larger than the petitioned area (see Newcomb, 1952; Drost, 1983; Parametrix, 1983; Hart Croswer, 1978; Shannon and Wilson, 1981; and Sweet, Edwards, 1984). On the basis of this available information, EPA initially determined that the aquifer area should be at least as large as the Tulalip Plateau area.

EPA then consulted U.S. Geological Survey staff engaged in numerical ground-water flow modeling of the Tulalip Plateau area and vicinity. Preliminary results of this modeling suggest that deeper aquifer zones of the Tulalip Plateau area (i.e., zones greater than approximately 200 feet in depth), below the elevation of the surface of the Marysville trough, are recharged by ground water moving westward from central Snohomish County. On this basis, EPA determined that the aquifer boundaries should be extended beyond the area of the Tulalip Plateau, to incorporate all areas with aquifer materials in hydrologic connection with deep zones beneath the Tulalip Plateau. Accordingly, EPA is now proposing to designate an area extending eastward from the Tulalip Plateau to Granite Falls, the Pilchuck River and the South Fork Stillaguamish River.

Therefore, the rationale for enlarging the originally petitioned area is to conform to EPA sole source aquifer Petitioner Guidance requirements regarding designation of hydrogeologically connected aquifer materials. The area was also enlarged to assure adequate protection to areas that might contribute or convey recharge to materials in hydrogeologic connection with deep wells in the petitioned area and vicinity. The Petitioner Guidance states that "a petitioner can petition for part of an aquifer if that portion is hydrogeologically separated from the rest of the aquifer, or, the petitioner can petition for an aquifer system to the extent that all aquifers in the system are hydrogeologically connected". Available information indicates that the originally petitioned area is hydrogeologically connected to surrounding aquifer materials, both laterally and vertically. In addition, deep wells (greater than about 200 feet) in and near the petitioned area are recharged by water migrating at depth from the east. (Table 1 lists depths of public ground-water system wells.) The proposed sole source aquifer area consists of all aquifer material that EPA considers to be hydrogeologically connected with the originally petitioned area, or consists of unconsolidated material that extends to regional discharge areas such as rivers or Puget Sound.

The proposed sole source aquifer area, the Tulalip Aquifer, consists largely of an accumulation of unconsolidated glacial and other surficial deposits in west central Snohomish County (Fig. 1). It is approximately 180 square miles in area. It is an aquifer system which extends from Puget Sound eastward to bedrock outcrops in the Cascade Mountains foothills. The boundaries were formulated by EPA by assessing available geologic and other maps (e.g. Booth, 1985; Minard, 1985a,b,c,d,e,f,g), to ascertain the extent of unconsolidated materials, and to identify regional discharge areas that would serve to bound the aquifer materials. It is bordered on the west by Puget Sound; on the north by the Stillaguamish River; on the east by the South Fork Stillaguamish River, outcrops of bedrock, and the Pilchuck River; and on the south by Lake Stevens and a tributary of Steamboat Slough. The Newberg Area sole source aquifer is also immediately east of the new proposed aquifer.

Ground water flows from the east to the west through the Tulalip Aquifer, with local ground-water flow systems present in the upper deposits located on topographic highs. Recharge to the aquifer occurs mainly in the form of direct percolation of precipitation. Other forms of recharge include percolation from lakes and streams located on topographic highs, and deep regional recharge flowing from the Cascade Mountains towards the west (Lum, in press). Recharge from the adjacent Newberg Sole Source Aquifer may also be contributing to the aquifer, along the eastern boundary near Granite Falls. Discharge from the aquifer occurs mainly as direct inflow into the Stillaguamish River, Steamboat Slough, Puget Sound, lakes located below the water table (Lum, in press), and other minor streams, creeks, and springs in the area. Discharge also occurs in the form of evapotranspiration from vegetation covering the area.

The portion of the Tulalip Aquifer boundaries that are contiguous with the Newberg Area sole source aquifer, along the Pilchuck River, represents an area where the Tulalip Aquifer may be in hydrogeologic connection with unconsolidated material outside of the proposed aquifer area. This boundary is assumed to be adequate for meeting the purposes of sole source aquifer designations since the adjacent material has been designated as another Sole Source Aquifer area. The Stillaguamish River, South Fork Stillaguamish River, Pilchuck River, Lake Stevens, and Steamboat Slough are assumed to be ground-water discharge areas. The western edge of the sedimentary rock unit outcrops (in the South Fork Stillaguamish River valley) were used as part of the eastern boundary of the Tulalip Aquifer area because of their consolidated nature and probable low water-yielding characteristics as compared to the unconsolidated glacial deposits. The bedrock boundary represents the extent of geologically similar aquifer material. The base of the Tulalip Aquifer is likewise defined as being coincident with the bottom of the unconsolidated glacial deposits (see Geology section).

