Prepared for

WRIA 55 and 57 Planning Unit

FINAL

Storage Assessment

Little and Middle Spokane Watersheds

DECEMBER 2004

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FINAL REPORT ON

MIDDLE AND LITTLE SPOKANE BASIN (WRIA 55 AND 57)

STORAGE ASSESSMENT

Prepared under Grants G0400354 and G0400355
from the Washington State Department of Ecology

Submitted to:

Spokane County
and
WRIA 55 and 57 Planning Unit

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EXECUTIVE SUMMARY

This report presents the results of a supplemental storage assessment conducted under Watershed Planning, Chapter 90.82 RCW, in Water Resources Inventory Areas (WRIAs) 55 (Little Spokane watershed) and 57 (Middle Spokane watershed). This report complements other watershed planning studies, such as the Level 1 and Level 2 Technical Assessments, and is intended to support development of a watershed plan. This assessment was completed in two phases, the first being an initial broad assessment of potential storage options in the WRIAs, and the second being a more focused assessment of three specific storage options.

The WRIA 55 and 57 Planning Unit are investigating storage alternatives that can enhance existing streamflow, prevent future decreases in low summer flows that may occur due to increased water use, increase water supply reliability, and meet future demand. The Little Spokane River and the Spokane River watersheds are snowmelt driven systems with peak flows generally occurring in the spring to early summer and low flows occurring in late summer. The demand hydrograph is inverse to the natural streamflow hydrograph, with peak demand during the summer, and minimum demand occurring during the winter.

Analysis for the first phase included estimating the quantities of in-stream water that may be needed in the future, characterizing the hydrology of the watershed from a perspective of water available for storage, and identifying a broad range of storage related options and concepts that may be considered for inclusion in a watershed plan.

The table below represents the quantities of water predicted to be necessary in the future to prevent decreases in summer streamflow due to increased water use. Low flows generally occur in August and/or September but can occur anytime between July and October.

Potential Instream Flow Reductions
(acre-feet)

	Little Spokane River near Dartford		Spokane River at Spokane	
	2 months	4 months	2 months	4 months
Junior Water Rights [1]	1,047	1,561	n/a	n/a
20-year growth: Projected Impact on Streamflow [2]	1,721	3,471	6,620	13,080
Full Inchoate Water Right Use: Projected Impact on Streamflow [2]	2,097	4,751	25,645	51,290
New Water Right Applications	4,731	9,539	8,775	17,693

1) Junior Water Rights are reported are for 2 and 3 month period rather than 2 and 4 months because lowest Instream Flow rate is applied for a 3 month period. The estimated volume is based on the Qi rate used continuously for the period shown. Actual impacts will be less.

2) Projected impacts of 20-year growth and Full Inchoate use are based on predicted streamflow results from the Mike SHE Model of the Little and Middle Spokane River.

Many storage concepts were considered for application in the first phase, these include:

- Wetland and riparian storage enhancement;
- Surface water reservoirs;
- Infiltration ponds;
- Capture and infiltration of run-off;
- Natural groundwater storage/management;
- Aquifer storage and recovery;
- Surface recharge, injection and wetland discharge of reclaimed water for streamflow augmentation; and
- Direct discharge of groundwater for streamflow augmentation.

These concepts, and specific options where these concepts could be implemented, were developed, presented, and discussed with the WRIA 55 and 57 Planning Unit. From this information the Planning Unit provided guidance on concepts, or specific options that were considered feasible and beneficial for further study in the second step. The Planning Unit focused resources for the second step on three specific options.

1. Aquifer storage and recovery (ASR) in the Lower Little Spokane Watershed, WRIA 55, using the Spokane Valley Rathdrum Prairie Aquifer (SVRP) as a source of water and the Lower Sand and Gravel Aquifer in the vicinity of the confluence of Deadman Creek with the Little Spokane River as the receiving water body.
2. Evaluation of new dam potential on Beaver and Buck Creeks in northwestern WRIA 55.
3. Saltese Flats restoration and storage potential with additional assessment for the potential for reclaimed water discharge to the Flats in WRIA 57.

These three options address and are applicable to the topics of environmental restoration, habitat improvement, providing for future water demand, and reclaimed water use among other benefits.

Aquifer Storage and Recovery (ASR) in the Lower Little Spokane Watershed (WRIA 55)

Aquifer Storage and Recovery (ASR) is a water management method in which water is recharged into an aquifer during times of surplus, and stored for a period of time (from months to years). The water is then withdrawn during periods of high demand or for emergency use. This water resource management tool has the potential of providing additional water for out of stream uses with minimal impacts on streamflow. The Lower Sand and Gravel Aquifer in the region of the confluence of Deadman Creek with the Little Spokane River was identified as a candidate aquifer for storage. Groundwater from the Hillyard Trough area of the Spokane Valley Rathdrum Prairie (SVRP) Aquifer is the identified source. Existing wells and transmission facilities exist to withdraw the source water, transport it through existing municipal distribution facilities, and recharge it into the target aquifer. The stored water is intended for use for meeting existing and/or future domestic summer peaking demand, and/or minimizing impacts to streamflow from peak summer withdrawals. Any leakage of stored water would result in the augmentation of streamflow.

The Whitworth Water District #2 overlies both the source aquifer (Hillyard Trough) and the recharge aquifer and is expected to need additional instantaneous water right capacity in the next five to ten years, but has sufficient annual water right capacity for the next 20 years. Obtaining additional instantaneous water right capacity through the issuance of new water rights is uncertain. An ASR program may more easily provide the needed instantaneous permitted capacity. The Spokane County Water District #3 also has wells in these aquifers and may also consider incorporation of an ASR program in the provision of future water supply management.

The assessment indicates that:

- Hydrogeologic data indicates the Lower Sand and Gravel Aquifer in the vicinity of the confluence of Deadman Creek with the Little Spokane River is a viable candidate for receiving water in an ASR program. The aquifer is confined and well bounded. The variable of least confidence is the degree of hydraulic continuity between this portions of the aquifer with the rest of the SVRP Aquifer along State route 2 in the vicinity of Mead. Confirmation of the suitability of the aquifer for ASR application is best further evaluated by a pilot test.
- The source aquifer (i.e., the Hillyard Trough portion of the SVRP Aquifer) is a sustainable seasonal (winter-spring) source of water for ASR.
- The quality of the source and receiving waters appear compatible.
- Existing infrastructure is well configured for ASR. High capacity groundwater wells are operated by the Whitworth WD#2 in both the source and recharge areas. Transmission capacity (i.e., intertie) between the proposed source and recharge wells exists, and may be sufficient to conduct a pilot test. Expansion of the transmission capacity in the next two years is planned and will improve the ability of the system to maintain an ASR program.
- There is a need for additional instantaneous water right capacity.
- There is sufficient annual water right capacity under which to operate an ASR program that may allow the exercise of additional instantaneous water right capacity.

Based on the findings of this study, ASR appears to be a viable tool for increasing the instantaneous water right capacity needed to provide for projected increase in municipal water demand. Further evaluation of the feasibility would consist of preparation of a detailed compilation of available data, and execution of a pilot test (subject to refinement):

Data compilation:

- Analysis of relevant water rights;
- Water level maps (potentiometric surfaces) by aquifer;
- Characterization of vertical gradients within the aquifer system;
- Detailed water quality review;
- Selection of recharge test well;
- Hydraulic distribution system modeling (maintenance of public supply and fire protection);
- Engineering of wellhead retrofits;

- Assessment of impacts on other groundwater users;
- Monitoring schedule (locations and frequency);
- Preparation of UIC registration and other regulatory considerations; and,
- Preparation of a pilot test plan for submission to DOH and Ecology;

Pilot test:

- Pretest monitoring. No pumping should be conducted from the Lower Sand and Gravel Aquifer for an appropriate time preceding the pilot test (e.g., one week to one month);
- Recharging water to the selected well from the Whitworth Water District #2 municipal distribution system for during the winter (e.g., 1,000 gpm for one month; water obtained through WWD #2 System 3);
- Observing aquifer response during a post-recharge period (e.g., one or two months) to evaluate the containment of recharged water;
- Recover the recharged water (e.g., 2,000 gpm for one month under existing water rights); and,
- Post-recover monitoring of aquifer groundwater levels (e.g., one week to one month).

Adequate monitoring instrumentation would be needed and may already exist (e.g., instantaneous and totalizing meters, and water level transducers and dataloggers). Time series water quality samples should be collected throughout the pilot test. Information collected during the pilot test could be used to support application for a water right under the ASR rule (WAC 173-157) for full implementation of an ASR program.

All proposed pilot test activities are anticipated to be consistent with existing water rights, and that no water right changes will be needed. Most ASR programs being considered in Washington State involve the use of chlorinated drinking water. The presence of disinfection byproducts presents a permitting challenge because of the groundwater antidegradation rule (WAC 173-200). Because the Whitworth Water District #2 uses no chlorination except for monthly low-level dosing, permitting of an ASR as proposed here with the Whitworth Water District #2 may be the easiest ASR program to permit in the state in this context.

Costs of conducting a pilot test program are quite variable, depending on existing infrastructure, well configurations and retrofit needs, existing instrumentation, available database, and other factors. Representative cost ranges from other projects are:

• Pre-pilot test activities (e.g., well testing, analysis, planning, permitting, etc.):	$30,000-$90,000
• Well retrofit:	$20,000-$60,000
• Pilot testing:	$70,000-$150,000
Total:	**$120,000-$300,000**

Additional effort for full program implementation may include permitting and routine monitoring.

This assessment focused on one option – that of assisting purveyors meet future water demand. Other localities in the watershed for this purpose may be possible, though the cost of implementing an ASR program usually requires a threshold population density to justify a program. The largest population densities are in the vicinity of the City of Spokane and along the Spokane Valley. Additional prospective receiving aquifers have not been identified in this area in the screening step of this project, although basalt aquifers in the region may be suitable. The SVRP Aquifer may be used as the source of water although the distance for transmission may require a higher benefit standard to justify associated infrastructure costs.

Application of ASR for streamflow augmentation would be most effective higher in the watershed. Appropriate receiving aquifers may exist in the Dragoon and Diamond Lake regional aquifers. In these areas, surface water is the most likely source water. This would require surface water treatment facilities which are costly (e.g., on the order of $1,000,000 per 1 mgd [~2 cfs] capacity).

Potential New Surface Water Reservoir on Beaver or Buck Creek (WRIA 55)

Surface storage reservoirs were considered in WRIA 55 to retain peak flows to release later for summer stream flow augmentation. A number of surface storage locations were evaluated in the First Step storage assessment using available published literature regarding the geologic, soil, and hydrologic conditions of areas as well as the length of stream flow benefit, potential aquatic and terrestrial impacts, and water quality impacts. Two locations were chosen for further evaluation, Beaver and Buck Creeks, in the northwestern portion of WRIA 55.

To facilitate a comparative analysis of both dam sites, a target annual reservoir storage of 4,750 AF was used. This represents the projected average volume of decrease in streamflow on the Little Spokane River resulting from full exercise of existing inchoate water rights. This volume is the equivalent of approximately 25 cfs released over three months. In order to determine if the site hydrology could meet the target volume, it was assumed that ideally, not more than 50% of flows would be retained between November and April. This assumption is not a recommendation; operations, such as this, would ultimately be a negotiated value based on many factors including downstream impacts, water rights, etc.

Two alternative locations for a new dam in the northwestern corner of WRIA 55 considered are:

- Beaver Creek in Stevens County, just upstream of Baker Lake Dam; and,
- Buck Creek in Pend Oreille County, north of Beaver Creek, approximately 1.75 miles upstream of Horseshoe Lake.

From an environmental perspective, little site specific data was available from which to characterize current conditions at either site. Therefore further study would be required to clarify site-specific conditions and potential impacts. From a technical perspective, available data on geology, hydrogeology, and hydrology indicate that either site could support a zoned earthen embankment dam.

Beaver Creek

In Beaver Creek, eastern brook and rainbow trout have been recorded, and three natural and one human-made barriers (Baker Lake Dam) are recorded downstream of the site. National Wetlands Inventory data (WDFW, 1987) indicate that the proposed Beaver Creek site would cause approximately 9.0 acres of wetlands to become inundated, although new seasonal wetlands could also be created.

The studied reservoir site on Beaver Creek was estimated to have insufficient inflow to support the target volume of 4,750 AF. Existing inflows could support a reservoir of between approximately 930 AF, assuming 50% of wet season inflow is retained, and 1,850 AF, if 100% of wet season inflow is retained. Reservoir sizing to support this range would require an embankment height of 25 to 40 feet, resulting in an available reservoir volume of 1,175 AF and 1,932 AF respectively. In terms of flow, 930 AF of storage is equivalent to approximately 8 cfs delivered continuously over a two month period, while 1,850 is equivalent to approximately 16 cfs delivered continuously over a two month period.

Buck Creek

In Buck Creek, eastern brook and rainbow trout, sculpin, and kokanee have been recorded. Two natural and one human-made barrier exist downstream of the site. Wetland survey data from the National Wetlands Inventory indicate that the proposed Buck Creek site would inundate approximately 16.4 acres of wetlands, although new seasonal wetlands would also be created.

The studied reservoir site on Buck Creek was estimated to have sufficient inflows to consider the target volume of 4,750 AF met. Assuming retention of 50% of wet season flows, an average of 4,560 AF of water would be stored. Reservoir sizing to support this range would require an embankment height of 85 feet (resulting in an available reservoir volume of 4750 AF). In terms of streamflow augmentation, 4,560 AF of storage is equivalent to approximately 38 cfs delivered continuously over a two month period.

While surface water reservoirs generally invoke negative responses, in this situation they are evaluated with an objective of improving instream flows in WRIA 55 with the potential additional benefits to junior water right and/or inchoate water right holders. The balance between these objectives is likely to be a primary factor in the regulatory feasibility of permitting either project. A project developed to benefit instream flows is expected to be more acceptable, and therefore more easily permitted, than a project intended to offset water use or serve water supply needs. Either way, it is important to fully disclose potential adverse environmental impacts, as well as to identify and describe potential environmental benefits so that project discussions are balanced. One method to do this is through development of an Environmental Impact Statement. Early engagement of agencies including the Army Corps of Engineers (ACOE), Ecology, County shoreline staff and the Washington State Department of Fish and Wildlife (WDFW) will be necessary. Developing a communication and permitting strategy to address environmental issues and ensure that all procedural requirements are met will help ensure that the process can proceed smoothly.

Costs for a dam on Beaver Creek sized to retain 50% of inflows (1,175 AF) are estimated between $4.2 and $9.1 million. For a dam sized to retain 100% of inflows (1,932 AF), costs are estimated between $11.8 million to $16.7 million. Costs for a dam on Buck Creek, sized to store approximately 4,750 AF of inflow (50% of inflows), is estimated to cost between $19.2 million to $24.1 million. Maximum unit costs for these three surface storage scenarios are approximately $5,400 per acre foot for reservoir storage on Buck Creek and between $7,700/AF and $8,600/AF for reservoir storage on Beaver Creek.

Saltese Flats Restoration

Saltese Flats is evaluated in this report for multiple purposes of: wetland restoration, enhanced groundwater recharge for streamflow augmentation from seasonal storage, and as a potential site for reclaimed water discharge. The Flats is located in the southwestern portion of WRIA 57, in a rapidly developing area just south of the City of Spokane Valley and west of Liberty Lake. It was once a seasonal shallow lake, wetland system that was drained in the early 1900's to be used for agriculture, and is now used for agriculture, stock and some recreation. Residential development is encroaching upon the historical wetland area. It is designated as wetlands by both the National Wetlands Inventory and the Spokane County Critical Areas Ordinance.

The Flats presents a unique opportunity for a multi-faceted project with benefits including: storage/streamflow augmentation, water quality improvement, wetlands restoration, reclaimed water polishing, open space preservation, habitat enhancement and educational benefits. In addition, many diverse environmental groups and federal agencies have expressed interest in the restoration of Saltese Flats and/or the use of reclaimed water for restoration, including: Spokane Audubon, Ducks Unlimited, Natural Resources Conservation Service, Ecology, and the WDFW, among others. Currently, undisturbed portions of the Flats are used by migratory water fowl, raptors, mammals and amphibians including state-listed endangered, threatened and candidate species, and restoration is expected to provide a significant increase is habitat available to such species.

The predicted natural inflow hydrograph to the Flats from Saltese and Quinamose Creeks peaks in the winter to early spring. Currently this water is directed to ditches and, primarily, passed through the Flats to Shelley Lake for infiltration to the SVRP Aquifer, with some diversions for irrigation and small storage projects. Restoration of Saltese Flats to a seasonal lake will result in a shift in the discharge hydrograph from the majority of discharge occurring in the winter and early spring to discharge and infiltration from the Flats occurring in a more distributed manner throughout the year, with greater discharges throughout the summer than normally occur.

The historic state of Saltese Flats as a seasonal lake indicates it has inherent potential for seasonal storage. Available site data indicate that the system is restorable; however development and zoning may limit the fulfillment of restoration for specific purposes. For example, topographic data indicate that land zoned for potential future development, may infringe onto lower elevation areas potentially restricting the use of natural topography for water containment.

The Flats appear to be located over a low permeability layer which prevents rapid infiltration and therefore results in storage of inflows. Existing data is insufficient to confidently define the rate of recharge through the Flats, and the extent of hydraulic connectivity with the Spokane Valley Rathdrum Prairie Aquifer. The rate of direct groundwater recharge from the Flats will ultimately determine the ratio of water stored and released as surface discharge to Shelley Lake versus the quantity which infiltrates directly through the Flats. This rate will also influence the storage size necessary to retain inflows in the Flats. However, in terms of streamflow augmentation, surface water that recharges at either Saltese Flats or Shelley Lake is expected to have benefits to Spokane River flows through increased discharge to the river in gaining reaches, such as downstream of Sullivan Road, and potentially decreased losses in losing river reaches.

Saltese Flats restoration was evaluated in two steps, first using only existing natural inflows, and second using the addition of reclaimed water. Taking into account potential restrictions to restoration, physical conditions, and goals, three configuration options were developed to bracket the system's potential:

1. Restoration of the seasonal shallow lake system (seasonal lacustrine system) using topography to contain seasonal water. This would involve the purchase of some areas zoned for future urban development. This option is estimated to have storage potential of approximately 11,400 AF, and a surface area of approximately 1,200 acres.
2. Restoration of the seasonal shallow lake system (seasonal lacustrine system) using dikes to prevent flooding outside of the Spokane County wetland critical area boundary. This option is estimated to have approximately 8,600 AF of storage potential and a surface area of 895 acres.
3. Restoration of a seasonal marsh/wetland system (palustrine/emergent) within the Spokane County wetland critical area, with little manageable storage. This option is estimated to have storage potential on the order of approximately 2,000 AF, and surface area of approximately 895 acres.

Total annual natural inflow to the Flats is estimated to range from 8,800 AF to 15,700 AF. A water balance for the Flats indicates that, after taking into account losses to evaporation and recharge to the SVRP, these volumes can be fully contained under the first two configurations. This would result in an estimated monthly average recharge to the Spokane Valley Rathdrum Prairie Aquifer, between July and October of between 11 to 35 cfs depending on the engineering configuration and the annual climate variability. The third configuration is intended, primarily for habitat enhancement and preservation, not as a manageable storage system, and most of the inflow would be immediately discharged.

The described configurations could also accommodate reclaimed water inflows. Regulatory guidelines for the discharge of reclaimed water to wetlands define criteria to protect the wetlands, groundwater quality, and human health. These guidelines define average annual loading and average monthly water level criteria that are directly correlated to the total wetted area and based on pre-augmentation conditions. Hydraulic loading criteria for the described configurations results in limits which range from approximately 44 cfs to 61 cfs of inflow. Additionally inflow management must ensure that water levels do not increase over pre-augmentation conditions by more than 10 cm. Because Saltese Flats is degraded, pre-augmentation conditions are not readily measurable and therefore will be based on agreed upon characteristics of the desired wetland structure and function and collaboration with Ecology and the Washington State Department of Health (Health).

Wastewater will need to be treated to Class A reclaimed water standards with potential additional treatment requirements necessary depending on wetland characteristics and connectivity with groundwater. Criteria may vary from guidelines if a project can be shown to provide a net environmental benefit and/or that exemptions from certain criteria will not result in degradation of the environment.

Restoring Saltese Flats to a seasonal, shallow lake/wetlands system is an option that has been of interest to several agencies and therefore could be expected to receive wide support. The site has the potential to provide seasonal storage, wetland habitat, reclaimed water polishing and public benefit in terms of open space, environmental educational opportunities, decreased flooding potential in winter and increased discharge to Shelley Lake in the summer. Opposition to restoration of the Flats range from resistance from current land owners, including objections to real and perceived impacts of delivering reclaimed water to the site. Wellhead protection concerns of downgradient groundwater users must also be taken into account.

The site appears to have a wide range of restoration options, in terms of size and configuration. To maximize the available opportunities this site presents, it is necessary to coordinate many different agencies and objectives to achieve the maximum benefit. A multiple objective operational model which can account for the costs, benefits, constraints, and interrelationships of all the components (wetland quality, streamflow augmentation, reclaimed water, etc.) would aid agencies in planning decisions.

Estimated Saltese Flats restoration costs vary widely depending on the configuration and the type and management of inflow. At this stage in planning cost estimates could be expected to vary as much as 25% from the estimated costs below. For restoration using existing inflows, the largest costs are related to land acquisition and water retention structures (where necessary). Estimated costs for restoration using existing inflows are as follows:

- $11.3 to $11.9 million for configuration option 1;
- $11.2 to $12.2 million for configuration option 2; and
- $3.4 to $3.6 million for configuration option 3.

The largest costs associated with restoration using reclaimed water are associated with conveyance and any required treatment plant upgrades. These additional costs were estimated to add $31.1 million to either of the options considered for restoration using natural flows. Treatment plant upgrades are not included in this cost estimate. Conveyance costs are estimated using average unit conveyance costs reported for outfalls from the Spokane County Regional Treatment Plant.

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1.0 INTRODUCTION AND BACKGROUND

This report presents results of the Storage Assessment for WRIA 55 and 57 completed under the Watershed Planning Act, Revised Code of Washington (RCW) 90.82. This report builds on information gathered throughout the watershed planning process and presented several reports, including:

- Little Spokane and Middle Spokane Phase 2 – Level 1 Assessment (Golder, 2003);
- Little Spokane River Basin Instream Flow Needs Assessment (Golder, 2003);
- Level 2 Technical Assessment: Watershed Simulation Model (Golder, 2004); and,
- WRIA 55 & 57 Watershed Simulation Model Scenario Analysis (Golder, in Draft).

This report is the result of investigation into storage options in WRIA 55 and 57 and presentation and discussion of this material with the Planning Unit for assimilation and resulting guidance. The "First Step" storage assessment encompassed a broad investigation into storage types and potential locations where each storage option could be considered. The results of the first step were presented to the Planning Unit in a technical memorandum titled Draft First Step Storage Assessment Technical Memorandum (First Step Memo) (Golder, 2004). The First Step Memo, reproduced in Appendix A, was presented to the Planning Unit on July 21, 2004. Subsequent to that presentation the Planning Unit directed Golder to further investigate several storage options before providing guidance for the second step. Therefore, additional assessment was completed, presented in a memorandum titled Storage Assessment Direction for the Second Step (reproduced in Appendix B), and a second presentation was made to the Planning Unit on August 18, 2004. As a result of this presentation Golder was provided guidance to begin evaluation of three options: restoration of Saltese Flats, investigation of ASR is WRIA 55, and analysis of the dam raise potential of Baker (Ponderosa) Lake Dam (hereafter called Baker Lake) in WRIA 55.

Initial investigation into the dam raise potential of Baker Lake Dam revealed that the current owner was not interested in selling or in allowing the existing dam to be modified. He recommended investigation into a new dam upstream of the existing dam on his property. This represented a unique situation in that the owner indicated he was willing to allow construction of a dam on his property and it would be upstream of an existing fish passage barrier (Baker Lake Dam). A brief memo outlining this information and several options for replacement of the option was presented to the Planning Unit (Draft Baker Dam Site Visit Results and Suggested Direction, included in Appendix C). This memo suggested that investigation of a new dam may be valuable, and that rather than focusing the designated funds on investigation of a single new dam location that two new dam locations be evaluated so that they could be compared in terms of costs, drawbacks and benefits. The suggested investigation sites were Beaver and Buck Creek where conditions (hydrology, geology, location) appeared favorable to a new dam. As a result this option was changed to assessment of new dam potential on Beaver Creek and Buck Creek in WRIA 55.

The final storage options chosen by the Planning Unit for investigation in the second step of the Storage Assessment are:

1. Aquifer storage and recovery (ASR) in the Lower Little Spokane River, WRIA 55, using the Spokane Valley Rathdrum Prairie Aquifer (SVRP) as source and the Little Spokane River Aquifer as the receiving water body.
2. Evaluation of new dam potential on Beaver and Buck Creeks in northwestern WRIA 55.

3. Saltese Flats restoration for storage potential with additional focus on the potential for reclaimed water discharge to the Flats in WRIA 57.

The locations of these storage options can be found in Figure 1-1.

1.1 Objectives

The intended objective of the storage assessment component of watershed planning is identified in Chapter 90.82.070 RCW:

> "The objective of these strategies is to supply water in sufficient quantities to satisfy the minimum instream flows for fish and to provide water for future out-of-stream uses … and to ensure that adequate water supplies are available for agriculture, energy production, and population and economic growth under the requirements of the state's growth management act, chapter 36.70A RCW. "

Based on the results of Watershed Planning work completed in WRIA 55 and 57 as well as conversations with Spokane County the following specific list of objectives was developed and presented to the Planning Unit in a Memo dated June 8, 2004.

<u>WRIA 55:</u>

1. Offset potential impacts on streamflow from future water supply development under existing water rights.
2. Offset potential impacts on streamflow of future water allocations (new water rights).
3. Prevent the interruption of exercise to junior water right holders during dry years in WRIA 55.
4. Improve flow-based aquatic habitat (for example flows for passage, and redd coverage) where flow is a potentially limiting factor.
5. Improve flow related surface water quality problems.

<u>WRIA 57</u>

1. Offset potential impacts on streamflow from future water supply development under existing water rights.
2. Offset potential impacts on streamflow of future water allocations (new water rights).
3. Use reclaimed water for groundwater recharge in WRIA 57.
4. Improve aquatic habitat through increased flows (for example flows for passage, and redd coverage) where flow is a potentially limiting factor.
5. Improve flow related surface water quality problems.

Enhancement of streamflow or prevention of further impacts to streamflow is typically a benefit of managing storage for existing or future uses. Table 1-1 summarizes, the volume, where they are able to be calculated, of water projected to be necessary to meet each objective. The First Step Storage Assessment in Appendix A has more detail on the quantities and locations to which each objective applies.

This report is not intended to provide a complete design of each storage option. Rather it is intended to provide the Planning Unit with sufficient planning level detail including the requirements of implementation, benefits, drawbacks, and factors contributing to costs.

1.2 Report Organization

This report includes a summary of relevant portions of previous memorandums (the full texts are included in the Appendices) and a preliminary assessment of the three identified storage options. Report organization is as follows.

- Section 2: A summary of the type of storage projects considered in WRIA 55 (Little Spokane Watershed) and WRIA 57 (Middle Spokane Watershed) and the specific storage options considered feasible subsequent to the First Step analysis.

- Section 3: Conceptual design, planning level costs, projected benefit and implementation considerations for aquifer storage and recovery (ASR) in the Lower Little Spokane River, WRIA 55.

- Section 4: Conceptual design, planning level costs, projected benefit and implementation considerations for new dam sites on Beaver and Buck Creeks in WRIA 55.

- Sections 5: Conceptual design, planning level costs, projected benefit and implementation considerations for restoration of Saltese Flats for storage.

- Section 6: Summary and discussion.

By convention, storage projects are typically developed in volumetric units, acre feet (AF), or million gallons (MG). Units of AF are used in this report. One AF of water is equivalent to 0.33 MG of water and can sustain a flow of one cubic feet per second (cfs) for approximately half a day, or provide a supply of 0.6 gallons per minute for one year.

1.3 Water Storage Task Force

The water storage task force was convened by the Washington State Department of Ecology (Ecology) in 2000 to examine the role of increasing water storage in water resources management. The report to the legislature, titled Water Storage task Force Report to the Legislature (Ecology, 2001), provides valuable information on storage and was used as a reference throughout this study.

During the legislative session, the definition of a storage “reservoir” was expanded to include underground formations. This led to the development of permitting for Aquifer Storage and Recovery or “ASR” projects. A 2001 report to the legislature, titled Chapter 173-157 and Aquifer Storage and Recover Report to Legislature provides information on ASR.

1.4 Water Storage SEPA Elements Related to RCW 90.82

WDOE has addressed six potential water storage alternatives in its programmatic EIS for watershed planning, as described below.

Alternative WP 19: Construct and operate new on-channel storage facilities. Under this alternative, a water storage facility would be created by impounding a river or stream. On-channel storage facilities could include large reservoirs on the mainstem of major rivers as well as small reservoirs on tributary streams. Construction could involve creation of an earthen dam or a concrete dam.

Alternative WP 20: Raise and operate existing on-channel storage facilities. Under this alternative the capacity of an existing on-channel reservoir would be increased by raising or enlarging the impoundment structure.

Alternative WP 21: Construct and operate new off-channel storage facilities. Under this alternative, an impoundment structure, either earthen or concrete, would be created in an upland location. Water would be diverted or pumped from a river to an off-channel location for storage.

Alternative WP 22: Raise and operate existing off-channel storage facilities. Under this alternative the capacity of an existing off-channel reservoir would be increased by raising or enlarging the impoundment structure.

Alternative WP 23: Use existing storage facilities for additional beneficial uses. Operation of a storage facility constructed to provide water for one specific beneficial use or group of uses could be modified to provide water for additional beneficial uses. For example, use of a storage facility originally constructed for municipal water supply could be expanded to supply water for irrigation or to provide additional flows for fish during critical life stages.

Alternative WP 24: Construct and operate artificial recharge/aquifer storage. Aquifer storage and recovery involves introducing water, usually surface water from rivers, into an aquifer through injection wells or through surface spreading and infiltration. The introduced water is stored in the aquifer until needed and then withdrawn from the aquifer through wells for beneficial use. Water to be stored in an aquifer must meet the state's ground water quality standards, Chapter 173-200 WAC.

The programmatic EIS is intended to provide support development of a watershed plan. Additional SEPA compliance may be needed for the implementation of specific recommendations and individual projects. Such compliance might be satisfied by a SEPA checklist for small projects, although larger projects may require a project EIS.

2.0 SUMMARY OF THE FIRST STEP STORAGE ASSESSMENT

This section provides an overview the First Step Storage Assessment Technical Memorandum (Appendix A). The technical memo served as the base investigation from which final storage options were chosen. This section includes estimates of excess water availability and a summary of surface water and groundwater storage options that were considered in the steps leading up to this report.

2.1 Availability of Excess Surface Water for Storage

A preliminary estimate of the amount of water available for storage was determined by classifying the amount of flow over the instream flow requirement as "excess" which could be withdrawn from the river for storage and beneficial use. Excess water was determined by comparing the minimum instream flow requirements with the 7-day average 10%, 50%, and 90% exceedance flows at each station. More details can be found in Appendix A. Table 2-1 describes excess water available at the Spokane River at Spokane and the Little Spokane River near Dartford.

2.2 Surface Water Storage

The types of surface water storage considered in WRIA 55 and 57 included expansion of existing reservoirs, increased storage in existing natural lakes, new storage on small tributaries or off-stream locations, wetlands restoration/construction, and small impoundments for infiltration or water supply. Overall more than 50 existing surface water bodies were assessed as well as several drained wetland areas. Assessment results indicated development, the location of a water body over permeable aquifer material, and size were the main reasons dams were not considered suitable for storage. Surface storage options that were considered feasible for further analysis in the First Step Storage Memorandum are summarized in Table 2-2 and are described briefly below. Additional information on the method of analysis and each storage option can be found in the original memorandums contained in Appendices A through C.

Surface storage analysis for all new or raised structures was completed using dam heights of 20 feet and 40 feet, for consistency. These heights should not be construed as recommended heights, but were used as a basis for comparative analysis.

2.2.1 Baker Lake Dam

This option involved raising an existing dam, Baker Lake Dam, to increase storage in the reservoir. Baker Lake Dam is located in Stevens County on Beaver Creek, a tributary of the West Branch Little Spokane River. Estimated available storage at the site ranged from 2,090 to 6,630 AF. Further analysis indicated natural inflow may only supply a reservoir of approximately 1000 AF. A site visit by Golder, Spokane County, and Natural Resource Conservation Service (NRCS) personal was made to this dam in August, 2004 in order to determine if raising the dam was feasible from both a logistical and technical perspective. The current owner indicated he was not interested in selling the existing dam or allowing it to be raised. He recommended a comparable site just upstream of the existing reservoir that he considered suitable for a new dam. The upstream site was ultimately determined to be valuable for analysis

2.2.2 Chain Lake

Chain Lake is on the Little Spokane River in Pend Oreille County just north of the Spokane County Line. There are buildings near the mid-point of the lake with a road leading towards them; additionally the Burlington Northern Railroad line goes along the northwest side of the lake. These two issues would restrict elevation increases to an estimated amount of 15 feet (contour intervals in this area are 40 feet). Estimated additional storage at 15 feet is 2,939 AF. The location of this lake on the mainstem Little Spokane River, and native kokanee habitat that exists within the lake resulted in its removal from further analysis.

2.2.3 Horseshoe Lake

Horseshoe Lake is located at the confluence of the West Branch of the Little Spokane River, Buck Creek and Spring Heel Creek. Buildings and a boat ramp exist along the west shore. The lake is shaped as a downward facing horseshoe with a primary channel extending south from the eastern arm and marshy channel extending south from the western arm. This resulted in several options for reservoir configuration including use of both or one channel leading south from the lake. Assuming use of both channels, estimated additional storage was 14,660 to 45,880 AF. Existing development as well as negative response to additional storage on the West Branch Little Spokane River resulted in its removal from further analysis.

2.2.4 Trout Lake

Trout Lake is located upstream from Horseshoe Lake on the West Branch Little Spokane River. On the south side of the lake there is a road and a few docks and buildings, but maps do not indicate extensive development. It appears that if the lake were raised by more than 30 feet it would flood back up into Spring Heel Creek towards Sacheen Lake. Estimated additional storage ranged from 3,831 to 12,489 AF. Existing development as well as negative response to additional storage on the West Branch Little Spokane River resulted in its removal from further analysis.

2.2.5 Lake of the Woods

Lake of the Woods is located off-channel from the Little Spokane River near Chain Lake. A road runs along the north side of the lake. It has no defined inlet or outlet channels but may be a depressional lake where run-off collects. It would likely require conveyance from the Little Spokane River to fill a dam on this site. At 20 and 40 foot dam heights estimated additional storage was 490 AF and 2,220 AF of storage respectively. Concerns regarding the capital and operations and maintenances cost of conveyance to this site resulted in its removal from further analysis.

2.2.6 New Dams

Portions of WRIA 55 and 57 were determined to be suitable for new dams based on geology, hydrology and critical habitat. In WRIA 55 three general areas were identified: the upland portion to the northwest in the West Branch Little Spokane River drainage, the northern Dragoon Creek drainage, and to the east and northeast, on the slopes of Mount Spokane, primarily in the Little Deep and Deer Creek drainages. In WRIA 57, two areas were considered feasible for new dams, the Newman Lake sub-basin upstream of Newman Lake, and the Liberty Lake sub-basin upstream of Liberty Lake. Both drainages are fed by run-off from mountainous areas (Mt. Spokane and Mica Peak respectively) and so may have significant run-off or water could be diverted or pumped from the Spokane River to fill storage needs. New dams were initially not considered a desirable option, but analysis of one new site in the West Branch Little Spokane River was chosen in order to provide a comparison to the Beaver Creek site upstream of Baker Lake Dam.

2.2.7 Newman Lake

Newman Lake was considered for storage in several different forms including a dam raise, operational changes, wetlands restoration and multipurpose use of their infiltration gallery. Ultimately it was determined that restoration of the wetlands surrounding Newman Lake would be the most feasible option (see Appendix A for more detail). Investigation into the potential for wetlands restoration determined that the Newman Lake Flood Control District is interested in removing lands around the lake from agriculture in order to improve lake water quality and reduce flooding problems (Barrentine, 2004). Additionally, the Natural Resources Conservation Service (NRCS) indicated that additional wetlands restoration work is feasible and desirable in the area (Fechter, 2004). However, two entities, the NRCS and Spokane County Parks and Recreation have already completed some restoration in this area, with additional investigations on the upstream areas underway. Therefore it was determined that wetlands restoration of the Newman Lake area is already being studied through other processes.

2.2.8 Saltese Flats Wetlands Restoration

Saltese Flats was once a shallow lake encompassing approximately 1,270 acres (NWI, 1980). The land was ditched and drained to be used for agriculture. The area is fed by the intermittent Saltese and Quinnamose Creeks. The creeks continue in several ditches across the Flats, eventually draining to Shelley Lake within the City of Spokane Valley municipal boundaries. The land has ecological significance due to some existing and restorable wetlands and the Washington Department of Fish and Wildlife (WDFW) has attempted to purchase it. To date this has not occurred due to failed price negotiations and the land is still privately owned. The size of Saltese Flats and its former state as a shallow lake indicated it could provide significant storage. This option was retained for further analysis for purposes of wetlands restoration and streamflow augmentation and as a potential site for the discharge of reclaimed water.

2.2.9 WRIA 55 Wetlands Restoration

In WRIA 55, 6 drained wetlands to the northeast of Diamond Lake, with a total area of approximately 840 acres, were identified for potential restoration. These wetlands historically acted as seasonal, palustrine, emergent wetlands (NWI, 1980). They present an advantage over many wetland restorations in that they are concentrated in area, large in size and appear to be hydraulically connected by surface channels (draining towards Diamond Lake). The fact that surface channel connections exist between wetlands may indicate that discharge from the wetlands occurs as surface water as well as, or rather than, groundwater. Therefore hydraulic control could possibly be exerted over the water stored in these wetlands through one or several control structures allowing water to be released when it’s needed. One concern that was raised is the potential for these wetlands to cause flooding around Diamond Lake. According to aerial photos taken between 1995 and 1998, the majority of the land is still used for agriculture and appears to be ditch drained. While these sites were considered feasible, there was concern over the true potential for streamflow augmentation from wetlands restoration. This option was not retained for further analysis.

2.3 Ground Water Storage

The types of ground water storage considered in WRIA 55 and 57 included aquifer storage and recovery, artificial recharge of diverted river, surface percolation of storm and reclaimed water and direct streamflow augmentation with groundwater (“pump and dump”). Groundwater storage options that were considered feasible in the First Step Storage Assessment in WRIA 55 and 57 are summarized below. Additional information on these storage options can be found in Appendices A through C.

2.3.1 Direct Augmentation from the SVRP Aquifer to LSR (WRIA 55 & 57)

This option consisted of pumping groundwater from below the clay lens in the Hillyard Trough, and discharging it to the Little Spokane River to increase streamflow during low flow years. This option was considered feasible because the SVRP Aquifer is sufficiently transmissive to fully recharge during the winter and not become drawn down by increased seasonal pumping. Existing water distribution infrastructure is available to transport water to the lower reach of the Little Spokane River, potentially allowing the river to meet regulatory instream flows. Insufficient data and understanding of the clay lens complicates the assessment of the feasibility of this option. Additionally, the length of stream benefit is relatively short including only the lower Little Spokane River, where streamflow is already naturally supplemented by inflow from the SVRP Aquifer. This option was not further evaluated.

2.3.2 Aquifer Storage and Recovery in the Lower Little Spokane Watershed

This option considered using the SVRP Aquifer as source water for injection to the aquifers between Dartford and the confluence of Deadman Creek on the Little Spokane River with the purpose being either for streamflow augmentation or water supply enhancement. Existing water distribution infrastructure, in the form of wells and transmission pipelines, were envisioned to provide a method for retrieving and transporting the water to the injection location. Injection into the shallower unconsolidated sediments or into the deeper basalt aquifer was considered. This option was retained for further analysis.

2.3.3 Recharge to Gravel Pits in WRIA 55

Gravel pits were considered as prospective aquifer recharge sites. Gravel pits are usually located in relatively permeable sand and gravel formations that could sustain high infiltration rates, and their topographic depressions provide hydraulic containment during infiltration. An assessment of gravel pits in WRIA 55 was completed to determine if suitable locations existed. Suitable locations were considered to be close to a potential storm water source, overlying sands and gravels and far enough from the river to provide lag time to meet streamflow augmentation needs. Only 4 locations were considered potentially suitable for infiltration:

- 10127, T29N R43E Sec. 14;
- 11589, T28N R43E Sec. 28;
- 12312, T29N R43E Sec. 14; and,
- 12626, T29N R43E Sec. 14.

Detailed stormwater information was not available but the topography and catchment areas of these gravels pits are relatively small and conveyance or diversion would likely be required in order to provide water to the sites. The SVRP in WRIA 57 was anticipated to be too permeable for infiltration for streamflow augmentation to be feasible.

2.3.4 Artificial Recharge of Deer Park Aquifer (WRIA 55)

This option involved diverting water from Dragoon Creek during high flow (e.g., December-April) periods to infiltration trenches for groundwater recharge. It was estimated that water would have to be delivered at least one mile away from the creek in order to achieve an adequate lag time for return of the recharged water via groundwater to the stream (e.g., three months between recharge and streamflow augmentation). Topography and stream locations in the area indicated a gravity fed diversion of that distance would not likely be feasible, and pumped conveyance would likely be prohibitive in cost.

2.3.5 Surface Percolation of Reclaimed Water

Preliminary site development studies and environmental analysis have been completed for the planned Spokane County Regional Treatment Plant (SCRTP). There is currently concern over proposed discharge from the SCRTP to the Spokane River due to ongoing Total Maximum Daily Load (TMDL) studies and the potential for water supply well contamination due to the high hydraulic connectivity between the river and the aquifer. Therefore this option assessed the possibility of surface percolation to the SVRP Aquifer and its potential benefit to Spokane River low flow. While surface percolation of reclaimed water may provide additional benefits in terms of water quality, it was not determined to provide significant benefit in terms of low flow augmentation over direct river discharge. Discussion at the mid-project workshop indicated that the Planning Unit would prefer to focus on options which provide greater benefit to Spokane River low flow.

2.4 Second Step Storage Focus

The First Step Storage Assessment and subsequent Planning Unit presentations and communications resulted in a body of information that allowed the Planning Unit to determine focus for the remaining assessment. The Planning unit chose to focus efforts on the following options.

1. Aquifer storage and recovery (ASR) in the Lower Little Spokane River, WRIA 55, using the Spokane Valley Rathdrum Prairie Aquifer (SVRP) as source and the Little Spokane River Aquifer as the receiving water body.
2. Evaluation of new dam potential on Beaver and Buck Creeks in northwestern WRIA 55.
3. Saltese Flats restoration for storage potential with additional focus on the potential for reclaimed water discharge to the Flats in WRIA 57.

3.0 ASR IN THE LOWER LITTLE SPOKANE WATERSHED

The first step of the storage assessment identified the following options involving groundwater storage, of which the first one was selected by the Planning Unit for further evaluation in the second step of the project:

- Aquifer Storage and Recovery (ASR) in the Lower Little Spokane River basin: This concept was selected by the Planning Unit for further evaluation in the second step of the storage assessment. Projected future growth in water demand is expected to exceed currently issued water rights, in the next five to ten years. Existing instream flow regulations may constrain the issuance of additional water rights. The concept being evaluated here is storing water during times of relative high availability (winter-spring) in aquifers near the confluence of Deadman Creek with the Little Spokane River for use in summer public water supply. Inefficiencies in the recovery of stored water for use in municipal supply would most likely result in the leakage of water from the aquifer system and augment baseflows of the Little Spokane River.

- Direct augmentation of Little Spokane River streamflow with groundwater from the SVRP Aquifer: This concept involves pumping groundwater from a deep portion of the SVRP in the Hillyard trough during low flow periods and discharging it directly to the Little Spokane River to augment stream flows. This concept was not selected for further development because increased streamflow would only occur below the USGS' Dartford stream gage station, and would not affect regulatory enforcement. Also, the affected reach already receives significant natural groundwater discharge from the SVRP through the Hillyard Trough and is not considered to be as impaired as other Little Spokane River reaches upstream of the Dartford gage.

- Recharge to gravel pits in WRIA 55: The benefits to the overall watershed hydrology by directing stormwater runoff to existing gravel pits was not considered sufficient for further evaluation at this time relative to other options. However, local stormwater management efforts should consider this action.

- Artificial recharge of the Deer Park Aquifer: Historical groundwater nitrate concentrations have impaired water quality in the City of Deer Park public drinking water wells. Artificial recharge to groundwater was considered to dilute the groundwater nitrate concentrations and/or direct groundwater nitrate plumes away from public drinking water wells. However, groundwater nitrate concentrations have decreased over the last five years and additional mitigation is no longer considered necessary.

- Surface percolation of reclaimed water: There may be constraints on the discharge of effluent from future wastewater treatment plants to the Spokane River, and the surface percolation of reclaimed water to the underlying aquifers was considered as a possible storage option. However, further evaluation of this option was deferred in favor of further evaluating the discharge of reclaimed water to restored wetlands of Saltese Flats.

3.1 Aquifer Storage and Recovery (ASR)

ASR is a water management method in which water is recharged into an aquifer during times of surplus, is stored for a period of time (from months to years), and then withdrawn during periods of high demand or for emergency use. The likelihood of securing new water rights for additional consumptive use in the near future is uncertain. Because of this and the expected deficits, the Planning Unit decided to investigate the feasibility of ASR in the southern portion of Lower Sand and Gravel Aquifer system as part of a collaborative effort to secure a municipal supply drinking water to local service areas, meet future anticipated demand, and minimize impacts to streamflow. ASR efficiency is often less than 100 percent due to seepage from the groundwater system. This can be a benefit to surface water flows in cases where recharged water seeps into and augments adjacent streams. In order for ASR to be feasible and implemented the following requirements must be fulfilled:

- There must be an adequate receiving aquifer for receiving and storing water;
- There must be an appropriate source of water for use in recharge; and,
- There must be an appropriate application to justify the funding, permitting and implementation an ASR program.

In the first step of the storage assessment, the aquifer system in the vicinity of the confluence of Deadman Creek with the Little Spokane River was identified as a candidate aquifer for receiving and storing water. The properties of the aquifer system in this area in regard to ASR are further evaluated in the second step of this storage assessment. An appropriate source of water for use in recharge in an ASR program usually has seasonal availability of acceptable quality. The portion of the SVRP Aquifer in the main Hillyard Trough was identified as a potential source of recharge water. Because the SVRP Aquifer has an exceptionally high degree of hydraulic continuity with the Spokane River, withdrawing from the Spokane Aquifer is comparable to withdrawing from the Spokane River from a quantitative perspective. The SVRP in the vicinity of the Hillyard Trough is fully recharged each winter and spring, and seasonal (winter-spring) withdrawals are not expected to have an adverse impact on summer streamflows or groundwater availability. Water quality of groundwater in the SVRP is also excellent and does not require advanced treatment for recharge purposes that is typical of using a conventional surface water source.

The Whitworth Water District #2 (WWD #2) overlies both the LSR and SVRP Aquifers with wells that are completed in both aquifers and connected by a common distribution system. This provides an infrastructure network that is easily modified for implementation of ASR without significant capital cost. The district is currently near the capacity of existing water rights, and increasing demand is expected to require additional water right capacity in the next five to ten years.

The purpose of this portion of the study is to provide a pre-feasibility study of employing ASR in the target unconsolidated aquifer system. The evaluation draws on much previous work performed by others, including drilling, well installation, aquifer testing, geophysical surveys, modeling, and geologic interpretation, as well as historical data collected by various water agencies, and information contained in recent Comprehensive Water Plans.

In general, the potential benefits of an ASR scheme could include:

- Provide an environmentally responsible means of meeting future water demand;
- Increase the reliability of municipal water supply;
- Offset potential impacts from future water supply development;
- Improve aquatic habitat through increased flows; and,
- Improve flow related surface water quality problems.

3.1.1 Specific Application and Purpose

The ASR configuration considered here consists of withdrawing groundwater from the Hillyard Trough area of the SVRP Aquifer during the winter and spring months (when groundwater levels and surface water flows are at their seasonally highs), delivering the water through existing municipal distribution facilities, and recharging the water into a suitable aquifer of the lower Little Spokane River area. The SVRP Aquifer is considered a sustainable winter source of water because historical and simulated groundwater hydrographs indicate that it is seasonally fully recharged. A suitable storage aquifer would hold the water until the summer withdrawal period.

Stored water could be used to meet existing and/or future summer peaking demand, and/or minimize impacts to streamflow from peak summer withdrawals. Any leakage of stored water would result in the augmentation of streamflow. The effect of leakage of artificially recharged water to augment streamflow depends on the degree of hydraulic continuity between the receiving aquifer and the river. Augmentation of instream flows is expected to increase flows at the USGS stream gage at Dartford, which is used for instream flow compliance monitoring and enforcement.

Whitworth Water District #2 anticipates that water demand in the Little Spokane River portion of their service area could exceed currently permitted instantaneous water supply and existing well capacity before the year 2007 (E&H Engineering, 2000) if growth patterns continue as in the past and no new water rights are acquired. Permitted annual quantities are sufficient to meet projected future demand past the year 2020.

The scope of this study is restricted to meeting future demand by using ASR to increase the permitted instantaneous withdrawal rate. Other solutions to meeting future demand that are not further developed in this assessment include conservation, acquisition of new water rights, and other mitigation strategies. Conservation may offer the most economical solution and is being rigorously developed as part of the watershed plan. Any one of these possible solutions may be considered separately, or as part of a coordinated water resource management plan.

3.1.2 Area Summary

The study area encompasses the southern part of the Little Spokane Watershed (WRIA 55), located in eastern Washington near the border with Idaho and situated on the eastern edge of the Columbia River Basalt Plateau. The primary drainage in this watershed is the Little Spokane River, which along with its tributaries, flows over and around several smaller aquifer systems (Figure 3-1). The natural drainage of the Little Spokane River Basin is entirely contained within the WRIA 55 boundary.

The predominant natural land cover in the lower Little Spokane River basin is scrub brush. Agricultural land use is concentrated in the Dragoon Creek and Deadman Creek sub-basins of the Little Spokane watershed, and scattered in lower density throughout the rest of the lower elevations of the watershed. Substantial suburban development is occurring in the lower reaches of the Little Spokane River north of the City of Spokane. Minor amounts of land are used for rangeland. Elevations in the basin vary from approximately 1,600 ft above msl in the southwestern portion of the basin to approximately 5,900 ft above msl on the summit of Mount Spokane.