DRINKING WATER SUPPLY

Drinking water for residents of, and visitors to, the proposed Tulalip Sole Source Aquifer area is supplied by ground-water and surface water sources. One criterion that must be met for an area to be considered a sole source aquifer area is that at least 50 percent of its drinking water must be obtained from the aquifer. Available data on drinking water consumption in the proposed area shows that this criterion is met. This evaluation is based on currently known drinking water consumption data.

Alternative sources of water supply, both within and outside the aquifer area, were also considered. Plans are being formulated to transport water from the city of Everett's surface water supply to densly populated towns located within the Tulalip Aquifer area (Claire Olivers, city of Everett, oral comm., March 1988). If implemented, imported surface water from Everett could potentially affect the qualification of the Tulalip Aquifer as a sole source of drinking water. However, no contracts or legally binding agreements have been signed, and future projections of factors such as area population and total area water use are considered speculative. Therefore, in accordance with EPA guidelines, this water source from outside of the proposed aquifer area, was not considered when evaluating the aquifer qualifications for sole source designation (EPA, 1987).

The following discussion presents an analysis of the available drinking water data, and the assumptions made to obtain estimates of total ground water and surface water used for drinking water purposes. Public water supply consumption values represent drinking water distributed to densly populated areas such as cities and towns, plus drinking water distributed to small, localized areas such as neighborhoods. Private consumption values represent drinking water consumed by individual households. Spring-water use is considered to be ground water and is included in the ground-water use calculations.

Surface-Water Use

Surface water used in the area for drinking water supply is obtained from lakes and streams. Most of the surface water is used by private households, with only one public surface water system in operation.

According to the Washington Department of Social and Health Services (DSHS) Water Facilities Inventory data base, the only public surface water system in the area is Lakeview Water Users located near Lake Stevens. The system serves approximately 50 people. The total surface water use by this system is estimated to be 6,450 gallons per day based on the maximum consumption rate of 129 gallons per day per person. This rate was obtained from the Seven Lakes Water Association Inc. daily pumping records which show a maximum usage of 325 gallons per day per connection. This value was divided by an assumed average household population of 2.52 persons (U.S. Census Bureau, 1986 estimate) to obtain the per capita use figure.

Private surface water use was estimated by determining the number of users in the aquifer service area who have Washington Department of Ecology (WDOE) water rights. This number of households was then multiplied by 150 gallons per day per connection. This usage rate is the same used in the Newberg Area Sole Source Aquifer determination, and is consistent with individual household usage figures presented in other publications (U.S. Dept. of Health, Education and Welfare, 1963). According to the WDOE water rights data base, a total of 65 private systems have surface water rights. This results is a private surface water use of approximately 9,750 gallons per day.

Combined public and private surface water use within the aquifer service area is estimated to be 16,200 gallons per day (Table 3). This value represents 0.3 per cent of the total drinking water used in the area.

Ground-Water Use

Total ground water usage by public systems using ground water sources is estimated to be approximately 5,999,661 gallons per day (Table 3). This value was obtained by multiplying the total population served by public ground-water systems in the aquifer service area by the per capita water usage rate for public water supply systems (129 gallons per capita per day).

Public System Ground-Water Use = $P_{Pub} \times R_{Pub}$

where P_{Pub} = Population served by public ground-water systems (= 46,509)

and R_{Pub} = Per capita water usage for public supplies (129 gallons per day).

therefore,

Public System Ground-Water Use = 5,999,661 gallons per day

The population served by public systems using ground water, 46,509 persons, was obtained from the DSHS database. Table 1 lists the 158 systems that serve the Tulalip Aquifer area.

Ground-water usage from private wells, 25,680 gallons per day, was estimated by multiplying the population using private wells by the usage rate for individual wells (60 gallons per capita per day).

$$\text{Private Ground-Water Use} = P_{Pri} \times R_{Pri}$$

where: P_{Pri} = Population served by individual wells within the aquifer service area;

= (Total Aquifer Area Population, 47,151) - (Population served by public systems, 46,559) - (Population served by private surface water systems, 164) = 428

and R_{Pri} = Per capita usage for individual water supplies (60 gallons per day).

therefore,

Private Ground-Water Use = 25,680 gallons per day.

The total drinking water consumed from ground water (public plus private supplies) is thereby estimated to be 6,025,341 gallons per day (Table 3). This represents 99.7 percent of the total drinking water consumed in the area. Therefore, the requirement that an area obtain more than 50 percent of its drinking water from ground water for sole source aquifer designation is met.