The climate of the lower Little Spokane River basin is generally warm and dry in the summer and cool and moist in the winter. Large variations in climate occur across the WRIA 55 basin, from a subhumid mountain climate in the north to semiarid in the south. Annual precipitation varies from an average of less than 20 inches annually in the southwest areas (including the immediate study area) to more than 40 inches in the north and east. A more complete description can be found in the Phase II - Level I Technical Assessment report (Golder, 2003).

3.2 Geologic Setting

The geologic units that occur within the study area can be divided from youngest to oldest into three major terrains (Figure 3-2):

- Unconsolidated deposits;
- Basalt flows and intercalated sediments; and,
- Crystalline basement.

The geology generally comprises vertically stratified and laterally discontinuous geologic units that have been modified at the surface by erosional processes. After the formation of the Columbia River Basalt flows and before the most recent glaciation, the Spokane River flowed westwards from Idaho through the Spokane Valley, northwards around Beacon Hill in what is known today as the Hillyard Trough. At this time, the ancestral Spokane River probably entered the Little Spokane River between Waikiki and Griffith Springs. The Spokane River would have flowed on a basement and basalt surface at an elevation of about 500 feet lower than today's ground surface. The ancestral Little Spokane likely flowed within the same general area as it does today, also on a predominantly basement and basalt surface and at a lower elevation than that of the present river elevation. A full description of the geologic history of the region in included in Section 4 of the Phase II - Level 1 Assessment Report (Golder, 2003). The main geologic units present in the study area are described below following a description of the refinement of existing cross sections and development of new cross sections.

3.2.1 <u>Geological Cross Sections</u>

Four existing hydrostratigraphic sections that were initially developed by Washington Department of Natural Resources (DNR) for previous water resource assessments of the area were updated. These original sections were included in the Phase II - Level I report (Golder, 2003), and are now named A-A' through D-D' (Figures 3-4 through 3-6). These sections show the general nature of the hydrostratigraphic units at the outer limits of the study area. The unconsolidated alluvial and glacial units overlie the (mostly) granitic bedrock, and range from a maximum thickness on the order of 700 feet near the center of the area, and thin to the west and east where they pinch out over the granitic bedrock outcrops just west of Dartford Creek and east of Colbert and Deadman Creek.

To the south near Wandermere Lake, the bedrock appears to rise close to the surface (Section C-C'). Although the alluvial units in the Lower Sand and Gravel Aquifer connect with the Hillyard Trough to the west of the lake, this feature provides some localized restriction to groundwater flow.

Five additional hydrostratigraphic sections were developed to more closely examine the nature and distribution of the aquifers in the area. The locations of these new sections, titled E-E', F-F', C'-D, G-G' and H-H' (Figures 3-2 and 3-3 [plan view] and 3-8 through 3-10 [cross sections]) along with the locations of the key wells. The primary source of information for the sections was drillers' logs stored in the Ecology database and well and field testing information provided by the local purveyors.

The Ecology database assigns a well location based on a "quarter-quarter" section, and the general accuracy is on the order of +/- ¼ mile. The lithologies included in each log were reviewed and elevations of units were estimated based on approximate ground surface levels. Depths to water were used, where given. However, because water levels were measured at the time of drilling and well completion, and were measured at various times of the year, care should be taken in interpreting these levels.

The aquifer extends further north, east and west than the inferred in the SAJB wellhead protection plan (CH2M Hill, 2000); the original footprint covered an area approximately 8,000 feet by 3,000 feet. The north-south length of the aquifer based on the Golder sections could extend a distance of up to 20,000 feet (almost 4 miles). However, the aquifer does not appear to extend further south than Wandermere Lake, where the bedrock rises to near land surface.

Although the Lower Sand and Gravel Aquifer appears to be well confined in most locations, the confining clay layer appears to be absent in the vicinity of Deadman Creek near Mead (Figure 3-8, Section E-E'). The aquifer is also locally discontinuous and appears to pinch out near the Soukoup well, and becomes unconfined north of Little Deep Creek at Colbert Road (Figure 3-10, Section C'-D). The estimated maximum width of the aquifer is on the order of 12,000 feet (Figure 3-8, Section E-E') and probably averages between 6,000 and 8,000 feet.

New sections G-G' and H-H' (Figure 3-11 and 3-12) show the interpreted hydrostratigraphy in the southwestern portion of the area of interest. The purpose of these sections was to assess the aquifer thickness and in particular, whether the bedrock high noted near Wandermere Lake extends westwards. The bedrock is sufficiently close to the surface to act as a barrier to groundwater flow.

The new geological cross sections also show the inferred position of the piezometric surface based on water levels measured by well drillers at the time of well construction. The depth to water in the wells located close to Little Spokane River ranged from 10 to 40 feet below ground surface.

3.2.2 Unconsolidated Quaternary Sediments

Quaternary (2 million years ago to the present) unconsolidated deposits comprise predominantly sands and gravels with minor amounts of silt and clay. Quaternary sediments within the study area were deposited during glacial advances and retreats up to the present day alluvial system. The unconsolidated Quaternary sediments (denoted with a "Q" prefix on Figure 3-2) occur within the valleys of WRIA 55. The present day thickness of the unconsolidated sediments ranges up to 700 feet or more within the Hillyard Trough area of southern WRIA 55 but is generally between 50 to 100 feet within the local valleys. The thickness of the sediments is a function of three features:

- The pre-Quaternary buried valley that was eroded by the ancestral Spokane and Little Spokane Rivers into the crystalline basement (granitic and metamorphic rocks) and basalt rocks;
- The glacial flood derived sand and gravel deposits that partially fill the early valleys and the lower reaches of the tributary valleys; and,
- The combined erosional / depositional surface of the present valley floors.

The main units that make up the unconsolidated Quaternary deposits, generally from oldest to youngest, are described as follows. The Lower Sand and Gravel, and Flood Sand and Gravel deposits form the principal aquifers within the ASR study area.

Lower Sand and Gravel Aquifer (Qfs/Qfg/Qfcg)

This unit overlies the Latah, basalt and basement rocks in the study area and occurs in the northern portion of the Hillyard Trough. It comprises medium dense to very dense, fine to coarse sand with some gravel and occasional gravel and silty sand zones. Meltwater streams draining major glacial ice lobes likely deposited these sediments. The thickness of the unit is estimated to range between 100 to 300 feet thick with an average thickness of about 200 feet.

The Lower Sands and Gravel Aquifer within the study area is an extension of the SVRP Aquifer, and extends several miles up the Little Spokane River Valley. It is comprised of laterally discontinuous strata of highly permeable sands and gravels within a matrix of finer sediments (Boese and Buchanan, 1996).

Glacial Lacustrine Deposits (Qgl)

The glacial deposits within the area are generally well-laminated fine sands, silts and clays that contain some interbeds of fluvial gravel. Stratified clay, silt and fine sand sequence appears to extend from the northern end of the Hillyard Trough beneath the Little Spokane River, northward to the Colbert area, and overlie the Lower Sand and Gravel Unit and may be up to 200 feet thick. This unit is not obviously exposed in the immediate study area, and acts as a confining unit to the underlying Lower Sand and Gravel Aquifer.

Flood Sand and Gravel Aquifer (Qfs/Qfg/Qfcg)

The Flood Sand and Gravel Units infill the Spokane Valley (ranging up to 700 feet thick) and blanket the Little Spokane River and tributary valleys. This unit is composed primarily of loose to dense, well-graded sand and gravel with cobbles, boulders and zones of silty gravelly sands. The proportion of cobbles and boulders within this unit decreases in a westerly direction across the Spokane Valley and the unit tends to be finer grained within WRIA 55 than within WRIA 57.

Within WRIA 55, the thickness of the flood sands and gravels ranges from less than 50 feet to 200 feet adjacent to the Little Spokane River channel. The flood deposits include bars and terraces of poorly-sorted sand and gravel up to several hundred feet thick in the center of the channel, generally thinning towards the west and east. This formation contains the water table and is in close hydraulic continuity with the Little Spokane River.

Loess (Ql)

Wind blown loess (known locally as the Palouse Formation) caps the basalt plateaus in the southern portion of WRIA 55. These eolian deposits comprise angular fragments of fine sand to silt sized grains of quartz, feldspar and mica derived from alluvium, flood sediments and glacial outwash deposits. As WRIA 55 occurs at the northern edge of the Palouse depositional area, the loess particles are relatively fine and the depth of the unit thin. Well logs from Green Bluff indicate loess thicknesses of less than 25 feet.

Recent Deposits (Qal/Qp/Qla)

Recent deposits include alluvium which occurs in present stream channels, and includes primarily reworked glacial sediments and flood deposits and gravel, sand and silt alluvial fans that have formed where steep drainages enter lower gradient drainage. Alluvium is generally lined on either side by glacial deposits in the stream channels.

3.2.3 Basalt Flows and Intercalated Sediments

The basalt rocks in the study area (indicated by “Tw” on Figure 3-2) comprise Miocene age Columbia River Basalt Group flows intercalated with fluvial and lacustrine deposits of the Latah Formation. Because WRIA 55 is located at the northeastern extent of the Columbia River Plateau, only two of the Columbia River Basalt flows extend into the basin. These belong to the Grande Ronde Basalt and the Priest Rapids Member of the Wanapum Basalt. The basalt flows are believed to have flowed in an easterly direction into the Spokane Valley from the Columbia Plateau. The basalts are gray to black, massive, fractured, sometimes with columnar joints, and often vesicular rocks.

The basalt rocks resist erosion and tend to locally form the flat-topped prairies (Halfmoon Prairie) and bluffs (Green Bluff). Within WRIA 55, the basalts occur primarily on the west side of the Little Spokane River, within the southern portion of the basin (Figure 3-2). The basalts occur within 100 feet from surface and are exposed as a series of erosional remnants following the last glaciation and the Missoula Floods.

The Latah Formation (indicated by “Tl” on Figure 3-2) consists of lacustrine silt and clay beds containing some fluvially deposited sand and gravel. Latah sediments are often orange where oxidized, off-white to dark-gray where not oxidized. They are very stiff to hard, silt and clayey silt to silty fine sand with minor sand and gravel beds. Robinson (1991) characterized the Spokane County Latah Formation as comprising 60% clay or silty clay, 30% silt and 10% sand and gravel. The sand and gravel beds ranged up to 20 feet in thickness (Robinson, 1991).

Stratigraphically, Latah Formation sediments may underlie or overlie the Grande Ronde, and underlie the Priest Rapids Member of the Wanapum Basalt. Latah Formation sediments are associated with the basalt exposures and occur in the south and central portions of WRIA 55 and are typically exposed along the steep bluffs that define the edges of the prairies.

3.2.4 Crystalline Basement

The crystalline basement in WRIA 55 is comprised of Precambrian (pre-570 my ago) metamorphics (e.g., quartzite, schist and gneiss) and Mesozoic-early Cenozoic (245 to 37 m. y. ago) plutonic rocks (e.g., granite) and are generally exposed on the higher ground above the valleys, including the western, northern and eastern portions of WRIA 55 (Figure 3-2). In the study area, younger units blanket these basement rocks.

In general, the depth to the basement rocks increases in a southerly direction within the valleys of WRIA 55 to a depth of up to 700 feet below grade in the North Spokane and Hillyard Trough areas. Based on well logs, there appears to be a subsurface ridge of basement rocks extending between outcrops near the confluence of Dartford Creek and the Little Spokane River, and outcrops approximately two miles to the southeast. This subsurface ridge is anticipated to have a strong influence on groundwater flow from unconsolidated aquifers to the northeast.

3.3 Local Hydrogeology

The important groundwater resource aquifers in the lower portion of WRIA 55 occur primarily within the Quaternary Unconsolidated Sediments described in the previous section, and include the Lower Sand and Gravel, and the Flood Sand and Gravel Unit, which yield hundreds to thousands of gallons per minute. The Recent alluvium, Glacial Lake Deposits, the fractured and weathered basalt, and crystalline basement rocks are locally important for small capacity exempt wells. Dense and unweathered crystalline basement rocks and basalt as well as glacial lake clays and dense Latah sediments act as important local aquitards, restricting vertical and lateral groundwater movement. The crystalline basement aquitard represents the effective lower hydrogeologic boundary of the region in the context of the ASR program being considered.

In order to obtain a refined understanding of the hydrogeology for evaluation of ASR, existing cross sections were improved, and new ones created (Figure 3-2). The purpose of these cross sections was to improve the understanding of the hydrogeologic conditions of the aquifer system, specifically:

- Aquifer thickness and lateral extent;
- The nature of any bounding units, and the degree of confinement; and,
- Likely natural sources of recharge and outflows.

3.3.1 The Spokane Valley – Rathdrum Prairie (SVRP) Aquifer

The SVRP Aquifer covers a total area of about 320 square miles, 120 square miles of which occur within Washington. Most of the SVRP Aquifer in Washington occurs within WRIA 57 although the northern portion of the aquifer extends into WRIA 55. The aquifer is one of the most productive in the United States and serves as the primary water source for more than 400,000 people in Idaho and Washington with more than 180 large purveyor wells pumping water from the aquifer. Because it supplies water to more than 80% of the population living above and in the vicinity of the aquifer, the EPA designated the SVRP Aquifer as a Sole Source Aquifer in 1978.

The SVRP Aquifer occurs within porous and permeable flood deposited sands and gravels that are bounded by low permeability basalt and crystalline basement rocks, and ranges in thickness up to 700 feet thick within the central portion of the Hillyard Trough. In the Hillyard Trough area, the SVRP Aquifer contains an intermediate clay layer that separates upper and lower sand and gravel layers. This clay layer is lacustrine in origin and has been eroded away on other areas.

The SVRP Aquifer in the Hillyard Trough area is being considered as the source of water for recharge in an ASR program. A full description of the SVRP Aquifer is presented in Section 5.2.3 of Golder's Phase II – Level 1 planning assessment report.

3.3.2 Lower Sand and Gravel

The Lower Sand and Gravel Aquifer within the area of interest are often considered an extension of the SVRP Aquifer. The materials are composed of unconsolidated sediments that range up to 600 feet thick. The most productive units are the flood sands and gravels that range in thickness from 50 to 200 feet. In the southern portion of the area (near the Whitworth WD #2 and Spokane County WD #3 wells), the aquifer is highly productive with specific capacities ranging up to 200 gpm/ft (Table 3-1). Corresponding estimated aquifer transmissivities range up to 400,000 gpd/ft. Aquifer recharge is assumed to occur along the edges of the aquifer, such as where the aquifer laps onto bedrock outcrops, and from the north in the vicinity of Dragoon and Deer Creeks.

The most focused assessment of the Lower Sand and Gravel Aquifer was completed by CH2M Hill (2000) in support of the Spokane Aquifer Joint Board's (SAJB) wellhead protection plan. The Whitworth Water District #2 wells (#8A-1, #8A-2, #8B) and the Spokane County Water District #3 (Pine River Park well) draw groundwater from the sand and gravel unit that is overlain by 100 feet or more of silt and clay. The report stated that the general groundwater flow direction in both upper and lower aquifers is toward the southwest. However there is a bedrock ridge impeding such southwesterly flow (Figure 3-11). Groundwater locally discharges from the upper unit into the smaller streams (Deadman and Little Deep Creeks). Groundwater flow maps prepared by Boese and Buchanan (1996) also support convergent flow in the Lower Sand and Gravel Aquifer on Deadman Creek in plan view (Figure 3-13). The degree of hydraulic continuity between the Lower Sand and Gravel Aquifer and streams is broadly limited by the confining Glacial Lacustrine clayey deposits. However, the tentative identification of the absence of the confining clay between Deadman Creek and the underlying Lower Sand and Gravel Aquifer in the vicinity of Mead is consistent with Boese and Buchanan's the potentiometric map (Figure 3-13) and this location being a point of upward discharge from the underlying Lower Sand and Gravel Aquifer. Well log data suggest that Deadman Creek is perched in this area, and groundwater does not discharge directly to the creek (Figure 3-8; Section E-E').

The groundwater system in this area of the Lower Sand and Gravel Aquifer area may have a hydraulic connection with the aquifer units within the northern portion of the Hillyard Trough through a trough following Highway 2 in the Mead area that is bounded by bedrock highs to the northwest and southeast (Figure 3-13). Groundwater flow mapping by Boese and Buchanan (1996) suggest that minimal flow occurs through this trough, and that a groundwater divide is present. Flow patterns are consistent with a strong influence of recharge from the topographic high south of Mead. Aquifer properties in this area are not well characterized, and are highly variable. There are few highly productive wells in this area, and the majority of wells suggest low aquifer transmissivity (Table 3-2; Figure 3-14). This is consistent with the characterization of the productive strata of the Lower Sand and Gravel Aquifer in this general area as being discontinuous.

3.3.3 Undifferentiated Sediments (Qs)

Several of the recent cross sections generated by DNR and others identified an undifferentiated sequence of clays; silts and sand exist outside the sand and gravel aquifer area that are not considered sufficiently transmissive or water yielding to be an aquifer. The geologic sections all indicate the existence of this unit, and likely enclose the sand and gravel aquifers. They receive recharge via infiltration of precipitation in areas such as Peone Prairie.

Boese and Buchanan (1996) considered these deposits to act as an aquitard of Pleistocene age. In general, the wells that are completed in this unit are privately owned, yield relatively small amounts of water and have low specific capacities (less than 5 gpm/ft).

3.3.4 Groundwater Flows and Levels

Although the amount of information on groundwater elevations and flow directions is limited, it is likely that groundwater flows in a southerly direction, discharging to major streams such as Dartford Creek, Deadman Creek and the Little Spokane River through vertical seepage.

The most detailed assessment of the area was completed by CH2M Hill (2000) in support of the Spokane Aquifer Joint Board's (SAJB) wellhead protection plan Pine River Park and lower Dartford Creek areas (in the southern portion of the Lower Sand and Gravel Aquifer). Groundwater levels from five Whitworth WD#2 wells (Rivilla, #8A1, #8A2, #8B and the Shady Slope well) were plotted. Figures 3-15 through 3-18 show the measured static (unpumped) and dynamic (pumped) water depths in four Whitworth WD#2 wells between 1998 and 2003. The static depths to water are typically between 30 and 70 feet bgs. Seasonal groundwater fluctuations generally appear to be on the order of 10 feet and reflect the combined influences of winter groundwater recharge and summer groundwater withdrawals.

The apparent differences between groundwater levels and stream elevations in the cross sections suggest that hydraulic continuity between the two is limited (Sections A-A', D-D', E-E' and C'-D; Figures 3-4, 3-7, 3-8 and 3-10, respectively) indicate that there is a hydraulic separation between the Little Spokane River and the Lower Sand and Gravel Aquifer. Although Section C'-D (Figure 3-10) suggests a degree of hydraulic separation between groundwater and the Little Spokane River, closer examination of the possible connection between the two at Cross Section C-C' is warranted (Figure-3-6).

3.3.5 Groundwater Production and Wells

The main municipal production wells in the Lower Little Spokane River area are operated by Whitworth WD #2 and Spokane County WD #3. Figure 3-19 shows the service areas of purveyors in the region. Table 3-1 summarizes the features of the six production wells. The well capacities are generally high, ranging from 450 to 5,000 gpm. The upper-end capacity is typically achieved for a well constructed in a highly transmissive Lower Sand and Gravel Aquifer. In general, the transmissivity of the aquifers is sufficiently high that excessive groundwater mounding is not expected during recharge through the high capacity production wells.

Total annual production for the three main Whitworth WD #2 wells is typically 2,000 to 2,500 acre-feet, and for the Spokane County WD #3 Pine River Park well is generally between 150 and 175 acre-feet.

Smaller, private production wells exist in the area which are considered "exempt", (that is, they produce less than 5,000 gallons per day for stock watering, domestic, commercial, or industrial purposes, or for irrigation of ½ acre or less of lawn or noncommercial garden). Records on groundwater production rates or performance tests for these wells probably do not exist for these wells.

3.3.6 Hydrology

The study area is drained by the Little Spokane River, the smaller tributaries of Little Deep Creek and Deadman Creek to the east, and Dartford Creek to the west. Mean annual flow in the Little Spokane River at Dartford (USGS Station #12431000) is 306 cfs and mean monthly flows range from 128 to 626 cfs. The USGS has recorded peak daily flow at 4,110 cfs and minimum flows, and low flow at 62 cfs. Peak seasonal flows occur in March/April (likely in response to snow melt), and low flows occur in August when all discharge is a reflection of groundwater baseflow contribution. Continuous flow gaging is not conducted on tributaries.

3.4 Operational Water Quality Considerations

Water quality considerations related to an ASR program include operational and regulatory. Operational considerations are discussed here, while regulatory considerations are discussed in the permitting section. Table 3-3 presents water quality results for WWD groundwater wells. Average values are presented for wells completed in the Hillyard Trough and represent candidate wells for providing source water for ASR, and for wells completed in the candidate ASR recharge area. This provides a comparison of the differences and similarity in general water quality and compatibility of the different waters when mixed as may happen during operation of an ASR program.

The water quality in the candidate source and receiving wells are reasonably similar and do not indicate adverse reactions from an operational perspective. This may be expected because both the source and receiving aquifers are composed of the same material (i.e., outburst flood deposits).

Potential reactions that are commonly evaluated in ASR programs are precipitation-dissolution, reduction-oxidation (redox) reactions, and biological growth. Iron, nitrate and sulfate are considered as indicators of potential redox reactions, and both source and receiving water quality are oxidizing. The low concentrations of iron in the candidate source wells are well below the Secondary Maximum Contaminant Level (SMCL), are not at levels that are suggestive of relatively reducing conditions, and are probably an artifact of sampling methodologies. The source of this iron may be associated with suspended aquifer material or pipe scale from well materials as suggested by the associated turbidity. Therefore the iron concentrations are assumed not to reflect actual dissolved concentrations, and therefore do not reflect actual water chemistry.

Precipitation-dissolution reactions commonly involve iron and manganese oxyhydroxides, and/or carbonates. Iron and manganese oxyhydroxides reactions generally require mixing of waters of different redox conditions. Because all of the water involved appears to be oxidizing, no such redox reactions are expected. The potential for carbonate reactions can be inferred from hardness concentrations. The difference in hardness between the two groundwater groups is not considered significant to suggest that any reactions will occur. More comprehensive water quality analysis including pH, calcium and magnesium could further confirm this interpretation.

Biological growth thrives where there is mixing of waters of two different chemistries. Because the two types of water are so similar, biological growth may not a problem. Additionally, the low total dissolved solids provides a weak medium for biological growth. However, biological growth is pervasive in groundwater wells, and generally only varies in degree. Therefore although the water quality conditions are not indicative of any large potential for biological growth, a degree of growth may be expected. This is common in ASR programs, is usually controlled by the use of chlorinated recharge water or periodic disinfection of a recharge well, and would be incorporated as a component of routine maintenance of operating an ASR program, as needed.

3.5 Engineering Considerations

Engineering considerations for an ASR program include infrastructure such as wells, transmission and pumps, and operational parameters such as pressure zones, and demand schedules. The Whitworth WD #2 operates six water systems in three areas (Figure 3-19). Systems 1 through 4 are within one contiguous area, while Systems 8 and 9 operate in two separate areas (Systems 5 through 7 does not exist). There are two standby groundwater supply sources in System 9, so the area is supplied wholly by water sources in the other systems through an intertie with System 8. System 8 is used primarily in the summer and obtains most of the winter water supply through an intertie with System 3. Systems 1 through 4 operate year round, are self sufficient with respect to water supply, and provide seasonal supply to Systems 8 and 9 during the winter.

The intertie between Systems 3 and 8 currently has approximately 1,000-2,000 gpm of unused transmission capacity during the winter above that required to supply both Systems 8 and 9 with no wells operating in System 8. This unused winter transmission capacity can be used to deliver water for ASR use from the Hillyard Trough wells to the System 8 wells for ASR recharge. This is subject to interruption by emergency incidents (e.g., broken main or large fire demand). Therefore the existing infrastructure can accommodate the delivery of water from the Hillyard Trough area for ASR recharge in the prospective recharge aquifer in which System 8 wells are completed.

3.6 Permitting Requirements

The following regulations are addressed in separate sections:

- Water Rights (WQAC 173-157 and RCW 90.44);
- Well Construction (Ch. 173-160 WAC);
- Water Quality (Ch. 173-200 WAC);
- Underground Injection Control Program (Ch. 173-218 WAC); and,
- Washington State Department of Health (Ch. 160-290 WAC).

3.6.1 Water Rights

ASR is permitted under Chapter 173-157 WAC (Underground Artificial Storage and Recovery). Three permits are necessary:

- A primary water right for the water that will be used for recharge;
- A permit to store the water; and,
- A secondary permit to withdraw the stored water and put it to beneficial use. (This permit is not always necessary, depending on the nature of the primary water right).

An analysis of WWD's water rights was not conducted for this assessment. However the 2000 comprehensive water system plan indicates that there is sufficient annual quantity to support an ASR program, and no additional primary water right is needed. Because the water rights most likely meet the definition of a municipal water right and will be used within the service area of the WWD, no secondary water permit to withdraw the stored water may be needed. Therefore, only a permit to store the water may be needed.