GROUND-WATER QUALITY

Ground water used for drinking water in the proposed sole source aquifer area is generally of good quality. Water from a small number of wells throughout the area is treated to remove chloride, iron, maganese, and suspended sediment. A small amount is also floridated. Marysville Utilities, the largest provider, treats to remove chloride. Recently, naturally occurring arsenic in the drinking water has shown up at elevated levels in several private wells completed in consolidated bedrock near the Newburg Area Sole Source Aquifer boundary. These wells are not currently being used for drinking water purposes.

POTENTIAL FOR AQUIFER CONTAMINATION

The unconsolidated, permeable nature of the glacial deposits that comprise the Tulalip Aquifer indicate that the aquifer is vulnerable to contamination. Contamination originating from the surface would most likely quickly penetrate downward through the upper unconsolidated deposits, and possibly move laterally along the Vashon till surface, or penetrate to greater depths. Wells which obtain water from these deposits are considered vulnerable to leaching contaminants.

The Tulalip Aquifer is vulnerable to contamination from a wide variety of sources, such as pesticide application, leaking fuel, or chemical storage tanks, agricultural runoff, animal wastes, septic systems, landfill leachate, and accidental spills of hazardous materials. If ground water were to be contaminated, its usefulness as a source of drinking water could be impaired or destroyed. Assuming that the technology to remove the contaminant, or contaminants, exists and is readily available, an increased expenditure of energy and funds would still be required to make the water usable again. If the technology is not available, or if the expense for decontamination is too high, the contaminated aquifer could become practically useless as a drinking water source, and its usefullness for other purposes could be greatly impaired.

ALTERNATIVE DRINKING WATER SOURCES

An analysis of alternative sources of drinking water supplies in and near the Tulalip Aquifer area indicates that there are no sources that can provide an economically feasible alternative. Although there is sufficient unallocated surface water from the Stillaguamish River, and potentially available imported water from the city of Everett, the cost of construction for diversion, treatment, storage, and distribution systems make these alternatives economically prohibitive to serve the entire aquifer service area.

The city of Everett is considering an expanded water supply service area that would encompass portions of the proposed Tulalip Sole Source Aquifer area. The city currently has an excess supply of water that exceeds the quantity of drinking water currently extracted from the aquifer. However, the city of Everett has determined that it is economically feasible to supply only those areas that have population densities greater than 400 people per square mile (C. Oliver, city of Everett, oral comm., March 1988). Much of the area proposed for sole source aquifer designation does not meet this density (Fig. 3). Therefore, water from the city of Everett cannot be considered an economically feasible alternative source of drinking water supply for the Tulalip Aquifer.

In addition to prohibitive costs of distribution, treatment, etc., of Stillaguamish River water, fisheries protection measures for the river require restrictions on water allocations. These restrictions would make it highly unlikely that the river could replace 100 percent of the drinking water consumed from the Tulalip Aquifer. A volume of 75,619,080 gallons per day

(117 cubic feet per second) was measured as the 57-year low flow at the U.S. Geological Survey stream gage at Arlington. The total amount of drinking water used from the aquifer (more than six million gallons per day) represents eight percent of this low flow. However, withdrawal of this amount of water from the river could have detrimental effects on fish, and, in fact, water is available for allocation only 50 percent of the time during of the year (K. Slatter, WDOE, oral comm., March 1988). Therefore, the Stillaguamish River cannot be considered a reliable source of drinking water for residents in the Tulalip Aquifer area.

An assessment of surface water as an alternative source of water for the North Snohomish County area was made by the North Snohomish County Regional Water Association (Rasmussen and Huse, 1987). They found that surface water, in general, in the area can not be considered viable alternatives to providing water to the region. They state:

> "The impoundment of surface water on the Tulalip Reservation has been investigated by others, as a source of water and was found not to be cost effective. Treatment of the supply would certainly be required. Surface waters from the Plateau area have been observed to contain high concentrations of total phosphorus and total coliform bacteria. The concentration of nutrients appears to be related to flow conditions. Nitrates and total nitrogen are greater in the wet run off season while total phosphorus shows the inverse relationship. Total phosphorus and ammonia concentrations are greatest in the dry season storm run off.
>
> Two additional subbasins with possible potential for water supply are the Stillaguamish River and Pilchuck Creek, a tributary to the Stillaguamish River. Development of either of these streams is not likely because of the importance of the Stillaguamish River to the management of fisheries resources in the Puget Sound area.
>
> In summary, the limitations to the development of surface water as a significant potable water supply would be:
>
> 1. Quality as previously mentioned (treatment would be required).
>
> 2. Water rights.
>
> 3. Reservoir sites are not available.
>
> 4. Lack of control over watershed uses (land use control for contamination prevention).
>
> Because of these limitations, the surface waters in northwestern Snohomish County do not appear to be a viable candidate for development as a regional water supply."