Contained within the issuance of a permit to store (and recover) water, is a determination of the recoverable volume and rates of recovery. To support this determination the following components must be included with an application:

- A description of the hydrogeologic system (conceptual model);
- A project operation plan;
- A description of the legal framework for the proposed project;
- An environmental assessment and analysis;
- A mitigation plan; and,
- A monitoring plan.

Typically, a pilot test is conducted to support an application. A pilot test plan usually identifies a recharge well; a recharge rate and duration, and a monitoring well network to collect data. A preliminary permit may be needed although this can be precluded if all wells (i.e., both the source and recovery wells) are operated within existing water rights, as is expected to be the case for WWD.

An important component of this assessment would include an evaluation of potential impairment of other groundwater users. Overpressurization of the aquifer may locally create flowing artesian conditions during recharge periods, while local excessive drawdown may occur during withdrawal. Selection of appropriate wells for ASR can avoid these potential problems.

3.5.1 Well Construction (Ch. 173-160 WAC)

According to WAC 173-160-390 (Standards for Construction and Maintenance of Wells), "Approval must be obtained from the department [Ecology] before starting any project related to the artificial recharge of ground water bodies." Existing water supply wells can generally be retrofitted for ASR applications. Major considerations are the need for a an adequate surface seal, a sufficiently large casing diameter to house pumps, water level monitoring equipment and associated hardware.

3.5.2 Groundwater Quality (Ch. 173-200 WAC)

Through this code, Ecology establishes an anti-degradation policy for the protection of groundwater for beneficial use. Of the beneficial uses, drinking water generally has the highest quality requirements of groundwater (WAC 173-200-040(1)(a)). It is assumed that directly injected water will be of drinking water standards because it is being delivered through the WWD drinking water system, and that compliance with the objective of this regulation is attained.

Groundwater criteria have been established by Ecology for a number of parameters, and establish background concentrations of other parameters as default criteria. Most municipal drinking water systems use chlorination disinfection, and the presence of chlorination disinfection byproducts is the most common parameter of concern in ASR programs in the context of this regulation. WWD does not routinely chlorinate their drinking water, except for monthly dosing to control bacteriological growth in the distribution system. Therefore this is not a significant concern for the permitting feasibility of the ASR program being considered. Further compliance with this regulation could be documented by water quality monitoring during a pilot test.

3.5.3 Underground Injection Control Program (Ch. 173-218 WAC)

Ecology regulates the injection of fluids into wells under the federal Underground Injection Control Program (UIC Program; 40 CFR 146). The primary intent of this program is to regulate the injection of waste fluids and stormwater. The fluid to be recharged for an ASR program is assumed to be water treated to drinking water standards that comply with the Safe Drinking Water Act. Recharge wells used to replenish the water in an aquifer qualify as a Class 5R21 injection well under federal regulations (40 CFR 146.5(e)(6)), and a Class V well under state regulations. Ecology is currently revising Chapter 173-218 WAC, and a draft of revisions (most recent update 9/15/04) is currently open for public review and comment. However, the portions most relevant to ASR wells involve registering the well with Ecology, and reference to WAC 173-200 (Antidegradation of Groundwater) and WAC 173-157 (Underground Artificial Storage and Recovery), and ASR wells are generally rule authorized.

3.7.1 Washington State Department of Health (Ch. 160-290 WAC)

Facilities used in an ASR program that are part of the drinking water system are permitted by the Washington State Department of Health (DOH). Routine inspections and monitoring are usually conducted in compliance with DOH regulations governing public drinking water systems. Retrofitting of the wells to allow both recharge and withdrawal of a well needs to be coordinated with the DOH regional engineer. Upon completion of retrofitting activities, the well and associated facilities need to be disinfected with techniques that conform with American Water Works Association (AWWA) standards or other standards acceptable to DOH.

Routine water quality monitoring would be conducted for compounds of concern and an extended list of analyses for the purposes of providing a detailed characterization of processes and an understanding of system operation and dynamics, as well as ensuring the protection and maintenance of drinking water quality standards as defined by DOH, and the federal Safe Drinking Water Act.

3.6 Economics

The cost of an ASR scheme is variable and site specific. A systematic assessment of costs for ASR systems has not been published, and the estimates presented below are based on limited research of ASR systems nationwide.

- Feasibility and pilot testing programs generally range between $100,000 and $500,000 for systems with existing infrastructure, which is the anticipated condition in this case.
- Published annualized unit costs for developed water using ASR range from $30 to $350 per acre-foot ($92 to $920 per million gallons) for systems that do not require new treatment facilities, which is the anticipated condition in this case.
- Unit costs for ASR facilities have also been expressed in terms of recovery capacity, and range from about $200,000 to $600,000/mgd of recovery capacity, with an overall average of about $400,000/mgd (Pyne, 1996).
- Operation and maintenance costs have been less well defined. However, typical annual costs are about $15,000/mgd of recovery capacity. Additional costs may be incurred as a result of monitoring requirements of an ASR permit issued by Ecology.

ASR systems can result in the more efficient use of off-peak capacity from existing infrastructure, which can defray or delay the cost of system upgrades to meet increasing peak needs. Permitting burdens involved in obtaining new water rights and possible associated mitigation requirements can be deferred.

3.7 Recommendations and Summary

The evaluation of the feasibility of a potential ASR scheme in the study area to meet the stated objectives requires an assessment of the following key factors:

- Availability of a reliable recharge source of sufficient quality.
- Hydrogeologic issues, particularly the receiving aquifer transmissivity and potential storage, and confining and lateral boundaries.
- The ability to cost-effectively deliver the recharge water to the point (or points) of recharge.
- Engineering issues, notably the effect of recharging using a well on the local distribution system.
- Regulatory issues, including water rights and permitting.

Based on the assessment, Golder has the following observations:

- Whitworth WD#2 has projected a need for additional instantaneous water right within the next five to ten years. A successful ASR project could satisfy this need through use of the current annual water right quantity.

- The Hillyard Trough appears to be a suitable seasonal (winter) source of water for ASR.
- The Lower Sand and Gravel Aquifer in the lower Little Spokane River basin in the vicinity of the confluence of Deadman Creek and the Little Spokane River is a candidate storage aquifer for ASR. Further assessment of the residence time of recharged water, and therefore the permittable recoverable quantity, requires further evaluation.
- The quality of the source and receiving waters appear compatible.
- Existing infrastructure is well-suited to the operation of an ASR program.

Based on the findings of this study, ASR appears to be a viable tool for increasing the instantaneous water right capacity needed to provide for projected increase in municipal water demand. Further evaluation of the feasibility would consist of preparation of a detailed compilation of available data, and execution of a pilot test (subject to refinement):

Data compilation:

- Analysis of relevant water rights;
- Water level maps (potentiometric surfaces) by aquifer;
- Characterization of vertical gradients within the aquifer system;
- Detailed water quality review;
- Selection of recharge test well;
- Hydraulic distribution system modeling (maintenance of public supply and fire protection);
- Engineering of wellhead retrofits;
- Assessment of impacts on other groundwater users;
- Monitoring schedule (locations and frequency);
- Preparation of UIC registration and other regulatory considerations; and,
- Preparation of a pilot test plan for submission to DOH and Ecology;

Pilot test:

- Pretest monitoring. No pumping should be conducted from the Lower Sand and Gravel Aquifer for an appropriate time preceding the pilot test (e.g., one week);
- Recharging water to the selected well from the Whitworth Water District #2 municipal distribution system for during the winter (e.g., 1,000 gpm for 30 days; water obtained through WWD #2 System 3);
- Observing aquifer response during a post-recharge period (e.g., 30 days) to evaluate the containment of recharged water;
- Recover the recharged water (e.g., 2,000 gpm for 30 days under existing water rights); and,
- Post-recover monitoring of aquifer groundwater levels (e.g., one week).

Adequate monitoring instrumentation would be needed and may already exist (e.g., instantaneous and totalizing meters, and water level transducers and dataloggers). Time series water quality samples should be collected throughout the pilot test. Information collected during the pilot test could be used to support application for a water right under the ASR rule (WAC 173-157) for full implementation of an ASR program.

The main components of the pilot-scale test may include:

- Preparation of a pilot test plan including:
  - Due diligence review of existing water rights;
  - Selection of a recharge well; and,
  - Conceptual hydrological model.
- Prepare an existing well for testing (e.g., wellhead retrofit of valving);
- Establish hydrologic baseline conditions (e.g., regular monitoring of groundwater levels, and stream, river and spring flows);
- Perform pilot-scale test:
  - Constant rate recharge phase;
  - Storage assessment;
  - Recovery period; and,
  - Well efficiency assessment.
- Test monitoring;
  - Recharge rates and volumes;
  - Water levels;
  - System pressure; and,
  - Water chemistry (source, receiving, extracted).
- Analysis of data, and assessment of water rights and permitting issues.

4.0 BEAVER AND BUCK CREEK NEW DAM ANALYSIS

This section describes planning level analysis completed to determine the potential size, location, cost, and flow benefit of two new dams in the upper portions of WRIA 55. The dams, shown in Figure 1-1, are new, on-channel dams located on Beaver Creek and Buck Creek (Figure 1-1) in the northwestern part of the WRIA.

The purpose of the dams is to augment stream flows and/or to offset potential impacts on streamflow due to current and/or future water supply development. For this analysis, a target volume of 4750 Acre-Feet (AF) was used. This is equivalent to the quantity of water predicted to be necessary to offset full use of inchoate water rights in WRIA 55. The target volume was calculated using results for water year 1994 through 1999 from the inchoate water rights scenario run in the Spokane Watershed Simulation model (Golder, in draft). Ultimately, final storage volume would balance augmenting existing streamflow versus offsetting additional water use.

This section includes the following:

1. The identification of two potential dam sites: one location on Buck Creek and one location of Beaver Creek;
2. A review of the potentially affected water rights and land ownership considerations;
3. A summary of relevant geologic, environmental and hydrologic conditions;
4. A description of typical dam configurations, considerations with respect to geology and geotechnical properties of soils in the area, and the quantity of water that is potentially available;
5. A summary of potential impacts of building a new dam on the environment and hydrology;
6. A summary of the potential permitting requirements;
7. Planning level cost estimates;
8. Discussion of impacts of a new dam; and
9. Recommendations.

4.1 Proposed Dam Locations

Based on earlier work and as directed by the Planning Unit, two alternative new dams are considered: one on Beaver Creek and one on Buck Creek. The locations were selected based on available published literature regarding the topography, geologic, soil, and hydrologic conditions of areas along Beaver and Buck Creek. The proposed embankment locations and areas of inundation are shown in Figure 4-1.

The Beaver Creek Dam site is located on Beaver Creek in Stevens County, just upstream of Baker Lake Dam, about 8.5 miles northeast of Loon Lake, Washington. It is a tributary to the West Branch Little Spokane River (Figure 1-1). The site is situated at an elevation of about 2,440 feet amsl in a relatively broad (700-1,200 feet wide), southeast-draining valley. The available topographic maps indicate that the valley bottom is marshy. The average gradient along Beaver Creek upstream of the proposed dam site is about 0.009 ft/ft (49 ft/mile). The average slopes on either side of the valley, at the proposed dam centerline, range from about 10 to 30 degrees (18-58 percent).

The Buck Creek Dam site is in Pend Oreille County, on Buck Creek about 1.75 miles upstream of Horseshoe Lake. Horseshoe Lake is part of the West Branch Little Spokane River. The proposed dam site is at an elevation of approximately 2,300 feet amsl, in an approximately 500-foot wide, south-east-draining valley. The location is just upstream of the confluence of Buck Creek and a south-draining unnamed tributary. The approximate gradient of Buck Creek, upstream of the dam location, is approximately 0.11 ft/ft (60 ft/mile). The valley walls on either side of the dam axis have average slopes that range from about 20 to 25 degrees (38-47 percent).

4.2 Existing Water Rights

There are few existing surface water rights on Beaver or Buck Creek. Table 4-1 summarizes these rights. There is one reservoir on Beaver Creek, Baker Lake Dam, with an annual allocation of approximately 360 AF. This right is specifically for fish propagation, recreation, and beautification. Construction and operation of a new dam would have to maintain current uses of the existing Baker Lake. On Buck Creek, Boise Cascade Corporation and the Washington State Department of Natural Resources (WDNR) have several claims for stock watering, with no amount specified.

Further downstream in WRIA 55, minimum instream flows are established including compliance points on the mainstem Little Spokane River at Elks Park, Chattaroy, at Dartford and near Dartford. The Elks Park point is upstream of any influence that the proposed new dams would have on the mainstem. The compliance point at Chattaroy is the first point downstream of the proposed dams, although only the point at Dartford is used for enforcement.

4.3 Land Ownership

The proposed Buck Creek dam site and inundated area is located almost entirely within Sections 35 and 36 in Township 31N, Range 42E. Both of these Sections are owned by Boise Cascade Corporation, a timber and paper company. The surrounding land is part of the Kaniksu National Forest. Appropriate measures would be required to acquire privately held land. The Pend Oreille County Assessors Office provided an assessment value of approximately $1,000 per acre for land in these sections.

The land on which the proposed Beaver Creek dam site and inundated area is located is owned by Mr. Jay Baker, who is also the owner of Baker Lake Dam. Similar to Buck Creek, appropriate measures would be required to acquire land from Mr. Baker. The Stevens County Assessors Office provided an assessment value of $29,500 for a 640 acre piece of land within Township 30N, Range 42E Section 11 owned by Baker Logging (approximately $50 per acre).

The assessed value of land is often lower than the sale value. Although it is difficult to generalize, the sale value of land could be as much as 50% higher than the assessed value. Based on this estimate, plus an additional 25% estimated contingency, the property value of land near Beaver and Buck Creeks may be as much as $1,850 per acre.

4.4 Geologic Conditions

Based on the available geologic mapping of the areas of the proposed Beaver Creek and Buck Creek dams, the dams appear to be feasible from a geologic perspective. There are no faults mapped at either site and there appear to be no significant adverse geologic conditions that would preclude siting dams at the two locations. Nevertheless, there are geotechnical issues at each site that will need to be addressed during a feasibility level assessment. For example, potentially thick, granular (e.g., gravel, cobbles, boulders) may underlie the proposed dam axes. These soils may have negative impacts on foundation stability, and on the potential for leakage beneath the dams, which could be addressed with a grout curtain. A full geologic review of the site is contained in Appendix D.

4.4.1 Beaver Creek Dam Site

Carrara and others (1995) also indicate that about 800 feet upstream of the proposed dam axis there are organic deposits underlying the valley that consist mainly of peat, woody peat, muck, and organic silt and clay. These organic deposits range from 3 to 33 feet thick, and are mapped to extend another 4,000 feet upstream (Carrara and others, 1995). These organic deposits would have to be excavated to avoid settlement of the foundation.

The bedrock underlying the slopes along the valley is late Cretaceous (70 million to 80 million years old) quartz monzonite and monzogranite of the Little Roundtop pluton (Stoffel and others, 1991; Waggoner, 1990; Miller, 1974). This igneous rock is deeply weathered and very coarse grained with crystals from 0.5 to 1 inch diameter.

There are no faults mapped in the Little Roundtop pluton, but there are faults mapped in the Precambrian Belt Supergroup rocks to the south, west and northeast of the dam site (Waggoner, 1990; Miller, 1974). The intrusion of the Little Roundtop pluton truncates the faults, and post dates them. Although there may be fractures such as joints in the intrusive igneous rocks of the Little Roundtop pluton, none are indicated on the available geologic maps (Waggoner, 1990; Miller, 1974).

4.4.2 Buck Creek Dam Site Geologic Conditions

The valley wall on the north side at the dam site is underlain by bedrock of the late Cretaceous Little Roundtop pluton. On the south side of the valley, the slope is underlain by bedrock of both the Little Roundtop pluton, and the Precambrian Prichard Formation. The quartz monzonite and monzogranite of the Little Roundtop pluton extend upslope to about an elevation of 2,400 to 2,440 feet amsl, while the Prichard Formation is present at elevations above this. The Prichard Formation is a low-grade metamorphic rock that consists primarily of argillite, siltite and quartzite. The Prichard Formation also has metamorphosed diabase igneous sills that have intruded the formation (Miller, 1974; Stoffel and others, 1990). One such sill is located at about elevation 2,600 feet amsl on the south side of the valley. The sill is about 500 feet wide and trends east-west. Stoffel and others (1990) consider the Prichard Formation to be about 1,500 million years old.

There are no faults mapped in the bedrock at the proposed site, and the closest mapped fault is near the mouth of Buck Creek where it enters Horseshoe Lake, more than 1.75 miles southeast of the dam site. Miller (1974) has mapped bedding structure in the Prichard Formation, and indicates that bedding strikes generally east-west, and dips to the south from 40 to 65 degrees. This bedding structure could provide flow paths for leakage around the proposed dam. Buck Creek drains east at this location, and the strike of bedding is east-west, with a moderate to steep (40-65 degrees) southerly dip. Depending on the nature, permeability and variability of the interbedded metamorphosed sediments, and the nature and permeability of the bedding contacts, there could be groundwater seepage through the abutments around the dam. Additionally, the nature and permeability of the contact on the south valley wall between the Little Roundtop pluton and the Prichard Formation are currently unknown, but may be another pathway for water around the dam. These are issues that should be addressed during the design process.

4.5 Wetlands

Beaver and Buck Creek watersheds contain a number of designated wetlands (WDFW, 1987; Figure 4-1). A dam built on Beaver Creek at the proposed location would inundate between 15.5 and 16.7 acres of wetlands upstream of the dam. According to the National Wetlands Inventory (NWI), approximately 10.7 acres of these inundated wetlands are classified as scrub-shrub or broad-leaved deciduous wetlands, while 5.7 acres are classified as shallow emergent persistent, and 0.5 acres are classified as aquatic bed,. A dam built on Buck Creek at the proposed location that would inundate approximately 34 acres of wetlands, all classified as scrub-shrub, or deciduous.

4.6 Habitat

Riparian zones along Beaver and Buck Creeks and the upland forests in the watersheds are dominated by ponderosa pine and mixed coniferous forest. Timber harvest is an important land use in these higher elevation forested watersheds and ponderosa pine forests are increasingly being replaced by other coniferous species. A number of priority species inhabit Beaver and Buck Creeks. The Columbia Spotted Frog has a close association with wetlands and riparian habitat and is regularly seen along the Little Spokane River and its tributaries. This amphibian is a federal species of concern and a Washington State candidate species under evaluation for possible listing as endangered, threatened, or sensitive (Northwest Power Planning Council, 2004). The Yellow Warbler is also closely associated with riparian habitat and has experienced population declines due to decreased habitat in the region.

A survey of aquatic habitat was completed in 2001 by the WDFW; this is the only available report on habitat in these creeks.

Beaver Creek substrate is predominantly gravel (35%). It supports two fish species: eastern brook trout (*Salvelinus fontinalis*), which is of highest abundance, and rainbow trout (*Oncorhynchus mykiss*). There are three natural barriers and one human-made barrier for fish passage on Beaver Creek. The first natural barrier is a landslide that buried 50 feet of the stream and is approximately 0.5 miles upstream of Horseshoe Lake. The second natural barrier is a 16 foot tall cascading waterfall located approximately 33 feet upstream from the landslide. The third natural barrier is a 17 foot tall waterfall, approximately 65 feet upstream of the previous waterfall. The human-made barrier is an earthen dam at Baker Lane that is approximately 4 miles upstream of Horseshoe Lake. All four barriers are located downstream of the proposed dam site.

Buck Creek substrate is predominantly sand (45%). The creek supports four fish species: eastern brook trout, rainbow trout, which is of highest abundance due in part to stocking, sculpin, and kokanee. Kokanee use Buck Creek as a spawning stream. However, the kokanee population has declined in recent years. On Buck Creek there are two natural barriers for fish passage and one human-made barrier. The first natural barrier is a 26 foot long chute with a 36% gradient, located approximately 0.75 miles upstream of Horseshoe Lake. The second natural barrier is also a chute that is 14 feet long with a 35% gradient, located approximately 0.25 miles upstream from the first chute. The human-made barrier is a culvert approximately 0.12 miles upstream from Horseshoe Lake. The proposed dam site is upstream of these three barriers.

4.7 Water Quality

Temperatures in Beaver Creek range from approximately 2.5 °C to 18.5 °C from June through October. The high end of this range slightly exceeds the Washington State surface water quality standard for temperature of 18 °C (Chapter 173-201A Washington Administrative Code).

Temperatures in Buck Creek range from approximately 4 °C to 18.5 °C from June through October. The high end of this range slightly exceeds the Washington State surface water quality standard for temperature of 18 °C, as in Beaver Creek.

Little water quality data, beyond general stream temperature ranges, were available in the portions of Beaver Creek and Buck Creek considered for this feasibility study. Maps of Section 303(d) listed water bodies, which are those identified as polluted by the Environmental Protection Agency, indicate that Beaver and Buck Creeks are not currently impaired or threatened. However downstream, the Little Spokane River does not meet state standards in various sections for dissolved oxygen, fecal coliform, pH, temperature, and Polychlorinated BiPhenyls (PCBs; Golder Associates, June 2003).

Sampling for water quality measurements (temperature, pH, dissolved oxygen) was conducted in Horseshoe Lake during a two-week period in September 2004, by Eastern Washington University. However, data from this study are not available at this time. Additional data collection efforts would be required to assess current water quality in these systems and to better assess potential impacts a new dam might have on water quality.

4.8 Hydrologic Assessment

Measured flow data were available on Beaver and Buck Creeks sporadically during months May-October from 1986-1990. Daily time series of flows were developed from a combination of these intermittent flow measurements and daily streamflow model results from the WRIA 55 Mike SHE Spokane Watershed hydrologic model for water years 1994-1999 (October 1993 through September 1999). An average ratio between measured and simulated streamflow was applied to simulated flows in order to develop monthly flows at the two desired locations for water years 1994-1999. Because the streamflow data used in this analysis are based on simulated flow, we refer to Beaver and Buck Creek flows as predicted flows (Figures 4-2 and 4-3).

4.8.1 Beaver Creek Hydrology

Beaver Creek has a drainage area of approximately 3,000 acres at the proposed dam site. Predicted mean annual flow at the Beaver Creek Dam site is approximately 2,200 AF/year, calculated over the 1994-1999 period. This volume will not satisfy the storage target of 4,750 AF. In order to achieve the target volume, a conveyance system would be required to divert water from an adjacent stream. Because that is not a desirable option, the dam will be conceptualized to contain a smaller volume of water.

Hydrographs for a typical dry year (1994), wet year (1997), and average year (1999) are presented graphically in Figure 4-2. In the three types of years, the hydrographs predict two flow peaks, one in January and one in March. Peak flows in January show the impact of increased rainfall during the winter, while peak flows in March show the impact of melting snow pack that has accumulated at higher elevations within the watershed. Because it is assumed that there is no significant water use in these areas and all water in the creeks is available, it can be inferred that evaporation and infiltration from the reservoirs are the only significant losses. Seepage rates around the dam are estimated to be in the range of 100 and 300 AF/year, based on an assessment of the geology and soils, as well as on experience with respect to quantities of water seeping around earthen dams, and the estimated infiltration rate of 10^{-5} cm/sec. The predicted average potential evaporation from the reservoir is between 230 and 270 AF/yr, and is considered insignificant relative to other variables of reservoir storage.

Although a more detailed study and consultation with regulatory agencies will be required to determine the percentage and/or quantity of water than can be detained in a new Beaver Creek water storage reservoir, assumptions were made here to develop a range of potential volumes that may be available for storage in the Beaver Creek Dam. A range between detaining 50% of the stream flow to a maximum possible of 100% of the stream flow between December and April was selected for evaluation. The period from December through April was chosen because this is the period of high flows. Table 4-2 summarizes the natural stream flow volume available for storage, assuming we detain 50% and 100% of the December through April stream flow.

4.8.2 Buck Creek Hydrology

Buck Creek has a drainage area of over 9,200 acres. Mean annual flow on Buck Creek is predicted to be 10,806 AF/year just downstream of the dam location, calculated over the 1994-1999 period. This annual volume is well above the storage target of 4,750 AF, which is the amount of water estimated to be necessary to meet the goals of the WRIA 55 watershed plan. Hydrographs for a representative wet, dry, and average year (1997, 1994, and 1999 respectively) are presented in Figure 4-3. Monthly flows on Buck Creek were developed in a similar fashion to those at Beaver Creek (see previous section).

Similar to flows in Beaver Creek, the hydrographs predict two flow peaks, one in January and one in March, although the flows are several times higher than in Beaver Creek. Seepage rates around the dam are estimated to be in the range of 100 and 300 AF/year, based on an assessment of the geology and soils, as well as on experience with respect to quantities of water seeping around earthen dams, and the estimated infiltration rate of 10^{-5} cm/sec. The predicted average potential evaporation from the reservoir is 330 AF/year and is considered insignificant relative to other variables of reservoir storage.

Because storage of 50% of December to April stream flow in Buck Creek provides close to the target volume of 4,750 AF, storage of a larger percentage of the streamflow was not explored. Table 4-2 summarizes the natural stream flow volume available for storage, assuming we detain 50% of the stream flow in this period. This volume is close to the target volume of 4,750 AF and so design of a reservoir that would contain the full target volume has not been developed.

4.9 Conceptual Dam Design

The following section discusses sizing and provides a conceptual description of the proposed dams. Embankment considerations are also included, along with a discussion of necessary further investigations, if either of these options is chosen for further consideration by the watershed planning unit. The resulting quantities of these variables are summarized in Table 4-3.

4.9.1 Dam Sizing

The proposed dam height and associated reservoir sizing is based on the quantity of water available for storage, as well as the potential reservoir volume based on topography. Reservoir capacity and storage at the Beaver Creek Dam location is limited by the available streamflow, as opposed to topography and reservoir design. Therefore, the size of the reservoir at Beaver Creek has been estimated based on detention of 50% and 100% of December through April stream flows (927 AF and 1,855 AF respectively), as described above. Using design increments of 5 feet for dam height, the conceptual level reservoir size ranges from 1,175 to 1,932 AF. An embankment height of 25-40 feet is required to create the desired reservoir volumes (including an assumed 5 feet of freeboard).

Buck Creek has substantially more flow than Beaver Creek and can supply 4562 AF of water based on detention of 50% of the stream flows between December and April, as discussed above, which is close to the target volume of 4750 AF. Using design increments of 5 feet for dam height, the conceptual level reservoir size is 4590 AF. This volume is attainable with an 85 foot high embankment (including an assumed 5 feet of freeboard).

4.9.2 Conceptual Dam Description

A number of site studies and additional information would be required to develop a final design. Therefore, the following describes what a "typical" conceptual dam embankment may be based on the available geologic information.

The most cost effective impoundment structure would likely be a zoned earthen embankment dam for both sites considered. A typical dam cross section is illustrated in Figure 4-4. Based on the available geologic information reviewed, both sites appear feasible from a geotechnical standpoint for such a dam. The embankment would consist of a structural fill shell consisting of granular material, with a central core of clay to minimize seepage through the dam. The upstream face would be sloped on the order of 2H:1V, with the downstream face on the order of 3H:1V. The actual slopes of the dam face will depend on the strength of the materials available for dam construction. The embankments would have a crest width to accommodate vehicular traffic; a minimum crest width is 12 feet, but 20 feet provides slightly more space and has been assumed for quantity and costing purposes.

The embankments would contain a sand blanket and chimney drain to collect seepage through the dam. To minimize seepage beneath the dam and around the abutments, a grout curtain consisting of closely spaced drill holes backfilled with grout under pressure, will likely be required. For costing purposes, it is assumed that the grout curtain will be 2/3 the height of the embankment. For initial evaluation of the leakage though the base of the reservoir, a hydraulic conductivity (permeability) of 1×10^{-5} cm/sec to 1×10^{-6} cm/sec is assumed, based on review of the available geologic and soils information and assuming a well constructed dam with seepage limiting features such as the grout curtain. It is assumed that no reservoir lining will be required.

Outlet works might consist of an intake tower, outlet conduit, energy dissipation structure at the toe of the dam, as well as a low level outlet to allow draining of the reservoir.

4.9.3 Beaver Creek Embankment Considerations

A 25-40 foot high dam would be required to contain the desired range of volumes at the Beaver Creek site. Depending on the depth to bedrock and nature of the foundation materials, over-excavation of the valley alluvium may be required to provide a suitable foundation for the dam. If bedrock is shallow or the soils are very weak (i.e. peat, soft clay), the excavation would extend down to the bedrock. If the near surface soils are suitable to support the dam, the excavation would likely extend five to ten feet below the existing ground surface in order to minimize the seepage beneath the dam. If the foundation soils are very permeable (i.e. very clean sands and gravels), a grout curtain or upstream low permeable soil liner would be required to minimize seepage loss beneath the dam.

During construction, a temporary stream diversion would be required and possibly construction dewatering during foundation excavation. The dam embankment shell would likely be constructed from materials that are locally available, while the clay core material will likely need to be imported from a clay borrow pit located approximately two miles south of the dam site. Alternatively, it may be possible to construct the clay core from local soils that are admixed with imported bentonite. The down stream drainage blanket and toe drain sand would be processed material that would need to be imported.

4.9.4 Conjunctive Operation of Proposed Beaver Creek Reservoir and Baker Lake

Downstream of the proposed Beaver Creek Reservoir is Baker Lake, which is privately owned and mainly supports recreational use. It is located approximately two miles upstream of the confluence of Beaver Creek with West Branch Little Spokane River. The reservoir has a maximum capacity of 710 AF, and a normal operating volume of 357 AF, which corresponds to the owner's reservoir right. A new water right on Beaver Creek would be junior to the existing reservoir right and this senior right must be honored ahead of a new right. Conjunctive operation of the proposed Beaver Creek reservoir and Baker Lake will be necessary to ensure the security of the senior reservoir right.

4.9.5 Buck Creek Embankment Considerations

A dam on the order of 85 feet in height would be required at the Buck Creek site. Based on the interpreted geologic site conditions, over-excavation of the valley alluvium deposits will likely be required to provide a suitable foundation for the earth dam. If the alluvium has low shear strength (i.e. peat, soft clay) or is very permeable (i.e. clean sand and gravel), the over-excavation may need to extend down to bedrock to provide a suitable foundation for the embankment.

During construction, temporary diversion of the stream would be required. Construction dewatering would also likely be required to accomplish the excavation. At each abutment, the valley sidewalls would also need to be excavated down to bedrock. To limit seepage around and beneath the dam, a grout cutoff curtain may be required, depending on the permeability of the bedrock. The dam embankment shell would likely be constructed from locally available materials, while the clay core material would likely need to be imported from a clay borrow pit located approximately four miles south of the dam site. Alternatively, it may be possible to construct the clay core from local soils that are admixed with imported bentonite. The down stream drainage blanket and toe drain sand would be processed material that would need to be imported.

4.9.6 Future Investigations Related to the Dam Structure

Site-specific geotechnical investigations would be required to provide the additional information required to further evaluate the feasibility of each dam site. A borrow source study would also need to be conducted to evaluate the suitability of local materials for dam construction. Further hydrologic analyses would also be required, including determination of flood flows at various recurrence intervals, more extensive flow monitoring throughout the year, and investigations into potential sedimentation in the proposed reservoirs. On Beaver Creek, analysis of the effect of more extreme flows (low and high) on the existing dam at Beaver Creek would also be required to ensure its safety and maintenance for current use under any new conditions.

4.10 Impacts and Implications of a New Reservoir

In addition to considerations of dam design and construction, it is as important to understand the potential benefits and drawbacks a new dam could have on the characteristics of Beaver and Buck Creeks and the inundated areas. The following sections discuss potential effects to wetlands, habitat, and water quality and identify how these effects may be partially or wholly alleviated through design and operations. Many negative problems, especially water quality related problems, are due to a combination of anthropogenic effects within the reservoir catchment which are exacerbated by the fact that water is not moving (such as algal growth). Because these reservoir are within an area that is currently protected from significant development (National Forest and private ownership) the quality of influent water is expected to be high.

4.10.1 Wetlands

Wetlands within the inundation area and downstream of the site can be impacted by flooding and a change in hydrologic regime. Riparian wetlands may experience decreased flow during winter months, while water is being held behind the dams and may experience increased flows during months of flow release. However because reservoir levels are expected to fluctuate on a seasonal basis, seasonal emergent areas would be expected to naturally establish along the perimeter of the reservoir, this natural process could be aided through design of wetland pockets along the edges of the reservoir. Detailed topography would aid in determining the best locations for such areas. Further assessment would be required to determine the extent and magnitude of modification to existing wetlands and the potential for mitigation.

4.10.2 Habitat and Water Quality

General knowledge of the effects of a dam on terrestrial and aquatic habitat, and water quality at the site and downstream are well documented in literature and can provide a framework from which to base further study and design considerations. Detailed review of environmental impacts on a site-specific basis for Beaver and Buck Creek would be necessary.

Potential detrimental effects of a dam on habitat and water quality include

- Inundation of terrestrial habitat.

- Changes in the timing and intensity of discharge which can alter downstream riparian habitat. Without periodic floodplain inundation, many species of vegetation may not reproduce effectively, increasing areas of dead and decadent riparian vegetation, and potentially opening pathways for invasive species. Riparian habitat types and species composition downstream of the reservoir may change as they accommodate to new levels and periodicity of flows and floodplain inundation.

- Changes to aquatic habitat types due to a new more regulated hydrologic regime. Alternating riffle:pool combinations may become more predominantly run-like in characteristics as flushing flows cease to scour out pools. Changes in channel planform are likely to occur as natural stream bank erosion is altered due to changes in peak flow hydrology. Overall reductions in habitat complexity are likely to occur downstream of the reservoir under the managed hydrology.

- Increased surface water temperatures. Water stored in a reservoir can have higher temperatures, than flowing water, at the surface, but often has cooler temperatures at depth.

- Potential accumulation of nutrients in the reservoir. This can result in a poor water quality in the reservoir, and therefore released waters. This may be a greater concern for reservoirs developed in areas that are prone to nutrient loading, such as in populated sub-basins.

- Retention of sediment behind the dam. This could result in a change in channel substrate downstream. Lack of scouring flows could increase substrate embeddedness, decreasing habitat quality. Sediment generation in the catchments of the proposed dams is strongly influenced by forestry practices, and attenuation of sediment generated by such land use practices may prove to be beneficial to downstream water quality.

- Oxygen transfer can be affected by reservoirs because they can lack vertical mixing during summer months (the process that supplies oxygen to the deeper parts of a reservoir). This can be translated in the low levels of dissolved oxygen in releases.

Potential benefits and design considerations include the following.

- Protection against low flow conditions in downstream reaches (West Branch Little Spokane River and the downstream reach of the Little Spokane River) that can endanger fishery populations.
- Potential release of cooler water. If colder water occurs at depth in the dam, design can take into account the need to release cooler waters to improve or mitigate existing downstream temperature problems.
- Protection against downstream flooding.
- Reservoir operations to ensure flushing and channel forming flows occur a certain percentage of time or a number of times over a multiple year period.
- Energy dissipation structures at the outlet can reaerate the released water.

4.10.3 Streamflow Augmentation Capacity

Available flow releases from the proposed reservoirs would be directly dependent upon climatic conditions and current storage, but would typically occur during low flow periods when flow augmentation would be beneficial for habitat and downstream water users. The volume of release on any given day would depend on the time over which the release volume is sustainable as well as the amount of water available in the reservoir.

Table 4-4 presents a range of streamflow augmentation schedules for a reservoir sized to retain 50% and 100% of wet season streamflow from Beaver Creek taking into account a full (average climatic year) or partially full (dry year) reservoir, as well as the target number of days over which a release can be sustained. Table 4-5 presents options available for release of water from the proposed Buck Creek reservoir, taking into account a full (average climatic year) or partially full (dry year) reservoir.

4.11 Permitting Requirements

Construction of new surface water storage or expansion of existing facilities will involve multiple federal, state, and local agency approvals and can require a lengthy study, and authorization process. The Judy Reservoir expansion, which increased the reservoir from 1,700 AF to 4,500 AF, took 11 months to permit (Ecology, 2001) and cost over $1.3 million (includes planning, permitting, design and legal fees, but excludes construction). The following are descriptions of permits or requirements at various governmental levels that may apply to construction of a new dam (WSORA, 2004).

To streamline the permit application process for water-related projects, Washington State has developed the Joint Aquatic Resource Permits Application (JARPA). The JARPA combines seven different permit applications into one. JARPA covers all of the most frequent federal and state permits relating to wetlands. These include the State Shoreline Management Act, State Hydraulic Permit, State Water Quality Certification, and Corps of Engineers Section 404 & Section 10 permits. The application still needs review by the respective agencies and each agency still issues separate permits in accordance with their existing authorities. Some local governments participate in the JARPA program, combining all or some of their environmental permit applications on the JARPA form. Expedited and consolidated versions of permits, such as the Watershed Restoration Permit, can be used if the project meets certain requirements, and the main goal is for fish and wildlife habitat. Individual permits are described below.

4.11.1 Section 404 Permit –Discharge of Dredge and Fill Material

Obtaining a Section 404 Permit is a Federal requirement. When locating a structure, excavating, or discharging dredged or fill material in US waters, a permit from the Army Corps of Engineers (ACOE) is required. Not every activity requires a separate, individual permit application. Certain activities and work can be authorized by letters of permission, nationwide permits, or regional permits. Nationwide Permit 27, for example, covers certain stream and wetland restoration activities. Whether or not the proposed project can fit within Nationwide Permit 27 will depend on the scope of the potential impact and mitigation measures.

There are no regional permits that cover the proposed project and letters of permission are only applicable when the proposed work would be minor, so an individual permit application will likely be required if the project does not qualify for a Nationwide Permit 27. The process typically begins with a pre-application meeting between the project proponent, Corps staff, and interested resource agencies. This meeting provides a chance for informal discussion of the project impacts, alternatives, and regulatory requirements. Once an application is submitted, the Corps prepares a public notice, evaluates the project, and prepares a permit decision document. Processing times range from three to six months for a nationwide permit, six months or more for an individual permit, and up to three or more years when an Environmental Impact Statement (EIS) is required (Clean Water Act Section 404).

4.11.2 Section 401 Water Quality Certification

Projects requiring a section 404 permit from the Corps are also required to obtain section 401 water quality certification from Ecology. This certification means that the project will comply with state water quality standards and other aquatic resource protection requirements under Ecology's authority. The 401 certification can cover both the construction and operation of the proposed project. There is no fee required for this certification and the applicant must complete the Joint Aquatic Resource Permit Application (JARPA). The timeframe for certification is a minimum twenty-day public notice and up to one year to approve, condition, or deny. Usually this process requires less than three months (Chapter 173-201A State Water Quality Rule Washington Administrative Code (WAC); Chapter 173-225 Federal Clean Water Act, Section 40 WAC; Chapter 90.48 State Water Quality Law RCW).

4.11.3 State/National Environmental Policy Act (SEPA/NEPA)

The Washington State Environmental Policy Act (SEPA) was modeled after the National Environmental Policy Act (NEPA). The two are very similar, with some subtle differences in scope of exemptions, threshold determinations, content, substantive authority and judicial review. If a project has a federal nexus such as federal funding, a federal permit, or a location on federal land, then NEPA review is required. If a project has possible environmental impacts in Washington State and it does not qualify for an exemption, then SEPA review is required. Both dam projects would fall under the scope of both SEPA and NEPA whether or not it occurs on federal land or receives federal funding.

The NEPA permitting process is intended to assess the environmental impacts of major projects with a federal nexus. It requires federal agencies to consider environmental impacts in making decisions, and to disclose the environmental impacts to the public. If there is more than one federal agency involved (for example, NOAA provides a restoration grant for a project that requires a Corps 404 permit on National Forest land), the choice of a NEPA lead agency is often negotiated among the agencies.

Under NEPA, an Environmental Assessment (EA) is prepared to identify the potential environmental impacts of a proposal. If the EA results in a Finding of No Significant Impact (FONSI), then a full Environmental Impact Statement (EIS) is not required. The general subject areas covered by an EA and an EIS are similar, but an EIS must meet more specific and stringent requirements. If mitigation measures can be built into a project to compensate for the significant impacts, then a mitigated FONSI can also avoid an EIS. If a project is questionable as to whether or not it will require an EIS, there may be advantages to doing the full EIS up front so that there is no need to justify a FONSI and defend it against challenges.

The SEPA permitting process is intended to ensure environmental responsibility of state and local decision-makers. It requires identification of a lead agency, which is responsible for the environmental analysis and procedural steps under SEPA. The lead agency evaluates the likely environmental impacts of the project. The lead agency and the proposal applicant work together to revise the proposal or identify mitigation measures that will be included in the permit. At that point the lead agency makes a determination of non-significance (DNS), a mitigated determination of non-significance including required mitigation measures (MDNS), or a determination of significance (DS/Scoping). A DS triggers the environmental impact statement (EIS) process, which further analyzes environmental impacts and mitigation measures.

Required SEPA/NEPA reviews must be completed before state and federal permits can be issued. In most cases, a coordinated process is used to complete both the Environmental Assessment requirements under NEPA and the SEPA checklist requirements with the same information, resulting in a joint FONSI/DNS or leading to a combined SEPA/NEPA EIS. As long as procedural requirements are followed and a careful record is kept, courts are very likely to uphold FONSI and MDNS decisions. The Corps of Engineers reports that less than one percent of the NEPA reviews they complete for Section 404 permits require a full EIS.

4.11.4 Water Rights

Both a primary surface water right and a reservoir water right will be needed. The primary water right allows the diversion of water for a beneficial use. A reservoir permit allows the permittee to store a specified quantity of water. The permit states the period during each year when the reservoir may be filled. Under most conditions, filling will be allowed only during winter or runoff periods (Chapter 90.03.370 RCW). Regulatory flows have been established year round, but are typically met during the period of December to April, when diversion of surface water for filling reservoirs is being considered. Therefore, water may be available for this purpose.

4.11.5 Dam Safety Construction Permit

A Dam Safety Construction Permit is required before constructing, modifying, or repairing any dam storing 10 AF or more of water. Dam construction plans and specifications must be prepared by a qualified professional engineer and carry the engineer's signature and seal. Permit processing time averages from 6 to 8 weeks, but varies depending on project complexity. Regular inspections are conducted by Ecology after construction of a dam to assure safety of life and property (Chapter 173-175 WAC).

4.11.6 WDNR Forest Practices Permit

Construction of a storage project on Beaver or Buck Creek could require building of an additional access road and could require timber clearing before a reservoir can be filled. A forest practices permit from the WDNR would be required before construction. Information is required on the location and extent of harvesting, road construction and maintenance activities, borrow and disposal areas, methods and equipment, size of needed rights-of-way, reforestation plans, stream crossings and drainage plans, indication of wildlife habitat to be removed, riparian protection, and location of water bodies and wetlands. The price permit fee is $50 if timber is harvested or $500 for conversion of the land use to a non-forest use (Chapter 222 WAC; Chapter 76.09 RCW).

4.11.7 Aquatic Use Authorization

The WDNR authorizes use of state-owned aquatic lands. This includes dredge disposal, easements for bridges and utility crossings (including outfalls), and sand and gravel removal. In addition to the JARPA, a supplemental application may be required. WDNR fees (rents) are determined by statue and WAC. The application process typically takes six months to one year and the authorization of use ranges between 10 to 55 years, but is dependant on many factors, including the type of activity and the class of land being leased. Beaver Creek and Buck Creek are not identified by WDNR as navigable waters, so the streambeds have not been and are not likely to be identified as state-owned aquatic lands (Chapter 332-30 WAC; Chapter 79.90-70.96 RCW).

4.11.8 Hydraulic Project Approval

Any form of work that uses, diverts, obstructs, or changes the natural flow or streambed, requires a Hydraulic Project Approval (HPA) from WDFW. Permit processing can take up to 45 days and requires a JARPA form, as well as a SEPA permit. There are no fees to obtain a HPA, and the approval is good for up to five years for a standard HPA (Chapter 220-110 WAC; Chapter 77.55 RCW).

4.11.9 Shoreline Substantial Development or Conditional Use Permit

Each local government has development regulations in its Shoreline Master Program that apply to shorelines of the state, including streams with mean annual flow over 20 cfs. Beaver and Buck creek flows are above this threshold, so they fall under the jurisdiction of the Shoreline Management Act and the local Shoreline Master Program. Local governments establish the guidelines for shoreline uses and the fees for shoreline permits. A Shoreline Substantial Development Permit (SDP) is required for any development with a fair market value over $5,000 or any development that interferes with the normal public use of the shorelines of the state. The SDP is reviewed and processed by the local government and then sent to Ecology. Depending on the requirements of the local program, projects may require a Conditional Use Permit or a Variance, which must be approved by both the local government and Ecology. It is very likely that the proposed dam will fall into this category of shoreline permits. For projects that are not exempt from SEPA, SEPA review will be required prior to issuance of a shoreline permit (WAC 173-27-180; Chapter 173-27 WAC; Chapter 90.58 RCW).

4.12 Planning Level Costs

Planning level costs have been prepared based on the conceptualized dams described in previous sections. The following list identifies the types of costs that might be encountered and provides a description of what they might include. Table 4-6 provides conceptual level cost estimates for each of the proposed dam sites, detaining 50% and 100% of flows on Beaver Creek and 50% of flows on Buck Creek.

- Land Acquisition – The County Assessors Office for Stevens and Pend Oreille Counties provided assessments of privately owned land near the proposed dam sites. The value of land ranged from $50 per acre near the Beaver Creek Dam site to $1,000 per acre near the Buck Creek Dam site. Because land is often sold for a price greater than the assessed value (refer to section 4.3) and because $50 per acre appears to be unreasonably low, we have estimated the value of land for both areas to be $1,850 per acre. Lower costs may be realized if easement agreements can be negotiated.
- Site Investigations – Site investigations would include geotechnical investigations, as well as surface water and hydrogeologic investigations. This could include obtaining topographic survey data, drilling boreholes, digging test pits, installing monitoring wells and measuring stream flow.
- Permitting – Permitting costs, including water rights, water storage, NEPA, SEPA, and dam safety, can be highly variable, dependent on the regulatory setting.
- Design – Design includes a detailed feasibility study as well as the engineering design itself. The engineering design cost has been estimated based on a percent of the total construction cost.
- Construction – Construction costs include the dam embankment, foundation or grout curtain, and outlet works. Field investigations will refine design concepts and will refine the estimated construction costs.
- Operation and Maintenance – Operation and maintenance costs are estimated for a period of 100 years.
- Potential Mitigation – The potential mitigation for impacts to wetlands could be a substantial cost and have a significant level of uncertainty. Previous experience suggests that a wetland mitigation rate of 2 to 3 times the area impacted may be required. Creation of new wetlands may be required.

4.13 Recommendations and Summary

The available information on Beaver and Buck Creeks indicates that both sites offer technically feasible sites for future on-channel storage. Additional analysis in the form of geotechnical investigations, a borrow source study, flood flow analysis, and sedimentation potential would be required to clarify design conditions. Beaver Creek inflows are predicted to be insufficient at diversion of 50% and 100% to meet the target volume while predicted Buck Creek inflows are sufficient to meet the target volume using approximately 50% of December to April inflow.

Costs for a dam on Beaver Creek sized at 1,175 AF to retain 50% of inflows are estimated between $4.2 and $9.1 million. For a dam sized to retain 100% of inflows, 1,932 AF, costs are estimated between $11.8 million to $16.7 million. Costs for a dam on Buck Creek, sized to store approximately 4590 AF of inflow (50% of inflows), is estimated to cost between $19.2 million to $24.1 million. Maximum unit costs for these three surface storage scenarios are approximately $5,400 per acre foot for reservoir storage on Buck Creek and between $7,700/AF and $8,600/AF for reservoir storage on Beaver Creek.

Permitting requirements for both sites is expected to be the same. Early engagement of involved agencies including the Corps of Engineers, Ecology, the respective Counties and WDFW is necessary to build support for a project such as this. Alternatively, agency, and other stakeholder, support for this project will likely depend on a full understanding of the adverse environmental impacts as well as the environmental benefits projected from the released water for instream flow enhancement.

Because environmental impacts are expected proactive mitigation during design can facilitate permitting. Plans for mitigation can be incorporated into the design of a new reservoir in anticipation of mitigation required by applicable permits. Because processing of various permits requires different lengths of time, proactive decision-making and planning could also greatly reduce the length of time required to obtain necessary permits for such a project.

5.0 SALTESE FLATS RESTORATION

Saltese Flats is a formerly seasonal, shallow lake/wetland system, located in the southeastern area of WRIA 57 (Figure 5-1). The land was drained for use in agriculture approximately 100 years ago. Three concepts are developed in this chapter for Saltese Flats, including: 1) wetland restoration; 2) enhanced groundwater recharge and streamflow augmentation; and, 3) as a potential site for reclaimed water discharge.

Wetlands are a vital component of a healthy ecosystem. Approximately one third of the natural wetlands in WRIA 57 have been lost, with the largest single reduction being Saltese Flats (Appendix A). Even in its reduced state, Saltese Flats provides sanctuary to a wide range of wildlife, including state listed threatened, endangered and candidate species. Migrating tundra and trumpeter swans use the area every spring and fall (WDFW, undated). Restoration of Saltese Flats could provide significant ecological benefits to the watershed.

Saltese Flats was originally a seasonal lake. The natural outlet in the north end of this basin was deepened in the early 1900s to drain the lake. Restoration of Saltese Flats could create a seasonal reservoir that would be replenished by natural runoff from Mica Peak. Controlled releases of surface water, as well as infiltrated water, from the Flats could augment Spokane River streamflow.

Clean-up Action Plan (also called Total Maximum Daily Load; TMDL) regulations being developed for the Spokane River may restrict existing and future discharges from wastewater treatment plants. Treatment of effluent to meet possible future discharge limitations may be costly, and alternative discharge options are being sought. Discharge of reclaimed water to wetlands is one possible alternative and the size of Saltese Flats (e.g., >1,200 acres) may accept significant volumes.

This section includes information and data related to:

- Existing and historical Saltese Flats characteristics;
- The technical and regulatory feasibility of restoring water to the Flats;
- The streamflow augmentation and aquifer recharge potential; and,
- The possibility of discharging reclaimed water to the site.

There are many possible configurations for Saltese Flats, and the “best” configuration will depend on the desired characteristics of the site and the technical, permitting, and funding parameters. An initial set of perspectives is presented below, and should be considered a starting point.