Deepening and/or drilling new wells to bedrock units beneath the aquifer would not be a viable method of obtaining safe drinking water should the aquifer become contaminated, because bedrock wells would probably not produce sufficient quantities of ground water, due to lower porosity and permeability. In addition, arsenic may be encountered in bedrock wells where ground water has passed through mineralized veins, as has occurred near Granite Falls.

SUMMARY

The proposed Tulalip Sole Source Aquifer area is located in northwest Snohomish County, Washington and covers approximately 180 square miles. The area originally petitioned by the Seven Lakes Water Association Inc. has been expanded to include the entire aquifer area. The aquifer is composed of mostly unconsolidated glacial deposits overlying consolidated sandstone, metamorphic, and igneous bedrock units. Ground water flows generally from east to west, with local systems present in topographically high areas.

To qualify as a sole source aquifer, an aquifer must supply at least 50 percent of the area's drinking water, and there must be no economically feasible alternative sources that can substitute for the total drinking water supplied by the aquifer (EPA, 1987). An analysis of available data indicates that the proposed area meets these criteria and qualifies for designation as a sole source aquifer area. Approximately 99.7 percent of drinking water in the area comes from the aquifer, compared to 0.3 percent from surface water sources. There are also no economically feasible alternative drinking water sources to supply the area should the aquifer become contaminated. Potential surface water sources are considered to be too costly when treatment, transportation, and fisheries habitat losses are considered, and deepening or drilling additional wells provides no assurance that uncontaminated water would be obtained because of the nature of the aquifer materials.

Designation of the area as a sole source aquifer would establish a process whereby EPA would review federal financially assisted projects proposed in the area. These reviews would be conducted by EPA to assure that proper design, construction, and operational controls are in place to protect the aquifer from contamination that may cause a significant adverse effect on the public health.

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APPENDIX 1

TABLES

TABLE 1

LOCATIONS AND NAMES OF PUBLIC WATER SUPPLY SYSTEMS USING GROUND WATER FOR DRINKING WATER, RESPECTIVE POPULATIONS SERVED, AND WELL DEPTHS.

(Multiple well depths indicate more than one well in use.)

Location (Township-Range)	System Name	Population Served	Well Depth (feet)
T29N, R5E	Bigsby-Willson Water System	18	162
T29N, R6E	Meadow Vista	24	195
	Lonnie Serrano Well	6	165
	Ivan Eisele	6	43
	Goodsell Community Well	9	150
	Musgrove Plat	9	65
	44th St. NE Pump Station	6	175
	Engels-Noffsinger Water System	6	354
	Happy Hill Community Club	69	220; 121
T30N, R4E	Kayak Ridge Water System	18	46
	Tulare Beach Water Association	141	65; 65
	Tulalip Water System	3,150	95;102;95
	Sunny Shores Community Club	60	195
	Sam Lake Improvement Association	75	420; 276
	Indian Lake Improvement Association	105	267
	Holtum Water System	8	146
	Doleshal & Olivera Water	4	170
	McCauley Water System	9	167
	Roland Lyons	12	168
	Kathann Estates	126	170
	Guertin, Raymond Water System	9	15
	Hinton Estates #7	6	180
	Knowles - Bodeen Water System	6	175
	Hinton Estates #6	6	118
	Hanson, Leonard Water System	3	140
	Santi, Ernie Well	6	142
	Spee-Bi-Dah	31	497
	Tulalip Shores Water Association	114	496; 137
	Miller - Garitee Water System	6	228
	Ness Water System	20	411
	Tulalip Wood Water System	39	241
	Arcadia Water Supply	30	247
	Upper Tulalip	24	380
	Marysville Estates - Aqua Hills	40	73; 128
	Wooding Bert Water System	6	140
	Olson, Vera Water System	6	unknown
	Potlatch Beach Community	15	171