5.1 Site Overview

Saltese Flats is in the southeast portion of WRIA 57, just west of Liberty Lake (Figure 5-1). Water drains north from Mica Peak, elevation ~5,000-ft, into Saltese and Quinnamose Creeks and towards the Flats. Currently, water from these creeks is directed toward ditches that run across and along each side of the Flats. The effect of these ditches is to drain the land for agriculture. The only surface outlet to Saltese Flats is in the northwest corner. The outlet discharges water to Shelley Lake, a natural sump (sinkhole), where it infiltrates into the Spokane Valley Rathdrum Prairie (SVRP) aquifer. The area around and upstream of Shelley Lake has been reported to flood occasionally and the northern end of the Flats to Shelley Lake is within the 100-year FEMA flood plain (Williams, 2004). The northern portion of the Flats also has the lowest elevation and becomes inundated in the spring with several small ponds retaining water year-round (WDFW, undated). The southern part of the Flats consists of palustrine, emergent wetlands bordered by uplands. An east-west ditch, which runs along the mid-line of T25N R45E Section 33, forms a distinct border between the northern and southern sections of the Flats.

There are four small dams located in and along the edges of Saltese Flats. Morrison Dam is the northern most dam on Saltese Creek at river mile (RM) 4.1 (Figure 5-2). Williams Dam and Deruwe Dam are also on Saltese Creek at RM 5.2 and 5.3. Dosser Dam is located on Quinnamose Creek where it enters the Flats. All of the dams are small-earth fill dams impounding between 39 and 55 AF. More information on the dams is available in Appendix A (Table 3-1).

Two wetlands boundaries have been designated, the first boundary was identified as part of the National Wetlands Inventory (U.S. Fish and Wildlife, 1987) and the second was from the Spokane County Wetlands Critical Areas. The National Wetlands Inventory develops boundaries using maps and aerial photo-interpretation. The Spokane County Critical Areas boundary is based on data from the Gap Analysis Program (GAP). GAP analysis identifies areas of high conservation priority and relies on current land cover and terrestrial vertebrate distributions. Land cover mapping is developed at a 100-hectare (247 acre) resolution from 1991 satellite Thematic Mapper images. Both methods have limitations based on data quality, scale, and inventory techniques and documentation of both recommend ground-truthing the results. A ground-based delineation of the Flats wetlands has not been completed.

A wetland categorization, using the Washington State Wetlands Rating System for Eastern Washington (Ecology, 2004), was completed by Ecology in September, 2004. The categorization is intended to be used as the basis for developing standards for protecting and managing the wetlands to reduce further loss of their value as a resource. Some decisions that can be made based on the rating include the width of buffers needed to protect the wetland from adjacent development; the ratios needed to compensate for impacts to the wetland, and permitted uses in the wetland. The method measures water quality, hydrologic and habitat functions. Saltese Flats was categorized, in its current state, as a Category III wetlands (on a scale of I – IV, IV is the lowest in terms of function). It was estimated that with improved management for water quality and hydrology it could be categorized as a Category I (Ecology, 2004).

5.1.1 History

Historical information about this site is primarily limited to Supreme Court proceedings and minimal anecdotal reports. According to Washington State Supreme Court documents from DeRuwe v. Morrison (Wn. 2D, 1948), Saltese Flats was once a seasonal, shallow lake of approximately 2.5 miles long and 1 mile wide at its longest and widest point. The basin was relatively level with a slope towards the north. The greatest depth was reported to be approximately 7 feet in the north end and less than 2 feet in the south. Natural depressions and patches of “tulls and rushes” are reported to have existed. Saltese Flats received rapid runoff of rain and melting snow, filling in during the wetter seasons and drying through infiltration and evaporation during the dry seasons. During high flows water would overflow and drain towards Shelley Lake (“a sinkhole”) and disappear. During dryer periods, when water levels were low, inflows from the creeks were small or non-existent (depending on accounts) and were reported to spread out and infiltrate in the Flats. In the early 1900’s, the northern and central portions were drained by a dike and levee system installed by local land owners (Morrison ancestors) in order to utilize the land for agriculture. The original outlet, which was approximately 10 feet wide, was “enlarged” and lowered as much as 15 feet to prevent the Flats from flooding. Additional modifications have been made since then, including ditches that run east-west towards the edges of the Flats near the mid-point of T25N R45E Section 33, a ditch that runs northwest from the midpoint, and at least three small reservoirs at the south end of the lake. An additional dam or berm, of approximately 1,000 feet in length, is reported to retain water at the mid-point of T25N R45E Section 33 in order to prevent it from entering the northwesterly draining ditch. This dam is reported to exist at some height between 1 foot (DeRuwe v. Morrison) and 5 feet (National Inventory of Dams).

The land is still primarily used for agriculture and some cattle grazing. Development has occurred along the edges, but most existing homes, are located outside of the National Wetlands Inventory (NWI) wetlands delineation. However, development patterns in the area may be changing, particularly in areas near the northwest outlet, the southeast corner and the mid point of the eastern side.

WDFW has attempted to purchase all undeveloped overlying Saltese Flats within the NWI boundary. This may have included easements or purchase, depending on individual land owners. WDFW determined a property located near the natural wetland outlet was critical to the success of the restoration due to the spatial location and magnitude of the owners' water rights on Saltese Creek. However the owner was unwilling to sell for the appraised value and grant funding requirements limited WDFW's ability to negotiate on price. No other properties were appraised and no additional wetland evaluation occurred. One portion of the property that was intended for purchase, on the northeastern side of the Flats is reported to have been sold for development. The owner of the remaining land, which is located in the deepest part of the former lake, has indicated he is still interested in selling but is not negotiating on the price.

5.1.2 Topography

Topographic contours at 5 foot intervals are available for the site from Spokane County and these are shown on Figure 5-2. Overlain on these figures are the extents of the wetland boundaries as designated by the NWI and Spokane County. This figure indicates that neither wetland boundary follows the topography of the area. The color coded contours show the additional area that would be inundated at each contour interval. The deepest part of the lake (lowest elevation) is in the northeastern corner where several year-round ponds are recorded to exist (WDFW, undated). In the southern end of the lake, there appears to be a berm or levee that may be causing water to pond in this higher elevation area. The levee was potentially created during construction of the ditch that runs east and west across the Flats. Ponding could also be caused or exacerbated by variations in sub-surface conditions.

5.1.3 Land Use

Saltese Flats is located just south the Urban Growth Area of Spokane Valley and Liberty Lake. Shelley Lake is located within the City of Spokane Valley municipal boundaries.

Spokane County zoning (2004) is shown in Figure 5-3. The majority of the Flats are designated as Rural Conservation, which applies to environmentally sensitive areas and encourages low-impact uses. A density of 1 dwelling per 20 acres is permitted or 1 dwelling per 10 acres through clustered housing. Some areas east and west of the Flats are designated as Rural Traditional which allows for 1 dwelling per 10 acres and resource-based industries (farming, mining, etc.). The northeast corner of Saltese Flats is designated as Urban Reserve which indicates the area is considered for growth within a 40-year planning horizon. Current density limits for urban reserve are 1 dwelling per 20 acres or 1 dwelling per 5 acres for clustered housing with stipulations that the remainder of the lot must be reserved for future urban use.

Spokane County has identified the Flats and adjoining riparian corridors as part of the Open Space Plan in its Comprehensive Plan. The upland portions of the sub-basin are designated as Forest Land and are protected as part of Spokane County's park system. The wetlands itself is identified under the County's Critical Areas Ordinance as a wetlands for protection. This indicates that building cannot occur within 75 feet of the wetlands boundary (the distance is a function of wetland category designation). Though the wetlands are protected by these designations, increased development has been occurring in recent years near the edges of the Flats.

Parcel data obtained from Spokane County indicate 67 parcels cross, or are contained within, the NWI delineation of Saltese Flats. Figure 5-3 shows all parcels which have a property use code of residential undivided and parcels designated as vacant. The extent of building on these parcels is not apparent.

The area between Saltese Flats, Shelly Lake and the Spokane River is becoming increasingly urban and falls within the Urban Growth Areas (UGA) of the City of Spokane Valley and Liberty Lake. The area around Shelley Lake is highly developed and a large development exists along Saltese Creek (it is fenced off in this area) between the Flats and Shelly Lake. Parcel coverage from the City of Spokane Valley was not obtained.

5.1.4 Hydrology

The Saltese Flats drainage basin covers about 14,000 acres. Measured discharge data from Saltese Flats does not exist. Water rights documents make mention of a visit to the Saltese Flats area in September 1969. At that time, the flow in Quinnamose Creek and the unnamed creek was about 0.1 cfs and Saltese Creek was dry. In the same document, it was noted that an uncited climatological study indicated that approximately 20,000 acre-feet of water will flow into the Flats in an average year (Dosser and DeRuwe vs. Department of Water Resources, 1971). Subsequent studies of the SVRP Aquifer provided estimate of aquifer contributions from adjacent sub-basins. Contribution estimates from the Saltese Flats sub-basin (including Shelley Lake) ranged from 17,400 AF/yr (USGS 1981) to 18,015 AF/yr (Buchanan and Olness 1993). Since all discharge from the Flats directly or indirectly infiltrates to the aquifer these estimates are considered indicative of the total flow through the Flats.

Storage requirements for purpose of streamflow augmentation are by nature seasonal. A more discrete estimate of flow is necessary to understand if a sub-basin will support seasonal storage, how that storage should be managed, and ultimately, how water retention structures should be designed. Monthly flow estimates can aid in determining storage potential and management. Peak flow estimates, such as those provided by FEMA Flood Plain studies can provide data useful for storage structure design.

Monthly average flow (Figure 5-5) was developed using measured flows from Liberty Lake and precipitation data from Spokane Airport and the PRISM model (Daly, 1997). Precipitation data from Spokane Airport (COOP station 457938) and PRISM modeled data (described in more detail in the Level 1 Technical Assessment, Golder, 2003) was used to estimate total annual inflow to the Flats. PRISM modeled average annual precipitation was 20.79 inches for the Saltese Flats basin. Measured precipitation data from the Spokane Airport was scaled so that the average annual rainfall was 20.79 inches between 1961 and 1990 (range used by PRISM). Values for the wet (26.9 inches), dry (15.0 inches), and average (20.1 inches) years were chosen from the scaled precipitation data using the 10%, 50% and 90% exceedance values respectively. The annual volume of runoff entering the Flats was calculated assuming that half of the precipitation was lost to evapotranspiration on an annual basis. The Liberty Lake monthly hydrograph was then used to distribute the annual runoff values to monthly values to create a Saltese Flats monthly hydrograph. Total annual inflow to Saltese Flats for wet, dry, and average years is estimated to range from 8,700 AF to 15,700 AF; estimated average monthly total inflow is shown in Figure 5-5.

The shape of the hydrograph is the same for wet, average and dry years because the monthly distribution was extracted from a single year of data. The actual hydrograph for flows coming into the Flats would not be expected to be the same shape every year due to seasonal variations in precipitation and run-off.

FEMA 10, 50, 100 and 500-year peak discharge estimates, shown in Table 5-1, were completed on Saltese Creek at Barker Road (near the outlet of the Flats) and Steen Road (just upstream of Shelley Lake). The flood plain study was completed in 1983 and revised in 1992. Peak discharge at Barker Road (Baker Road displayed on Figure 5-1) range from 31 cfs to 101 cfs for the 10-year and 500-year peak events respectively. At Steen Road (Figure 5-1) peak discharge is much higher ranging from 65 to 505 cfs for the 10-year and 500-year peak events respectively.

5.1.5 Soils

Soils data from the Spokane County Soils Survey indicate that soils of the Semiahmoo series dominate in the central area of the Flats. These soils are poorly to very poorly drained organic soils that formed from decomposed grasses, sedges, and other water-tolerant plants (NRCS, 1968). Physical properties of the all the soil series found in the Flats area include: permeability in the range of 0.6 to 2.0 inches per hour; available water capacity of 0.25 to 0.3 inches/inch; and 30 to 60% organic matter. The tributary valleys feeding the lake contain poorly to moderately drained silt-loams and silty clay loams of the Peone, Narcisse and Konner series, which are commonly found in stream beds and on the edges of lakes and bogs.

5.1.6 Geology

Saltese Flats is located in a topographic embayment of the Spokane Valley in the Precambrian bedrock hills of the south side of the valley. The upland hydrologic catchment of Saltese Flats is underlain by bedrock that dips under Saltese Flats. Saltese Flats is directly underlain by a thin veneer of peat and bog deposits over low permeability interbedded silts, clays, and sand of the Latah Formation. Shelley Lake, to which water drains from Saltese Flats, is located at the southern edge of extremely permeable sand and gravel deposits of the SVRP Aquifer.

Local geology is represented in Figure 5-6. The figure depicts surficial geology, well locations, and cross section locations. Geologic cross-sections through the Saltese Flats are shown on Figure 5-7a and 5-7b, a regional cross section showing the Flats and the Spokane Valley Rathdrum Prairie Aquifer is shown in Figure 5-7c.

The geologic units in the vicinity of Saltese Flats include crystalline bedrock and unconsolidated sediments. The crystalline bedrock consists of Precambrian (570 million years ago) metamorphic rocks (e.g., quartzite, schist and gneiss) that are exposed in the upland areas surrounding Saltese Flats on the east, south, and west sides. Crystalline bedrock also occurs in the subsurface in the southern part of Saltese Flats. The upper ten to about 40 feet of the crystalline bedrock is soft and weathered. The crystalline bedrock is logged as granite on water well logs from the area. Columbia River Basalt and interbedded Latah formation sediments are also present in the subsurface on the north side of Saltese Flats (Figure 5-7b).

The unconsolidated sediments include peat, silt and clay, and sand and gravel. Based on well log information from a well located near the center of Saltese Flats (155203) the peat is approximately 25 feet thick, and is underlain by about 25 feet of silt and clay (Figure 5-7b). Sand and gravel with thin lenses of silty or clayey sand occur below the peat and silt. The total thickness of the unconsolidated materials in the center of Saltese Flats is not known.

5.1.7 Hydrogeology

In general there is insufficient information on groundwater elevations, seasonal groundwater elevations, and flooding scenarios to fully characterize groundwater conditions. Well log data and published geologic mapping from the Saltese Flats area were used to evaluate the hydrogeologic conditions. Well logs evaluated are included in Appendix E.

Groundwater occurs in the crystalline bedrock and in the unconsolidated materials. In the crystalline bedrock, groundwater occurs under confined conditions in fractures. Well yields in the crystalline bedrock are variable. Reported yields ranged from less than one gallon per minute (gpm) to about 10 gpm, with occasion wells having yields up to about 100 gpm. The depth to water in wells completed in the crystalline bedrock is variable. Wells completed in upland areas further to the south and west areas surrounding Saltese Flats have a depth to water that is generally greater than 100 feet below ground, while wells completed along the eastern boundary, close to the edge of Saltese Flats (represented by well #15606, Figure 5-7a) have water levels slightly above the ground surface (flowing artesian). Water levels in wells completed in crystalline bedrock in the southern portion of Saltese Flats are about 40 to 50 feet below ground. There is no well data along the western boundary of Saltese Flats.

Only one well log (well #155203) is available in the unconsolidated materials of Saltese Flats. The well log describes drilling to 242 feet. The general groups of materials recorded on the log were, from ground surface, peat, clay, fine to coarse sand, granite, clay, gravel and mud. The well log did not include information on the wells yield, depth to water, or screened interval, but did indicate units where significant water occurred during drilling; in the sands at 50 feet and again at 190 feet. This indicates that groundwater in the vicinity of the well may be under confined conditions; however, the water level in the sands underlying the silt and clay is not known. The silt and clay present in the upper 50 feet of the well may also act as a local perching layer, allowing water to pond in the peat above the silt and clay.

The data indicate that groundwater in the crystalline bedrock is recharged by infiltration of precipitation and run-off from the upland areas east, south, and west of Saltese Flats. Groundwater in the crystalline bedrock likely discharges to the unconsolidated sediments along the margins of Saltese Flats and down gradient towards the SVRP Aquifer to the north. Groundwater in the unconsolidated sediments is expected to be recharged by precipitation and by seepage from the crystalline bedrock. Groundwater in the unconsolidated sediments is also likely to discharge to the SVRP. Available data cannot clarify the relationship between perched water and groundwater in the unconsolidated materials of Saltese Flats or the relationship between these two layers and the sands and gravels of the SVRP Aquifer.

The peat, silt, and clay materials shown on well logs within and along the edges of the Flats are considered low-permeability materials. Typical permeabilities are summarized below (Freeze and Cherry, 1979; Dominico and Schwartz, 1990; Beckwith and others, 2002):

- Peat: saturated hydraulic conductivities range from 280 to 2.8×10^{-2} feet/day.

- Silt: saturated hydraulic conductivities range from 0.28 to 2.8 x 10^{-4} feet /day.
- Clay: saturated hydraulic conductivities range from 1.4 x 10-3 to 2.8 x 10^{-6} feet/day.
- Unfractured granite, saturated hydraulic conductivities less than 3 x 10^{-5} feet/day.

The low permeability of the bedrock and silt and clay materials likely limits infiltration through these materials. At Saltese Flats, this limitation is confirmed by historical evidence that the lake level would rise during periods of runoff, overflowing to Shelley Lake, rather than infiltrating.

Almost the entire Saltese Flats sub-basin is identified as a high susceptibility aquifer recharge area under the Spokane County Critical Aquifer Recharge Area (CARA) designation and rating system. The CARA system is intended to be a determination of susceptibility of contamination to groundwater applied via scientific analysis of soils, hydraulic conductivity, annual rainfall, the depth to aquifers, the importance of the material between soils and aquifers (Vadose zone), and wellhead protection information at a 40-acre grid. The available information on the geology of the Saltese Flats area indicates that the majority of water does eventually reach the SVRP Aquifer, but that water stored in the Flats would be expected to infiltrate more slowly than this designation would suggest. Additional analysis of geologic and hydrologic information would be required to gain a better understanding of this system.

5.1.7.1 Relationship between the SVRP Aquifer and Saltese Flats

Though a relationship between the SVRP Aquifer and the Saltese Flats sub-basin obviously exists, available data cannot fully define that relationship. The data indicate that overall permeability, which indicates recharge potential, in the Flats could vary widely both spatially and with depth. If permeability is at the lower end of reported rates then the majority of water reaches the SVRP Aquifer through Shelley Lake. If permeability is at the higher end of reported values then a large portion of water reaches the SVRP Aquifer through infiltration and groundwater flow under the Flats.

The Mike SHE Model of the Little and Middle Spokane Watersheds provides an indication of the potential movement of water infiltrated in the Flats or Shelley Lake. Figure 5-1 displays a predicted delineation of gaining and losing reaches (Golder, 2004) (gain/loss state of reaches varies seasonally) in relation to Shelley Lake and Saltese Flats. Sullivan Road is one approximate location where the river switches from a losing reach (water recharging the aquifer) to a gaining reach (receiving water from the aquifer). A model scenario in which water was injected near the intersection of Barker and Trent roads, north of the river, may emulate what would happen to water infiltrated into Shelley Lake or the Flats (Golder, in Draft). In the scenario, 100 cfs was injected continuously between April 1 and June 1. In general, injected water dispersed quickly. In May and June a shallow mound of increased water levels (0.01 to 0.25 feet) was visible stretching across the width of the aquifer and to the east and west. During the injection period an increase in river flow in the Spokane River at Spokane of as much as 70 cfs was predicted (70% of injected rate). In June, following injection, the predicted change in discharge to the river, at Spokane, was between 20 and 50 cfs (June) but was not visible in predicted discharge by August.

Based on these scenario results, it is assumed that infiltration that occurs at Shelley Lake, from Flats surface discharges, or at Saltese Flats, would raise groundwater levels in the vicinity and around the river resulting in increased groundwater discharge to the river in gaining reaches.

5.1.8 Habitat

Portions of Saltese Flats are currently used by a significant number of birds, mammals and amphibians. The following fish and wildlife species and communities are known to use habitat found in the Flats (WDFW, undated):

- Waterfowl, including the following duck species: mallard, pintail, widgeon, shovelers, teal, redheads, scaup, goldeneye and bufflehead, use the Flats during spring migration.
- Tundra and trumpeter swans use the area every spring and fall.
- Raptors including red-tailed hawk, rough-legged hawk, northern harrier, Cooper's hawk, sharp-shinned hawk, merlin, kestrel, peregrine falcon, prairie flacon, golden eagle, bald eagle, osprey, goshawk, gyrfalcon, short-eared owl, long-eared owl, and saw-whet owl.
- Mammals include raccoon, beaver, muskrat, mink, and white-tailed deer. Elk can be found in the foothills and valleys south east of the Flats.
- Mammalian predators include coyotes, bobcats and cougar.
- Amphibian and reptiles include spotted frog, painted turtle, chorus frog, common and western garter snakes, and yellow racer.

Of the above species, several are listed with special status including peregrine falcon which is state-listed as endangered, the bald eagle which is state-listed as threatened, and golden eagle, merlin, Columbia spotted frog and western toad which are all state candidate species.

5.1.9 Water Quality

No water quality data has been collected on Saltese Creek (upstream of downstream of the Flats) or on Quinnamose Creek. Due to the low development density of the majority of the upstream watershed it is expected that the water draining this area would be of high quality. Though areas to the east and west could contribute poor quality storm run-off and septic sub-surface flow to the Flats. Current stock grazing within the Flats would also be expected to contribute to poor water quality.

5.1.10 Water Rights

Existing water rights were extracted from Ecology's Water Rights Tracking System (December, 2003 version). The database is not complete in the information that it contains, and Ecology provides no assurance on the accuracy of the data. Water rights were extracted for sections that surround the Flats:

- Township 25N, Range 45E Sections 19, 27-29, and 31-34; and, Township 24N, Range 45E, Section 4 and 5 which comprise the sections surrounding the Flats; and,
- Township 25N, Range 45E Sections 20; and, Township 25N, Range 44E Sections 24 which comprise the areas surrounding Saltese Creek between the Flats and Shelley Lake and Shelley Lake.

There are 25 surface water rights, including certificates and claims, estimated to total to 1,847 AF in the area surrounding the Flats (shown in Table 5-2). Claims do not generally have quantities recorded therefore a duty of 3 AF per acre was applied (Golder, 2003). Of those rights, 19 have a purpose use that is irrigation. The remaining rights have purposes of domestic and/or stock watering or fire protection. The largest water rights are held by Millar A. Morrison for 553 AF of water for irrigation purposes and the Saltese Farm Syndicate for 458 AF for purposes of domestic general and irrigation.

There are 26 groundwater rights, including certificates and claims, for a total of 1,041 AF in the area surrounding the Flats (shown in Table 5-3). The majority of the rights have multiple purposes of use that include domestic, irrigation and stock watering. Of those rights, 24 have domestic use purposes defined, and the remaining two have purposes of irrigation and stock watering specified.

An analysis of wells through the well log database indicates that there are wells along the edges of the Flats for which water rights cannot be directly associated. These wells may be exempt wells which, while not recorded in Ecology's water rights tracking database, are considered water rights.

If property is acquired for wetlands restoration, consideration should be given to the fate of valid water rights. In general, these only include rights that have been beneficially used with no historical period of non-use of five years or greater. The largest use of water is for the purpose of irrigation, and wetlands restoration will preclude continued agricultural operations. Under certain conditions, valid water rights can be transferred to other entities and/or places. There is considerable general interest by other parties (both private and public sectors) in the purchase of available water rights. Parties that may purchase both the land and associated water rights for the purpose of transferring the water rights to some other application may be motivated to donate the land to wetlands restoration in order to facilitate the water right transfer.

5.2 Design Considerations

In assessing Saltese Flats for restoration using natural inflows, design considerations must take into account the physical and logistical conditions in relation to goals. General goals for this system include wetland restoration, increased groundwater recharge, and streamflow augmentation. Physical and logistical considerations include storage potential, Shelley Lake requirements, Spokane River effects, construction requirements, wetlands characteristics, water quality, and public perception. These considerations are discussed in this section.

5.2.1 Storage Potential

Available storage is determined from existing topography, originally presented in Figure 5-2. The relationship between elevation, water surface area, and volume, at 5 foot intervals, is presented in Figure 5-8. The connecting line shown in the figure is an interpolation between the points and represents an approximation of the actual value. Volume cannot be calculated for the 2040 foot contour since it is the lowest elevation available. This figure indicates that between elevations of 2045 and 2060 feet there is approximately 2,000 to 18,000 AF of storage available. Factors that can directly reduce the maximum available storage include land use, leakage, and availability of water.

5.2.1.1 Zoning

The Spokane Critical Areas Ordinance and resulting zoning protect portions of the Flats, but these boundaries do not follow topography. As a result zoning, planned, and existing development may reduce the storage potential reached through topography.

5.2.1.2 Infiltration

Geologic information, primarily encompassed by one well driller's log, indicates that materials underlying the Flats are of low permeability and would likely prevent significant infiltration.

However, anecdotal information regarding seasonal lake losses to the ground, as well as a well log near the northern end of the Flats, indicate that the subsurface may be comprised of higher permeability materials and therefore could have higher infiltration rates. Increased infiltration could change expected system operation through decreased manageable surface storage potential. Decreased leakage would increase surface storage potential and, in turn, storage available for summer surface discharge. Increased storage would require larger outlet works. Further investigation of infiltration would be necessary in order to develop water management practices.

5.2.1.3 Water Available for Storage

Water available for storage is dependant on inflows to the Flats and losses from the Flats. A monthly storage profile is a simple water balance that portrays how much water is available as storage. It can indicate:

- How often and how much the Flats would fill over a range of conditions;
- How estimated physical parameters impact storage, such as evaporation and infiltration; and,
- The outflow potential, which indicates groundwater recharge and streamflow augmentation potential.

The following formulation of a storage profile was used:

Outflow = Inflow – Evapotranspiration – Infiltration

- Inflow to the Flats is represented by surface water inflows from the surrounding sub-basin (Figure 5-5).
- Infiltration was estimated using reported values for infiltration to materials found in Saltese Flats. An infiltration rate of 0.028 feet per day was used; this is in the higher end of literature reported rates discussed in Section 5.1.7. Monthly infiltration from the Flats is calculated as the infiltration rate multiplied by the estimated monthly area of inundated ground (assumed to be equal to the monthly water surface area) of the Flats.
- Evaporation from the water surface was approximated using monthly pan evaporation data (Liberty Lake Water and Sewer District, unpublished). An annual evaporation rate of 35.2 inches is estimated. Evaporation from the water surface is calculated as the monthly evaporation rate multiplied by the estimated monthly surface area of the Flats.
- Outflows occur when net inflow (inflow – evaporation – infiltration) and existing storage are greater than maximum available storage. Outflow can be unplanned, often referred to as spill, or planned to meet the primary goals of storage. Planned releases are not included in this water balance.
- Maximum available storage is assumed to extend to elevation 2055 feet resulting in a total available volume of 11,417 AF.

Figure 5-9 provides a summary of the storage profile for a wet, average and dry year. Monthly Stored Water represents water stored in the Flats at the end of a month after accounting for losses to infiltration and evaporation. The maximum storage available at 5 foot intervals, based on topography, is also shown. This figure shows maximum accumulated volume generally occurs in June with net losses occurring throughout the summer due to infiltration and evaporation. Figure 5-9 shows the following elevation – storage relationship:

- Elevation 2055 feet (11,417 AF) is adequate to retain the estimated monthly average flow throughout the winter. This system would have, approximately, a 10% chance of being filled in any year;
- Elevation 2050 feet (6,139 AF) is only reached during the wet and average years, and would have, approximately, a 50% chance of being filled in any year; and
- Elevation 2045 feet (1,988 AF) is reached during all years, and would have, approximately, a 90% chance of being filled in any year.

5.2.2 Receiving Water Body Requirements – Shelley Lake

Shelley Lake and the Saltese Creek outlet channel are both within an urban area and may have requested, or required, discharge amounts in order to retain water levels in the lake or flows in the creek. It appears the Shelley Lake and Saltese Creek can flood occasionally during the winter and spring and that during the summer water is pumped from the ground and discharged to Shelley Lake for aesthetic reasons. No information was available indicating the current relationship, or dependence of Shelley Lake on Saltese Flats discharge. Surface water rights were not recorded on the outlet channel or Shelley Lake.

Alternatively, Shelley Lake may have infiltration limitations that require moderation of maximum discharge from the Flats to prevent flooding and fluctuations in water levels. It appears that Shelley Lake has the capacity to infiltrate peak spring snowmelt discharges that currently pass through Saltese Flats. Therefore it is likely that Shelley Lake could also handle flow that would be released through a system that involved retaining higher flows and releasing them throughout the low flow period. However, other discharge sites may be necessary, or desired. Options include:

- A former gravel pit, just north of Shelley Lake that was once used as an emergency overflow for Shelley Lake. The gravel pit is owned by Spokane County, and the land on which the ditch connecting the lake to the pit is still privately owned characterized as undeveloped.
- Another location overlying the SVRP Aquifer. Potential sites are shown in Figure 5-1, segregated by public and private owned land. Parcels were screened for those recorded as vacant, with sizes greater than 1 acre, and occurred over the SVRP Aquifer.
- Discharging directly to the Spokane River through a conveyance system.

5.2.3 Spokane River Effects

Though lag time (time between when groundwater recharges and the effects on streamflow are realized) in the SVRP Aquifer appears to be minimal (e.g., on the order of a week), the aquifer properties in the vicinity of Saltese Flats and Shelley Lake may cause groundwater flow to the river at a rate lower or higher than that predicted by model scenario runs. Therefore lag time may need to be considered in storage management in order to maximize streamflow augmentation needs.

5.2.4 Construction Considerations

In general restoration of a wetlands or shallow lake system that is drained by a ditch, such as Saltese Flats can often be reversed simply by plugging or filling in the ditch. However, to manage stored water releases and prevent flooding of developed areas outlet control structures and dikes may be required.

Outlet works allow the system to be managed for specific purposes, such as groundwater recharge, streamflow augmentation, and wetland habitat or water quality. The Saltese Creek ditch that drains the Flats appears to be a constrictive location suited for a control structure.

Because topographic inundation contours and zoning do not coincide, there is potential, depending on final design, that this system would require an embankment or dike in areas where existing homes or properties need to be protected from potential flooding.

5.2.5 Wetland Considerations

Restoration generally means actions performed to re-establish historic functions and processes in a system. Enhancement indicates that focus is placed on select functions, processes, and values for improvement. In this project, the Planning Unit is interested in investigating the potential for restoring Saltese Flats and enhancing its storage potential.

The key to any wetlands restoration is hydrology. The depth, timing, and seasonal nature of inundation determine the ecological characteristics, such as the composition of plant and animal communities in the wetlands (Ecology, 1997). Other functions also need to be taken into account including soil structure, water quality, food-chain support and human use of the site. Therefore any storage option will need to balance considerations for storage with those of wetland communities.

5.2.6 Water Quality

Specific considerations for the type and loading of pollutants must be taken into account during design if the wetland is to be used for water quality treatment. In general, the amount of treatment a wetland can supply is dependant on the hydrology (time in wetlands, volume, seasonality, etc.) and the wetland structure (plants, flow paths, etc.).

Wetlands are described as the “earth’s kidneys” because of their ability to filter out pollutants from the water as it flows through the wetlands. Wetlands are particularly good at the removal of total suspended solids (TSS) and Biochemical Oxygen Demand (BOD). Suspended solids can settle out in slow moving wetlands. Other pollutants, such as nitrogen, are converted to less soluble forms required for plant growth, or gasses that escape to the atmosphere (EPA 2004). Wetlands are not generally known for long-term removal of phosphorus (Sauer and Kimber, 2001), although site specific conditions vary.

5.2.7 Public Perception

Neighbors of projects regarding managed water bodies can be expected to have input regarding how the system should be managed in terms of water levels, aesthetics, smell, land cover, and wildlife, among other things. Currently, houses and small parcels at the edge of the Flats are sold with advertising indicating “Views of Saltese Meadows!” Existing land owners may not be amenable to having existing land “in their backyard” flooded. Other issues, such as West Nile virus, can also cause negative responses to beneficial projects, such as this. On the other hand, recreation opportunities and wildlife accessibility that currently exist in limited areas could be significantly increased by this project. Views of a lake or wetlands, as well as the knowledge that this project is intended to benefit both Spokane River flow and wetland habitat, may be desirable characteristics to many land owners.

5.3 Conceptual Design Using Existing Inflows

This section describes conceptual level design and estimated storage benefits for Saltese Flats assuming that natural inflows are used to restore the shallow lake/wetland system and that this water is partially managed for late summer streamflow augmentation.

Three Saltese Flats restoration configurations were developed. These should not be construed to comprise all the available options for storage and restoration. The restoration configurations considered for Saltese Flats using natural inflows are:

- Configuration 1, assumes that all land within the 2055 foot elevation contour is purchased and restored to a seasonal lacustrine system with emergent vegetation along the borders;
- Configuration 2, assumes that only land within the Wetlands Critical Area (zoned for rural conservation) is purchased and restored to a seasonal lacustrine system with emergent vegetation along the shallow borders; and,
- Configuration 3, assumes that available land within the Wetlands Critical Area (zoned for rural conservation) is preserved and/or restored to a marsh state, with pockets of shallow, palustrine, emergent areas, significant inundation (> 2 to 3 feet) would not occur, and storage would not be actively managed.

Estimated storage benefits are presented in terms storage available in July and its equivalent discharge rate for low flow augmentation between July and October for each configuration. July represents, generally, the earliest month that low flows would occur on the Spokane River. For simplicity, it is assumed that any stored water that is available in July is released as surface water, at an average rate, between July and October, accounting for indirect discharge to the SVRP and losses to evaporation during that time. This is considered a conservative estimate of available flow and greater releases over shorter periods (for example two months instead of four months) would be possible. Table 5-4 summarizes the results of this storage profile for the three configurations discussed. The table reports the following calculated monthly storage profile parameters:

- Maximum available volume (AF) for each configuration;
- Maximum inundated surface area (Acres) for each configuration;
- Volume of stored water (AF) available for release in the beginning of July;
- Average rate of water discharge (cfs) assuming that the volume available in July, less expected losses to infiltration and evaporation through the summer, is discharged at an average rate between July and October;
- Average rate of discharge to groundwater (cfs) presented as an average for the period July through October.
- Expected losses to evaporation (cfs) presented as an average for the period July through October.

The results shown in Table 5-4 indicate that under the two manageable storage configurations (1 and 2) between approximately 3,244, and 8,609 AF of water was available for release in July depending on the climatic year (dry, average, wet). That volume, translated into an average rate of discharge for July through October, results in surface releases of between 1 and 21 cfs, and groundwater recharge of between 10 and 17 cfs. Configuration 2 results in greater stored volume in July than configuration 1; this is due to the difference in the surface area in contact with the ground and with the air. Because

Configuration 2 results in a less spread out lake, the total volume of infiltration and evaporation is calculated to be lower.

5.3.1 Configuration 1-Restoration to Elevation 2055 feet

The extent of inundation for configuration 1 is shown in Figure 5-10. This configuration would result in a seasonal, shallow lake/wetlands system (lacustrine, with little to no littoral zone) with a surface area of approximately 1,237 acres and a wet season depth of up to 15 feet. A maximum of 11,417 AF (of storage is available. It's expected that the existing outlet to Shelley Lake could continue to be used for discharge from the Flats.

Some physical modifications to the Flats would likely be necessary including: plugging of ditches which direct water out of the Flats, and construction of an outlet structure, on the Saltese Creek outlet channel to Shelley Lake, in order to manage water surface elevation and releases. This configuration would require an outlet structure of sufficient capacity to handle outflows on the order of 80 cfs (based on the 100-year peak discharge reported by FEMA). Improvements in conveyance to Shelley Lake and maintenance at Shelley Lake may also be required. If it is determined that an additional receiving body is needed for discharge from the Flats additional conveyance and maintenance of that infrastructure would be required.

In general, the lake would fill in the winter and drain during the summer. Based on existing topography year-round ponds and wet meadows would exist throughout the summer in the north east corner and potentially in the south end where water currently accumulates (represented on Figure 5-10). The timing of discharge to Shelley Lake would be modified from current conditions so that during the winter and early spring the lake will likely receive little flow as the Flats are being filled and would receive steady flows during the summer and early fall when water is being released to meet streamflow augmentation goals.

Potential benefits of this scenario include a relatively large water storage and discharge potential; restoration to a condition closely resembling the recorded natural condition excepting management to prevent flooding; significant length of seasonally inundated shoreline (approximately 10 miles) where persistent and non-persistent emergents can exist in addition to semi-permanently flooded areas dominated by aquatic bed species; summer discharges that could maintain Shelley Lake water levels; increased habitat; and improved water quality.

Drawbacks include the potentially higher cost of purchasing or obtaining easements on land outside the Spokane County Critical Area that is zoned for future urban development. In addition, this option would seasonally inundate an area in the south of the Flats that was described as "pristine" wetlands by the WDFW during the wet season (WDFW, undated).

Expected storage available for augmentation in July, as described in Table 5-4, indicates that between 3,244 AF for dry years and 8,375 AF for wet years will be available in storage in the beginning of July. Losses to evaporation range from 5 to 7 cfs. This results in and average net discharge (surface discharge to Shelley Lake and recharge through the Flats) between July and October of between 11 to 32 cfs.

5.3.2 Configuration 2 – Restoration within the Critical areas to Elevation 2055 feet.

The extent of inundation for configuration 2 is shown in Figure 5-10. Configuration 2 and 3 cover the same horizontal extent. This configuration is similar to configuration 1 but assumes that only land within the Spokane County Critical Areas designation is used for storage, up to an elevation of

2055 feet. This would result in a seasonal shallow lake wetlands system with a surface area of approximately 895 acres and a maximum depth of 15 feet during the wet season. This configuration would result in a maximum available volume of 8,609 AF.

This configuration is independent of existing topography. As a result, construction of an embankment or dike would be required in areas where natural topography does not contain the system. Potential dike locations are shown on Figure 5-10. At an elevation of 2055 feet, one main dike would be required for a total length of approximately two miles on the east, north and west side of the Flats, with other smaller dikes also potentially necessary (Figure 5-10). The main dike would be between approximately 10 and 20 feet in height. This system would be similar to that of Newman Lake which has a 1.6 mile long dike, constructed of native peat materials, surrounding the south side of the lake. Based on a geotechnical assessment of the unconsolidated materials which comprise Saltese Flats (primarily peat and clay with some silt, sand and gravel), these material appear feasible for construction of such a dike. In addition, a control structure on the Saltese Creek outlet to Shelley Lake would be required to manage stored water levels.

In general, the lake would fill in the winter and drain during the summer. Similar to configuration 1, and based on the existing system, it would be expected that even when “fully” drained, year-round ponds and wet meadows would still exist in the north east corner and potentially in the south end where water currently accumulates. The timing of discharge to Shelley Lake would be modified from current conditions so that during the winter and early spring the lake will likely receive little flow as the Flats are being filled, and would receive steady flows during the summer and fall when water is being released for streamflow augmentation goals.

Potential benefits of this scenario include: a large maximum storage and discharge potential; decreased loss to evaporation due to less surface area being in contact with the ground and with the air; decreased total land acquisition, more acceptable aesthetics (for some land owners) due to decreased seasonal land surface exposure along the lake margins due to the dike; summer discharges that could maintain Shelley Lake water levels; increased habitat; and improved water quality

Potential drawbacks include: increased costs due to the necessity of construction of one or several dikes and maintenance of those dikes; less seasonal, shallow emergent areas along the lake margin as well as less diversity in wetland structure due to the dike (3.5 miles excluding diked edges); inundation of an area in the south of the Flats that was described as “pristine” wetlands by the WDFW during the wet season.

Expected storage available for augmentation in July indicates that between 3,955 AF for dry years and 8,609 AF for wet years will be available in storage in the beginning of July (Table 5-4). Estimated losses to infiltration, reported as an average rate, between July and October range from 10 to 14 cfs. Losses to evaporation range from 4 to 6 cfs. This results in average surface discharges on the order of 4 to 21 cfs.

5.3.3 Configuration 3 – Preservation of the Existing System

This configuration (Figure 5-10) involves preservation and, as possible, restoration of lands within the Critical Areas boundary to elevation contour 2055 feet while preventing the need for dikes or natural inundation outside that boundary. Based on topographic contours (5 foot interval), inundation to a significant, actively manageable depth within the Critical Area would not be possible without a dike due to the conflict between topography and zoning. Currently two main areas exist as marshlands and ponds, shown on Figure 5-10, these would be preserved and water could be restored to soils currently grazed or used for agriculture. The Saltese Flats Wetlands Critical Boundary area within the

2055 elevation contour is 895 acres and assuming that an average depth of 2 feet was restored to this system the volume would be 2,078 AF.

This option would involve seasonal changes in water levels, but not to the extent discussed in previous configurations. Water levels may vary on the order of 1 to 2 feet with the majority of winter flow continuing to pass through the wetlands to Shelley Lake in ditches. While it is anticipated that this option will, inherently, result in increases in stored water, it is not expected that the majority of it will be actively managed.

Some physical changes to the existing system may be necessary or desired in order to promote successful function in the wetlands. One option would be to continue to utilize the ditches to pass excess flows through the Flats during high flows but alter these ditches using gates or diversions to increase the amount of water available to adjacent, currently drained, areas. Alternatively construction of systems that promote dispersion of influent water across the Flats may be beneficial. Topographic modifications to increase the ponding or sheet flow of water across the Flats may also be desired. An outlet structure would likely still be desired in order to control winter releases and prevent flooding in the Flats and downstream.

Potential benefits of this scenario include increased habitat and improved water quality; increased groundwater levels in and around Saltese Flats. Dampening of peak flows that would normally discharge to Shelley Lake. Decreased costs and management requirements over managed storage configurations.

Potential drawbacks include little to no manageable storage, potentially less diversity in wetland structure.

It is assumed that little to no surface discharge would occur during the summer months when inflows are low. This is due to the fact that the majority of existing inflows would likely be lost to evaporation and transpiration within the wetlands. However the fact that water will be held on the surface in pools and marshes and in the soil column will be expected to result in increased groundwater levels that could inherently have positive affects on Spokane River Flow.

5.3.4 Discussion

Results for each configuration, shown in Table 5-8, indicate that there is a greater proportion of recharge through Saltese Flats than surface discharge to Shelley Lake from July to October. This occurs because of the relatively high infiltration rate (0.028 feet/day) applied to the Flats soils and sub-surface, the actual infiltration rate could significantly change the volume of surface storage in this system. Saturated horizontal conductivities in the literature present a range from as high as 280 feet/day in the peat layers to as little as 2.8 x 10-6 feet/day in clay layers. However, whether water infiltrates in the Flats, or at Shelley Lake, summer low flow augmentation potential would likely be similar since both paths are expected to eventually reach the SVRP Aquifer and augment the Spokane River.

Results indicate that Configuration 2 will result in greater volumes of stored water in July, and average discharge rates between July and October than Configuration 1. This result may be counterintuitive since the available volume of Configuration 2 is lower than Configuration 1. This is due to the fact that Configuration 2 will result in less spreading of water (surface area of 895 acres vs. 1,237 acres in Configuration 1), and therefore less interaction with the ground (infiltration) and air (evaporation).

Ultimately design needs to account for final objectives (e.g. storage, wetlands restoration, etc.) and would require collaboration with stakeholders and agencies to balance those objectives and the physical and regulatory constraints in the system.

5.3.5 Regulatory Considerations

The definition of wetlands in RCW 36.70A.030(20) is:

> "Wetland" or "wetlands" means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Agencies having regulatory jurisdiction over wetlands in Spokane County include: Spokane County, the Ecology, the Corps of Engineers (Corps), Environmental Protection Agency (EPA), and WDFW. The state and federal regulatory programs are designed to address all significant impacts to wetlands.

The following wetland-related regulations (individual regulations are described in more detail in Section 4.11) would generally apply to restoring Saltese Flats for water storage purposes:

- Spokane County Critical Areas Ordinance (under Growth Management Act).
- Spokane County Shoreline Management Plan (Shoreline Management Act).
- Section 404 of the Federal Clean Water Act administered by the ACOE.
- Section 401 of the Clean Water Act, issued by Ecology with notification to the Corps when required.
- Hydraulic Project Approval (HPA, under Chapter 75.20 RCW), issued by WDFW.

To streamline the permit application process for water-related projects, Washington has begun implementing the Joint Aquatic Resource Permits Application (JARPA). The JARPA application combines seven different permit applications into one. JARPA covers all of the most frequent federal and state permits relating to wetlands. These include the State Shoreline Management Act, State Hydraulic Permit, State Water Quality Certification, and Section 404 & Section 10 of the Federal Clean Water Act. The application is still reviewed by the respective agencies and issued separate permits in accordance with their existing authorities. Some local governments also participate in the JARPA program, combining all or some of their wetland related permits on the JARPA form.

Wetland restoration and enhancement activities are grouped into compensatory and non-compensatory. They are classified as non-compensatory if they are designed to improve wetland functions (and/or increase wetland acreage) and are not being completed to compensate for impacts caused by development. Restoration of Saltese Flats wetlands for water storage purposes are considered non-compensatory. Non-compensatory projects fall under numerous regulatory exemptions. However restoration activities involving dredging or filling of wetlands would invoke regulatory authority. For example, to restore the historic water level in Saltese Flats and use that water in a manner suited to augment low river flows, a dike may need to be built and/or a water control structure may need to be installed on Saltese Creek. This sort of activity is regulated by local, state, and federal agencies.

Generally, projects impacting wetlands are required to develop a mitigation plan to replace the loss of wetland functions. The Saltese Flats restoration project, however, would be considered "self mitigating" in that it may cause temporary impacts (during construction) that are ameliorated by the significant increase in function resulting from the activity. As a result, voluntary wetland restoration work does not require the wetland to be restored to a certain size or area. However, it is strongly recommended that applicable resource agency staff be involved for review and comment on the proposed design.

To determine the location and amount of wetland expected to fall under regulatory authority from restoration related construction activities, the (existing) exact locations of wetlands in the vicinity of the work will need to be documented. To determine the full extent and coverage of wetland areas, a wetland delineation of the area will be required.

5.3.5.1 Wetland Mitigation Banking

In developing the design for wetland restoration and implementation of Saltese Flats for water storage, consideration should be given to opportunities to use the site as a wetland mitigation bank. Mitigation banking is a concept that is receiving increasing attention and support. The general idea is to create or restore a large wetland area and use the "credit" to compensate for wetland impacts that occur elsewhere. A large scale project such as Saltese Flats could act as a wetland mitigation bank for wetlands that may be impacted in the Spokane Valley, or potentially throughout WRIA 57, in the future. As such, in developing the Saltese Flats area as a mitigation bank, the implementing agency could receive compensation from developers seeking wetland mitigation credits in the future.

A draft pilot rule is available in Chapter 173-700 WAC. Ecology has received $120,000 in funding for 2005. The funding will be used to facilitate the pilot rule process and guide the implementation of the draft state wetland mitigation banking rule on a test or pilot basis. There are still some obstacles remaining that continue to make banking problematic. There is need for a method of quantifying wetland functions to establish wetland credits and debits to be used in banking "transactions." There is also a need to establish how banking will mesh with the existing regulatory processes.

5.3.5.2 Water Rights

Restoring Saltese Flats to its original hydrologic condition should not require a water right. However, certain restoration configurations may result in the seasonal retention of water, or a higher lake stage, than otherwise would have naturally occurred, if the additional water stored is derived from natural runoff, then a primary surface water right and reservoir right may be needed. If the additional water stored is derived from reclaimed water, as described in the following section, then only a reservoir right may be required, although this is not certain.

5.3.5.3 Dam Safety

A Dam Safety Construction Permit is required before constructing, modifying, or repairing any dam storing 10 AF or more of water. Dam construction plans and specifications must be prepared by a qualified professional engineer and carry the engineer's signature and seal. Permit processing time averages from 6 to 8 weeks, but varies depending on project complexity. Regular inspections are conducted by Ecology after construction of a dam to assure safety of life and property (Chapter 173-175 WAC).

5.4 Saltese Flats Restoration Using Reclaimed Water

A Clean-up Action Plan (also called a TMDL) is currently being developed to protect oxygen levels in the Spokane River and will likely result in changes to discharge limits of pollutants which impact oxygen levels, such as phosphorus, ammonia, etc. Final approval for wastewater discharge from expansion of the Liberty Lake Wastewater Treatment Plant and construction of the Spokane County Regional Treatment Plant are on hold until the Clean-up Action Plan is completed. It is anticipated that the plan will require a higher level of treatment for all point source dischargers than currently exists, including for these treatment plants (final TMDL discharge limits may be affected by an ongoing Use Attainability Analysis for the Spokane River). As a result, alternatives to discharging water to the Spokane River are being investigated. One potential alternative is to discharge reclaimed waste water to wetlands, such as Saltese Flats. Table 5-5 displays all current and potential point dischargers to the Spokane River that may be affected by the TMDL, the locations of these dischargers are shown on Figure 5-1.

This section builds on information and configurations described in the previous section describing additional design and permitting considerations for discharging reclaimed water to Saltese Flats. In this preliminary feasibility stage there are many uncertainties, as a result, there are a wide range of configuration and management options available (as was discussed for configurations for natural flow conditions in Section 5.3. It is not possible to describe all possible options in detail but this section attempts to present the range of options that are available.

Specific topics discussed in this section include regulatory requirements for reclaimed water discharge to wetlands, inflow management and receiving water body considerations. This section does not identify specifics related to treatment plant design or costs of treatment. Rather, this section evaluates the potential for Saltese Flats to be a receiving area for reclaimed water inflow based on regulatory requirements and Saltese Flats characteristics.

5.4.1 Regulatory Requirements

Water Reclamation and Reuse requirements have not yet been codified for all reclaimed water uses, but those that have, are outlined in Chapter 90.46 RCW - Reclaimed Water Use. Guidelines for reclaimed water use are summarized in Water Reclamation and Reuse Standards, September 1997. These guidelines were created by Ecology and Health in accordance with RCW 90.46. The guidelines describe allowable beneficial uses and the required level of reclaimed water treatment for each beneficial use.

Guidelines for reclaimed water released to a wetland are intended to ensure proper wetland function, prevent degradation to existing wetlands and groundwater, and ensure public health protection. Ecology has indicated that the guidelines should not be interpreted strictly because they are ultimately dependant on site specific attributes. The final application of regulatory requirements will be dependent on a site specific study and collaborative process that will involve multiple agencies and stakeholders.

Many of the criteria discussed in the standards are set to protect existing natural wetlands. Because Saltese Flats is in a degraded state, and is not for the most part functioning as wetlands, reclaimed water augmentation may be determined to be a “net environmental benefit” to the system. In such a case modifications to the criteria may be acceptable. Ecology has indicated that the standards were not intended to be a burden that prevented beneficial discharges of reclaimed water from occurring, but simply were intended to protect and prevent degradation to existing wetlands (Lund, 2004).