continued

Table 1, continued

Location (Township-Range)	System Name	Population Served	Well Depth (feet)
	South View Water System	24	175
	Brade Carroll Well	9	162
	Milt Hutchinson Well	6	11
	Short Plat 231-79	15	139
	Seg, 51-84	6	160
	Chealco Water Supply	78	191
	Snug Harbor Mobile Home Park	71	153; 153
T30N, R5E	Kahm Water System	9	110
	Short Plat 224-81	6	63
	Boggs, James Water System	9	25
	Glunt Kenneth Water System	6	42
	Garner OL Well	15	33
	Sands Mobile Home Park	52	24; 23
	Cross Water System	9	25
	Mobile Manor	276	50; 50; 50
	Barkly Manor	36	27
	Country Mobile Estates	65	45
	Marysville Highlands	6	182
	Allendale Community Water	45	90
	Grace Water Association	9	100
	Marysville Highlands East Comm. Water	12	98
	Private Water District Association	12	80
	Lauck Road Association	12	48
	Raab, Sherrill Water System	9	80
	Schmidt Water System	3	30
	Indian Creek Water System	21	45
	John Duncan Community Well	6	32
	Cobian, Eitelberg, Stover Well	9	37
	Grannis Tracts Duplex	6	unknown
	Grannis Tracts Lot 13	6	65
	Grannis Tracts Triplex	9	unknown
	Carl A. Southard	8	unknown
	McBee, Molly Water System	6	20
	Costa, Manual Water System	6	75
	Kent Boyd Water System	6	unknown
	Lake Cassidy Estates	42	105
	Paradise Resort	2	30
	Miner, Jerry Water System	6	165
	Murphy, Donald Water System	6	16
	Keister Water System	6	15
	Hoffman Duplex	6	150
	Short Plat 398-70	12	83
T30, R6E	Vanbeek, Clarance Water Sytem	9	unknown
	Sunken Acres Water System	18	100
	Cedar Lane Water Association	290	17; 17; 17
	L & B Water System	9	120
	Perrigoue Farm	9	unknown
	Nelson-Moberg	6	unknown
	Waites Apartment	21	20; 200
	Jehova Witness Church	3	116

continued

Location (Township-Range)	System Name	Population Served	Well Depth (feet)
	Poeshel and Schultz #4	15	75
	Taklo-Wilhelm Water System	6	60
	Driscoll Water System	6	90
	Rodeo Downs Water System	6	55
	Angerbauer Water System	6	80
	Schindler Water System	12	110
	Short Plat 565-70 and 566-70	9	unknown
	Wicklund Builders	14	300
	Getchell Park Community Water	120	42
	Cedar Springs Camp	11	unknown
	Cascade Forest Products	6	25
T31N, R4E	Marysville Utilities	31,000	328,40,450
	" "		200
	Tony Dimak	90	unknown
	Anderson Roger Water System	6	16
	Ford, Louis Spring	12	unknown
	Summerset Water System	9	90
	Ridgecrest Water System	9	155
	Lakeside Shores Improvement Assoc.	105	231; 349
	Lakewood West Water Association	45	280
	Poeschel and Schults System 3	90	220; 160
	Orchard Beach Community	90	47
	Lake Goodwin Resort	2	140
	Glonek Water System	6	220
	Loch-O-Rama	63	200
	Lake Ki Sunrise Water	96	154; 155
	Mt. View Assembly of God	3	62
	45 Road Water System	9	216
	Kingston Water District	30	302
	McAllister & Braaten Water System	6	272
	Seven Lakes Water Association	3000	272; 24
	" "		176; 470
	" "		180; 25
	Aeschlima, Foster Water System	6	320
	Cedar Grove Resort	9	65
	Tall Firs Assessors Plat	75	unknown
	Lake Goodwin, Short Plat 41-84	4	80
	Camp Killoqua	3	155
	Bartlett Tract	12	178
	Cascade Crest Estates Water System	9	220
	Cascade View Water System	18	220
	Fire Trail Acres	15	169
	Warm Beach	900	unknown
T31N, R5E	Hinton Acres	6	114
	Fletcher, Loren Water System	15	18
	Arlington Water Dept.	4200	40; 40; 40
	" "		185
	Eagle Ridge Water System	146	38
	Grove, John Water System	9	40
	Burnhill Mobile Home Water System	9	398

continued

Table 1, continued

Location (Township-Range)	System Name	Population Served	Well Depth (feet)
	Arlington Terrace	29	76
	Poeschel and Schultz #5	48	70
	Cedar Stump Tavern	3	40
	Smokey Point Mobile Park	80	17
	Webber, Leroy Water System	6	30
	Airway Mobile Park	90	64
	Watson, James Water System	9	235
	Bartle Water System	4	215
	Davis Chris Water System	6	-?-
	McPherson Hills Water System	20	250
	Top of the Hill Homeowner's Assoc.	78	50; 182
	Edgecomb Landowners Assoc.	21	173
	McKeown Acres	12	43
	Short Plat	9	165
	Forest Grove Mobile Home Park	78	35
	Bertilson Water System	6	80
	Hinton Estates	6	100
	Glasgow Water System	18	85
	John Klein Spring	30	unknown
T31N, R6E	Stilli Ridge Estates	33	30; 40
	Elmer Klein Dairy Farm	9	22
	River Meadows County Park	4	71
	Hammer Water Association	21	334
	Short Plat 37-79	6	unknown
	Tobias Water System	9	299
	Total	46,509	

TABLE 2

TULALIP AQUIFER AREA CENSUS TRACTS AND TRACT POPULATIONS

CENSUS TRACT	POPULATION
532	3857
531	3604
535.01	6158
530	5416
528.02	6224
529.01	5299
529.02	5356
527	5712
1/2 of 526	4824
1/8 of 535.02	701
TOTAL	47,151

TABLE 3

SUMMARY OF ESTIMATED DRINKING WATER USE
TULALIP AQUIFER SERVICE AREA

DRINKING WATER TYPE AND USE	POPULATION SERVED	MAXIMUM USE (gallons per day)	PERCENT WATER USED
Ground Water			
Public[1]	46,509	5,999,661	
Private	428	25,680	
Total Ground Water	46,937	6,025,341	99.7
Surface Water			
Public[1]	50	6,450	
Private	164	9,750	
Total Surface Water	214	16,200	0.3
TOTAL DRINKING WATER	47,151	6,041,541	100.0

[1]Data from Washington Dept. of Social and Health Services data base.

APPENDIX 2

FIGURES

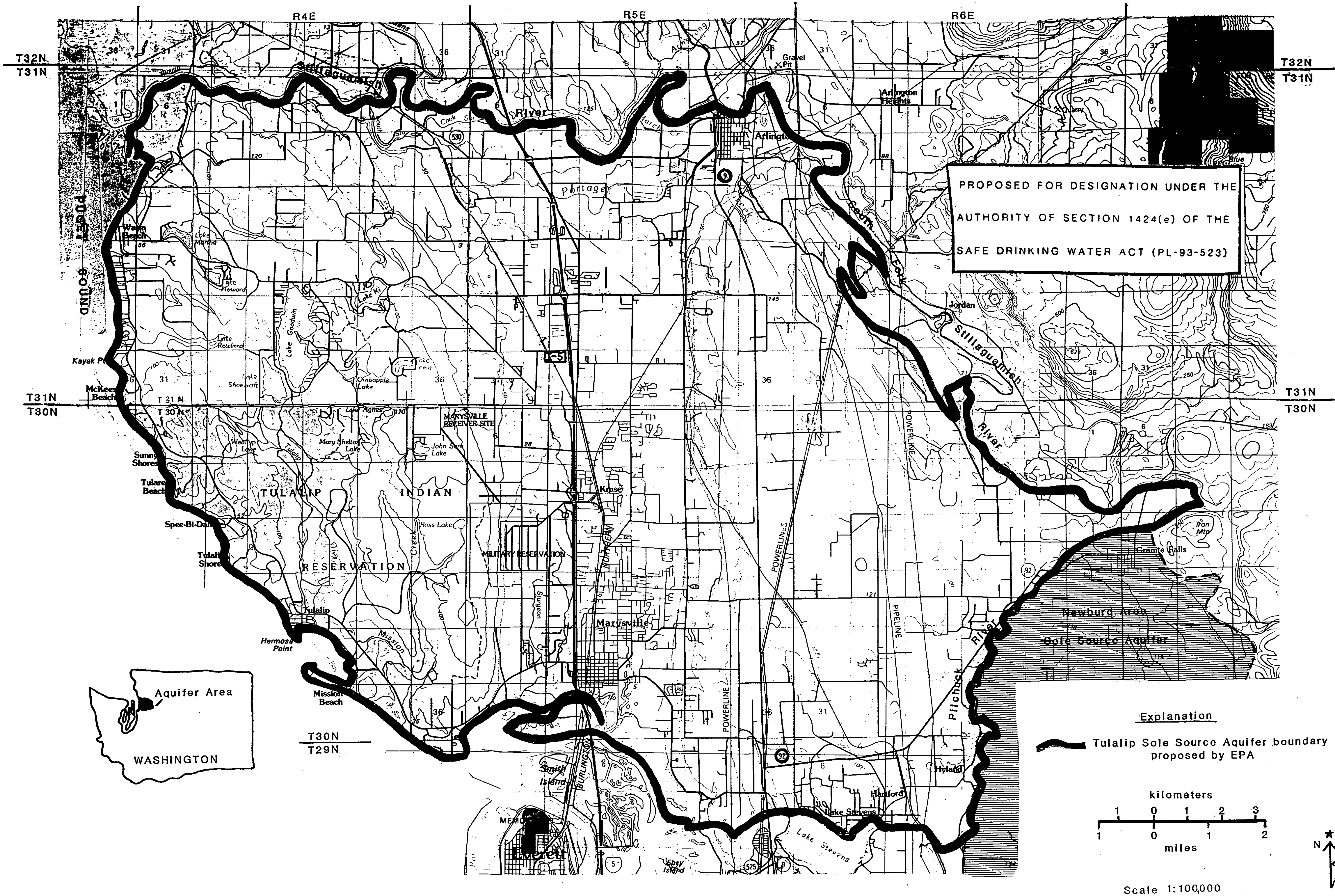

Figure 1.-Map showing Tulalip Sole Source Aquifer boundary as proposed by EPA.
Base map is modified from U.S.G.S. Port Townsend Quadrangle, 1975.

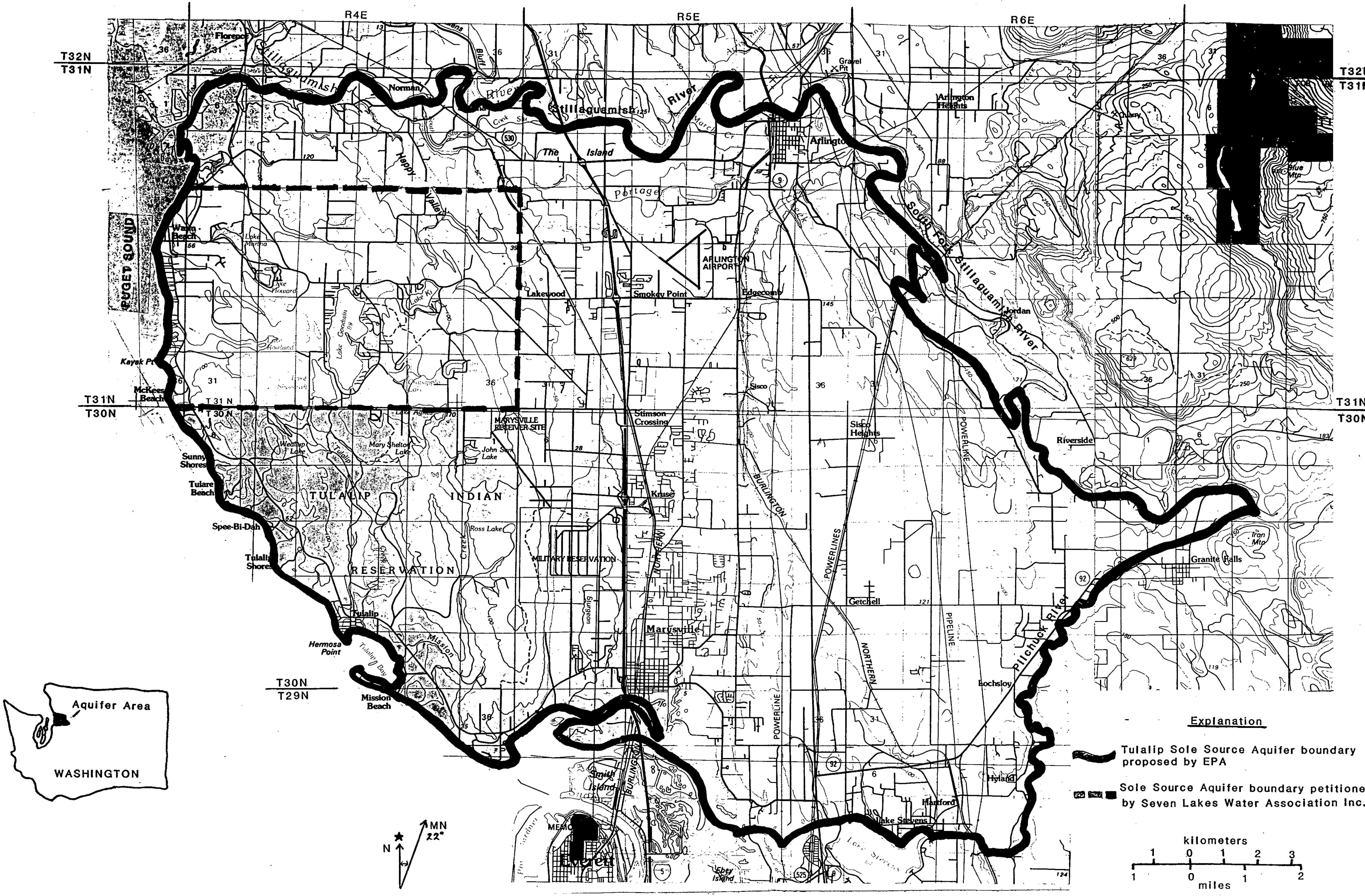

Figure 2.-Map showing Sole Source Aquifer boundary petitioned by Seven Lakes Water Association Inc., and boundary proposed by EPA.

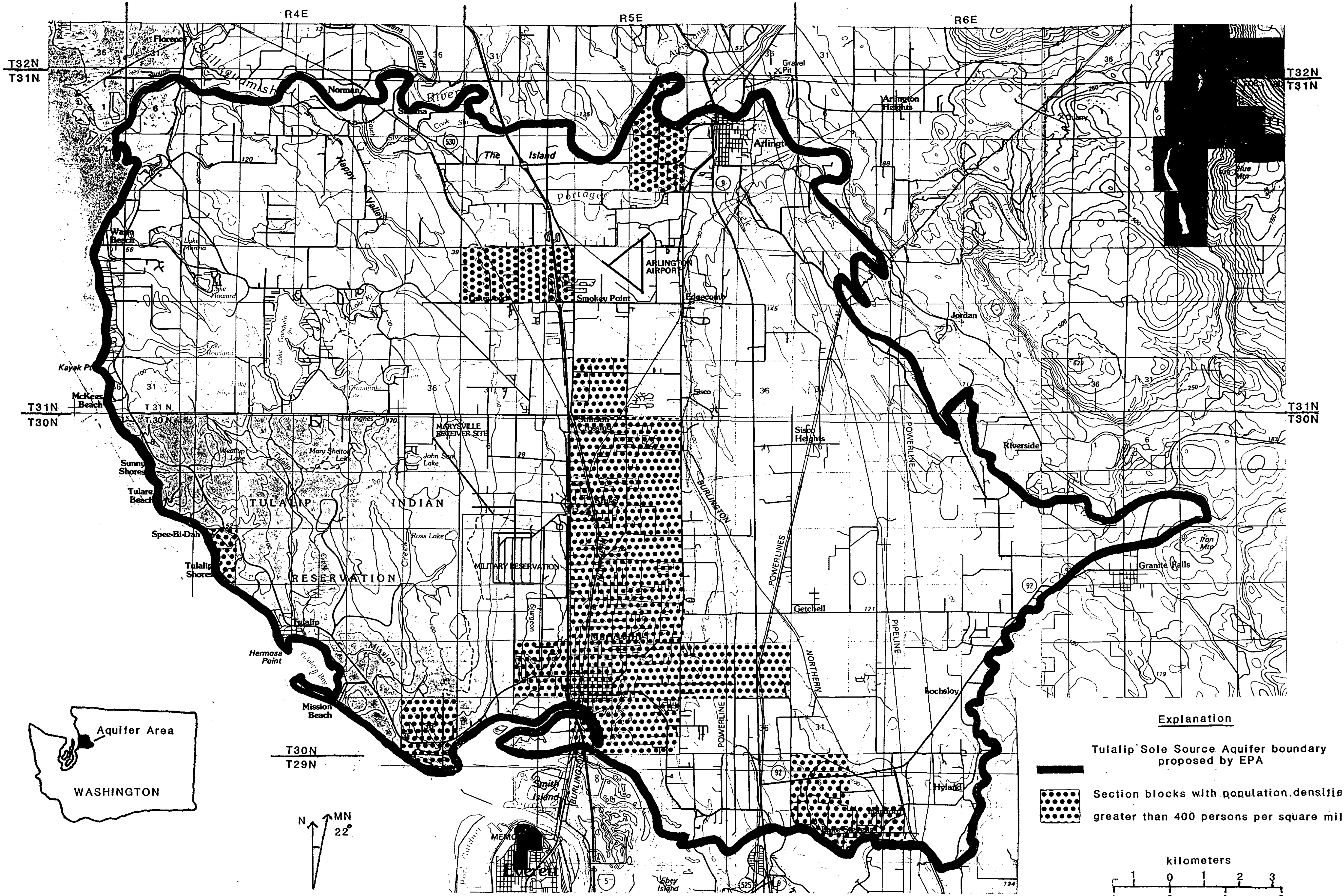

Figure 3.-Map showing section blocks located within the proposed Tulalip Sole Source Aquifer area that have population densities greater than 400 persons per square mile (City of Everett, 1982).