The guidelines for reclaimed water discharge to wetlands include criteria related to design and monitoring. Criteria related to design are defined within the following five groups.

1. General design criteria establish the measures that need to be taken to protect the public, and water supplies from coming into contact with the reclaimed water.
2. Hydraulic and hydrologic criteria limit the annual rate, and monthly timing and volume of water that can be discharged to a wetland through loading rate and water level fluctuation criteria. These criteria are intended to ensure proper wetland function for individual systems.
3. Water quality criteria set guidelines for the concentration of certain constituents in the wetlands and the rate at which the constituents can be added to the wetland. These criteria are also intended to ensure proper wetland function.
4. Biological criteria provide protection for the existing or planned structure and function (vegetation, species, etc.) of the wetland.
5. Groundwater protection criteria provide for protection of groundwater recharged by such wetlands.

Specific criteria requirements are presented in Table 5-6. The effects of these criteria on design are discussed below.

5.4.1.1 General Criteria

A 500 foot buffer must be established between the highest elevation inundated area and any potable water supply wells. In addition, a 500 foot buffer would have to be established around any site where Saltese Flats discharges reclaimed water for infiltration; currently Shelley Lake and the portion of Saltese Creek that connects the lake to the Flats. Approximately 22 wells are located within 500 feet of the 2055 elevation inundated area and Shelly Lake (Table 5-7). Available information does not indicate whether these wells are used for potable supply. Only one well within the 500 foot buffer could be associated with a water right claim. The well owned by Saltese Flats Farm Syndicate could be associated with the owner of 4 water rights for an estimated total annual quantity of 8 AF. Domestic exempt wells may constitute the remaining wells in Table 5-7. Additionally, other undocumented domestic exempt wells could exist.

5.4.1.2 Hydraulic and Hydrologic Criteria

Hydraulic criteria require that additional average annual loading is not increased by more than 3 cm/day (1.2 inches/day) for Category III wetlands. Hydrologic criteria require that average monthly water levels do not increase more than 10 cm (3.9 inches) over pre-augmentation conditions (there may be further limitations based on vegetation richness, presence of breeding amphibians and the fen component of a wetland). Application of these criteria will depend on wetted surface area, as well as operations (releases, recharge, etc.).

Table 5-8 presents these criteria as volume and rate limits for configurations 1 through 3 described for Saltese Flats (see Section 5.3). The values presented in Table 5-8 were calculated using several simplifying assumptions.

- Reclaimed water inflow is an addition to existing natural inflow.
- Reclaimed water inflow is dispersed over the entire available surface area in the configuration, not just the inundated area (inundated area varies seasonally and would result in more constraining criteria when water levels are low than when they are high).
- Discharges from the Flats do not occur specifically to accommodate additional inflows of reclaimed water.

- Recharge and losses to evaporation are negligible.

These criteria result in an allowable additional annual average loading limit of 61 cfs for configuration 1 and 44 cfs for configuration 2 and 3. This indicates that Saltese Flats can be a receiving body for as much as 61 cfs (under configuration 1) of reclaimed water, but that storage management will need to ensure that water levels do not increase more than 10 cm in any one month (or by the criteria that are ultimately applied). While 10 cm. calculated using existing area, is equivalent to between 5 and 7 cfs of total monthly inflow there will be losses to evaporation, recharge to the ground and, if desirable, releases from surface storage. Also shown in Table 5-8 is the available storage in the Flats, calculated as the difference between maximum available storage over that already estimated to be input from natural inflows and maximum stored water in a wet, dry and average, year. This table indicates that the availability of additional storage space (over natural inflows) will be limiting in wet years, but in general management of water will occur to meet monthly water level limits of 10 cm.

5.4.1.3 Water Quality Criteria

Water quality criteria are primarily dependant on the beneficial use of the wetland. Saltese Flats is assumed to have the potential for human contact recreation and educational beneficial uses. Therefore treatment to, at a minimum, Class A reclaimed water standards would be required. Additional treatment to specific wetland water quality criteria may also apply unless net environmental benefit can be demonstrated. Additional phosphorus treatment could be applied if Saltese Flats or Shelley Lake is considered a phosphorus-limited water body. These water quality criteria are described in Table 5-6.

5.4.1.4 Biological Criteria

Biological criteria are established for the following wetland structural components: vegetation, macroinvertebrates, amphibians, fish, and birds. Biological criteria are also established for populations of threatened or endangered species. A complete survey of pre-augmentation conditions would be required.

5.4.1.5 Groundwater Protection Criteria

Groundwater protection criteria require that a hydrogeologic investigation be completed to determine if groundwater recharge is occurring and if so, the timing and quantity of that recharge. In addition, if parameter concentrations in the reclaimed water are greater than 50 percent of the ground water quality criteria (WAC 173-200) then additional monitoring is required to ensure that anti-degradation standards are met (Ecology, 1997). Ecology also indicated that if “significant” groundwater recharge is occurring then groundwater recharge criteria may apply (anti-degradation standards WAC 246-290 and monitoring to ensure that drinking water quality standards are met at the point of withdrawal). Data indicate that Saltese Flats indirectly recharges to the SVRP Aquifer, but the extent and rate of recharge from the Flats is unknown. Discharge that occurs through Shelley Lake would likely constitute significant groundwater recharge and would therefore be required to meet groundwater recharge criteria. Natural attenuation of constituents in the wetlands as well as in subsurface flow through the Flats or Shelly Lake is expected to greatly facilitate compliance. Table 5-9 displays groundwater recharge criteria as well as average SVRP Aquifer groundwater quality as measured in Consolidated Irrigation District and Vera wells, and in Barker Road monitoring wells.

5.4.1.6 Monitoring requirements

Discharge of reclaimed water to wetlands requires monitoring of all criteria. Monitoring requirements are summarized in Table 5-10. Sampling methods, station locations and numbers of stations are determined on a case-by-case basis.

5.4.1.7 Permitting Requirements

Ecology recommends obtaining permits and project approvals early in the project design processes because often it is an ongoing and iterative process. Most restoration projects must be reviewed under the State Environmental Policy Act process and a permit under Section 404 of the Clean Water Act could be required.

Reclaimed water generation and use must be covered under a permit that is issued jointly between Ecology and Health (Ecology 1997). It is issued to the generator of the water, who has the right to the distribution and use of the water. The permit conditions govern the location, rate, water quality and purpose of use. If the release would be governed under another permit (e.g. a NPDES permit for discharges to streams), the two permits are usually combined. A SEPA, NEPA and engineering report are all required. In addition certain funding options may have additional permits required (an example is the Federal State Revolving Fund loan which requires a SERP permit).

5.4.2 <u>Inflow Management</u>

Inflow management refers to the management necessary to balance two potential sources of water (existing natural inflow and reclaimed water inflow) as well as meet regulatory requirements. Discharge from municipal wastewater plants shows little seasonal variation throughout the year. Natural inflow, on the other hand, (and therefore water level) is expected to show large seasonal variations. The constant nature of reclaimed water discharge can help ensure that, even in dry years, the Flats will have available inflow which will prevent loss of vegetation or habitat.

Three general options exist for managing inflows.

1. Reclaimed water can be considered as an addition to natural flows – This assumes that reclaimed water is only discharged to the Flats when space is predicted to be available. This management option may result in uncertainties regarding the rate of reclaimed water that can be accommodated in any one month.

2. Reclaimed water can be considered as a replacement of natural flows – This management option will result in less constraints on inflow because the volume previously filled by existing inflows could be filled by reclaimed water inflows, regulatory hydraulic loading criteria would limit average annual inflow to between approximately 43 and 61 cfs, depending on the configuration (see Table 5-8) and site specific requirements. This management option would require diversion of existing inflows around Saltese Flats.

3. Reclaimed water and natural inflows can be combined as some ratio in between.

At this stage in the planning process it is not possible to determine which scenario is most beneficial. The final result will be dependant on goals, the specific quantity and quality of the reclaimed water inflow stream, wetland characteristics and discussion with regulatory agencies. An operational model would provide an ideal method for accounting for multiple scenarios, constraints, and physical configurations and their effect on the system in order to determine the most beneficial modes of operation.

5.4.3 Receiving Water Body Requirements – Shelley Lake

Design considerations must take into account the additional discharge that would occur due to reclaimed water inflow to the Flats, these could include:

- Verification of the infiltration capacity of Shelley Lake to determine if an additional discharge location is required. Potential infiltration sites were discussed in Section 5.2 and shown on Figure 5-1.
- Verification of the quality of water discharged from Saltese Flats to prevent anti-degradation of the water quality of Shelley Lake and to groundwater.

5.4.4 Discussion

Saltese Flats has the potential to support the discharge of reclaimed water. The quantity and timing of water this system could accept would depend on the site-specific regulatory requirements, wetland characteristics and inflow management.

Reclaimed water discharged to the Flats would be required to be treated to Class A Reclaimed Water Standards due to the potential for human-contact. Additional treatment may be required depending on the current wetland condition, receiving water body conditions and groundwater quality effects. While these regulatory water quality requirements for discharge to wetlands in general appear cumbersome, there is significant flexibility in the application of these guidelines that can only be taken into account with a more focused site investigation and quantification of the net environmental benefit.

The primary advantage of discharging reclaimed water to Saltese Flats, over other river discharge or surface percolation options is that reclaimed water discharged to the Flats will be able to provide additional benefits in terms of wetland restoration and streamflow augmentation.

5.5 Cost

Planning level costs have been prepared based on the conceptualized configurations described in the sections above. An uncertainty of 25% is assigned to the cost estimates. The following list identifies general costs that would be encountered.

- Land Acquisition – The cost for acquisition of privately held undeveloped lands appear to range from approximately $1,500 per acre within the Saltese Flats Boundary (based on appraised value of lands for WDFW project in 2002) to $17,000 per acre for land with development potential on the margins of the Flats (Spokane County, 2004). This cost would be expected to be greater for any lands with existing dwellings. Homes along the edge of Saltese Flats are for sale at prices between $200,000 and $400,000 for parcel sizes of generally 10 acres to 20 acres. Because Configuration 1 has a larger area outside of the Spokane County Critical Areas boundary, that therefore may be developable, its average cost per acre of land would be expected to be higher. A cost per acre of $3,000 was assumed within the Wetlands Critical Area and $17,000 outside of this critical area. Total costs include a 20% transaction fee. Total costs for land range from $3.2 to $10.2 million depending on the configuration.

- Site Investigations – Site investigations may include wetland delineation and assessment, geotechnical and hydrogeologic investigations, and surface water and water quality assessments. This could also include obtaining topographic survey data, drilling boreholes, digging test pits, installing monitoring wells, and measuring stream flow and water quality. Investigation costs range from $50,000 to $200,000 for restoration using natural inflows and are estimated to be approximately $500,000 for investigations for reclaimed water inflow.

- Permitting – Permitting costs may include water rights, water storage, SEPA/NEPA, dam safety, and reclaimed water permits. Permitting costs can be highly variable and unpredictable and are dependent on the regulatory setting. Permitting is estimated to range from $75,000 to $1,000,000 for restoration using natural inflows and from $500,000 to $1,500,000 for permitting reclaimed water inflow.

- Mitigation – It is assumed that the overall project benefits will provide mitigation for any potential negative impacts. Therefore, there may not be any additional mitigation costs, and are not considered.

- Design and Construction – Design includes a detailed feasibility study including site assessment and monitoring as well as the design of any engineered system. The engineering design cost has been estimated assuming 30% of the total construction cost. Construction costs include labor and materials associated with any engineered system such as dikes, foundation, and outlet works. Construction costs may also include topographic modifications to improve wetland function. Additional construction costs associated with reclaimed water inflow could include passive structures to enable even dispersion or spreading of discharge across the wetland. Design considerations for reclaimed water Field investigations will refine design concepts and will influence the estimated construction costs. Design and construction costs range from $0.1 to $7.8 million for restoration using natural inflows, with Configuration 2 estimated to have the greatest costs due to required construction of a containment system. Design and construction costs range from $1.1 to $8.0 million for restoration using reclaimed water inflows.

- Operation, maintenance and ongoing monitoring - Operation and maintenance costs include operation of the control structure, maintenance of all constructed systems and any ongoing monitoring requirements. This value is reported as an annual rate. Operations and maintenance costs are expected to range from $50,000 to $150,000 for restoration using natural inflows and range from $100,000 to $200,000 for reclaimed water inflow.

- Conveyance costs – Conveyance costs are included as an entirely separate line item in this cost estimate to capture the potential cost of a conveyance system to transport reclaimed water from a wastewater treatment plant. For purposes of this assessment the general location of the proposed SCRTP site is used to calculate distance from Saltese, approximately 11 miles. Unit costs of conveyance were estimated using average capital costs developed for outfall conveyance for the SCRTP. Average unit costs were $518 per linear foot of conveyance. Actual costs would vary depending on the route and conditions over which conveyance would occur. Costs of conveyance for reclaimed water are estimated to be approximately $30 million dollars.

- Revenue from Wetlands Mitigation Banking –Because the primary objective of the proposed configurations is environmental restoration, marketing mitigation credits was not considered. If adequate funding for restoration was not obtained, marketing mitigation credits could be considered. The value of mitigation credits is not well established. Estimating revenue from the marketing of mitigation credits for this site would require a financial study, including the identification of the market and potential buyers of mitigation credits.

Costs do not include any required waste water treatment plant upgrades or modifications.

In general the cost of land acquisition and, for Configuration 2, development of an embankment is the largest costs when evaluating the potential for restoration using natural inflows. Costs associated with the addition of reclaimed water to the project will primarily be due to conveyance as well as smaller costs associated with permitting, design and construction, site investigation, and operations and maintenance. This is due to the detailed analysis and monitoring that is required for such a system. Table 5-11 provides general cost estimates for each of the proposed configuration.

5.6 Potential Funding Sources

Currently funding exists for this project through a grant obtained by the WDFW. The grant was obtained from the IAC (Interagency Committee for Outdoor Recreation), for ~$1.5 million, in order to purchase land in the Flats. This grant expires December 31, 2005. This particular funding is transferable to public entities and the WDFW has indicated it is still interested in this project and interested in collaborating where possible.

Many other funding sources exist to implement the restoration programs. The Spokane County Soil Conservation District and the Natural Resources Conservation Service offices in Spokane County can provide information for current Department of Agriculture programs available to landowners to implement restoration projects.

In addition, the following funding programs are among many others that also can provide monies for wetland restoration:

<u>Environmental Protection Agency 319 Implementation Grants and Washington Centennial Clean Water Fund</u>

Through its 319 program, EPA provides formula grants to the states and tribes to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA). Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed. Examples of previously funded projects include installation of best management practices (BMPs) for animal waste; design and implementation of BMP systems for stream, lake, and estuary watersheds; basin-wide landowner education programs; and lake projects previously funded under the CWA section 314 Clean Lakes Program.

<u>US Fish and Wildlife Service Partners for Wildlife and Endangered Species Program Private Grants Stewardship Program</u>

The Partners for Wildlife and the PGSP support on-the-ground conservation actions as opposed to planning or research activities. Eligible projects include those by landowners and their partners who need technical and financial assistance to improve habitat or implement other activities on private lands. The acquisition of real property through fee title or easements will not be funded through this program. Individuals or groups working with private landowners on conservation efforts are encouraged to submit project proposals provided they identify specific private landowners who have confirmed their intent to participate on the project or provide other evidence in the project proposal to demonstrate landowner participation will occur.

Army Corps 206 Program – Aquatic Ecosystem Restoration

The ACOE ecosystem restoration program covers structural or operational changes that will improve the environment. This includes reconnecting old river channels and backwaters, creating wetland sub-impoundments on the perimeters of reservoirs, improving water quality through reduction of erosion and sedimentation, manipulating wetlands vegetation in shallow headwaters of reservoirs, and placing woody debris and revegetation of floodplains and riparian zones. The project must be sponsored by or coordinated with a city, county, state, or tribe. The ACOE share of the project may not exceed $5 million. Funding can be used to define the problem, evaluate solutions, select a plan, develop the design, and construct the project. The ACOE provides engineering and technical capabilities in completion of the feasibility study, design and construction of the project. The cost-share is 65% ACOE / 35% non-federal.

National Fish and Wildlife Foundation General Challenge Grants

This program funds land acquisition and conservation easements as well as other habitat enhancement projects. The program requires a 2:1 match of non federal funds.

IAC – Washington Wildlife Recreation Program

IAC funds habitat acquisition projects. However, a locally approved plan that meets IAC guidelines is required for submission of a proposal.

National Fish and Wildlife Foundation – Bring Back the Natives Grant Program

Land acquisition can be funded through this program. Requires 1:1 or 2:1 match. Grants range from $10K-$100K.

Natural Resources Conservation Service – Wildlife Habitat Incentives Program

This program is organized through Conservation Districts. Applications must be coordinated with the CD and is intended to be a resource for individual landowners.

Washington Department of Fish and Wildlife – Landowner Incentive Program

This program provides financial assistance to private landowners for the protection, enhancement, or restoration of habitat to benefit species-at-risk on private lands. $50K is the maximum grant.

US Fish and Wildlife Service – 5 Star Restoration Challenge Grants

Grants are available for habitat restoration. Awards are between $5K and $20K.

5.7 Conclusion

Two main options were discussed in this section, restoration of Saltese Flats with existing natural inflows, and restoration of Saltese Flats with the addition of reclaimed water. Within the assessment of these two options a range of configuration and management options are described. In order to select or narrow down configuration and management options, and move into a more detailed feasibility analysis it will be necessary to clarify the relative importance of objectives, the physical characteristics of the system, and to further involve agencies in clarifying regulatory requirements.

Restoration of Saltese Flats using natural inflows appears to be a feasible option with benefits in terms of streamflow augmentation, wetland habitat, water quality improvement, flood management and educational benefits. The largest factors cited to effect the required size and/or available volume stored are restrictions due to zoning and/or development and the magnitude of infiltration of water in the Flats. Additionally, to operate this system in a manner that maximizes Spokane River low flow augmentation, increased understanding of travel time and the affect of stored and infiltrated water on the gaining river reaches will be necessary.

Restoration of Saltese Flats using reclaimed water as additional, or replacement of, inflows is also a feasible option with similar benefits as that of restoration using natural inflows plus additional benefits related to polishing of reclaimed water, use of reclaimed water for additional beneficial purposes (wetland restoration) and increased stored volumes. A key factor in advancing this option is to clarify the quality and quantity of reclaimed water inflows and the wetland characteristics that are desirable and maintainable in Saltese Flats based on physical conditions.

6.0 SUMMARY AND CONCLUSION

Three distinct storage options were discussed in this report. Options ranged from accessing storage potential in groundwater, to wetlands, to surface water reservoirs. Each of these options has specific benefits and drawbacks in terms of spatial application, cost, and total storage potential. The benefits and drawbacks are summarized below, as well as next steps that would need to be taken in each option if they were to be further advanced.

6.1 ASR in Lower Little Spokane Watershed

Description: The specific ASR configuration considered consisted of withdrawing groundwater from the Hillyard Trough area of the Spokane Valley Rathdrum Prairie (SVRP) Aquifer during the winter months, transporting the water through existing municipal distribution facilities, and recharging the water into the Lower Sand and Gravel Aquifer in the vicinity of the confluence of Deadman Creek with the Little Spokane River.

Objectives: To use stored water to meet existing and/or future summer peaking demand in the Whitworth Water District #2, and/or augment Little Spokane River streamflow by leakage of stored water.

Benefits: The Whitworth Water District #2 will need additional instantaneous water right capacity to serve projected demand increase the next five to ten years, but has sufficient annual water rights for approximately 20 years. Obtaining additional water rights is uncertain. ASR offers a means of using available annual water right quantities to create seasonal instantaneous water right capacity. Leakage back to the Little Spokane River would augment low streamflows from Deadman Creek and downstream. Because the Whitworth Water District #2 does not routinely chlorinate its water supply (other than monthly dosing to keep the system clean), a major regulatory obstacle is removed from the permitting process.

Drawbacks: The length of stream that would benefit is relatively short and may not be the reach of stream with the greatest need for improvement or protection. Although the aquifer appears to be well bounded and therefore contain recharged water, leakage from the recharged aquifer in the Mead area to the Hillyard Trough remains an unknown variable.

Costs: Feasibility and pilot testing programs generally range between $120,000 and $300,000 for systems with existing infrastructure. Operating costs are less well defined, available data suggest that annual operating costs are typically about $15,000/mgd of recovery capacity.

Additional Data Needs:

- Aquifer properties, extent and connectivity with surface water in the study area. Storage ability can be estimated empirically through pilot testing, and potentially computer simulation modeling.

- Quality testing of source and receiving aquifers. Can be verified through pilot test.

- Verification that infrastructure can support transmission of water. Can be verified through collaboration with Whitworth Water District #3.

Next Steps:

- Preparation of a plan and execution of a pilot test involving:
  - Pretest monitoring. No pumping should be conducted from the Lower Sand and Gravel Aquifer for an appropriate time preceding the pilot test (e.g., one week);
  - Recharging water to the selected well from the Whitworth Water District #2 municipal distribution system for during the winter (e.g., 1,000 gpm for 30 days; water obtained through WWD #2 System 3);
  - Observing aquifer response during a post-recharge period (e.g., 30 days) to evaluate the containment of recharged water;
  - Recover the recharged water (e.g., 2,000 gpm for 30 days under existing water rights); and,
  - Post-recover monitoring of aquifer groundwater levels (e.g., one week).

- Monitoring before, during and after the pilot test including:
  - Instantaneous and cumulative flow;
  - Water levels; and,
  - Time series water quality.
- Regulatory requirements of a pilot test may include the following:
  - Compliance with DOH requirements (WAC 246-290) of disinfection and water quality sampling upon completion of well retrofit;
  - Registering a recharge well under Ecology's Underground Injection Control program (WAC 173-218); and,
  - Notice to Ecology under WAC 173-160 (Well Construction).

Information collected during the pilot test could be used to support application for a water right under the ASR rule (WAC 173-157) for full implementation of an ASR program. All proposed pilot test activities are consistent with existing water rights, and no water right changes are needed.

6.2 Beaver and Buck Creek New Dam Analysis

Description: Planning level analysis and comparison of two alternative on-channel dam sites in WRIA 55. Analysis included potential size, on-channel location, cost and flow benefit for sites on Beaver Creek and Buck Creek in northwest WRIA 55. Using an assumption of 50% retention of wet season inflow, Buck Creek was predicted to be able to supply and store, on average, approximately 4,560 AF of water while Beaver Creek was determined to able to store approximately 930 AF of water.

Objective: To augment low summer stream flow in WRIA 55 between July and October using stored surface water.

Benefits: The length of augmented streamflow benefit spans the majority of the West Branch Little Spokane River and downstream to the mouth of the Little Spokane River. Both sites could improve existing water quality through dam design that promotes low temperature releases from the deeper waters of the reservoir, reaerates (increases dissolved oxygen) water at the outlet works, and promotes seasonal wetlands establishment along the perimeter of the reservoir. Additionally, the sub-basins are un-populated and relatively protected (Buck Creek is in the Kaniksu National Forest, Beaver Creek is almost wholly contained within a single owner's land) therefore nutrient loading to the water body may not be an issue.

Drawbacks: Dams can have perceived and real impacts on an ecological system, primarily in terms of aquatic habitat and water quality. Construction and operations and maintenance costs can be high.

Costs: Costs to build the dam (including permitting, investigations, construction, etc.) on Beaver Creek were estimated for two reservoir sizes (50% retention versus 100 % retention of wet season flows) 1,175 and 1,930 AF. Costs for the first size range from $4.1 to $9.1 million ($3,500 to $7,700 per AF). Costs for the second size range from $11.8 million to $16.7 million ($6,100 to $8,600 per AF).

Costs to build the dam (including permitting, investigations, construction, etc.) on Buck Creek were estimated for one reservoir size, 4,750 AF. Costs range from $19.2 to $24.1 million ($4,300 to $5,400 per AF).

Additional Data Needs:

- Baseline data regarding water quality and terrestrial and aquatic habitat.
- Physical investigation of the site, which would likely include geotechnical, hydrogeologic, and hydrologic components.

Next Steps:

- Initiate a consultative process with permitting agencies including the ACOE, Ecology and the county shoreline staff.
- Developing a communication and permitting strategy to address these issues and ensure that all procedural requirements are met.
- Clarify storage objectives; augmentation of existing flows verses offset of future uses.
- Determine a project sponsor (agency or group that will oversee the effort through investigation, design and construction as well as acquiring funding).

6.3 Saltese Flats Restoration

Description: Planning level analysis of the potential of restoring seasonal function to the formerly shallow lake/wetlands system of Saltese Flats. Additional analysis to determine the potential for discharging reclaimed water to this system. These are described separately below.

6.3.1 Saltese Flats Restoration with Natural Inflows

Objectives: To restore structure and function in the currently degraded wetlands system. To improve water quality of discharge water from Saltese Flats. To augment low summer stream flow in the Spokane River, recharge of stored water to the SVRP Aquifer.

Benefits: Significant increases in the area available for food and refuge for migratory waterfowl, mammals and amphibians. Large storage volume and discharge potential due to the size of inflows and site topography. The site is upstream of a gaining reach of the Spokane River (Sullivan Road) and therefore it is expected that return flows to the river would occur in this reach. Environmental educational benefit close to an urban area. Potential wetland mitigation banking credits.

Drawbacks: Potential inundation of developable land. Existing land owners may not be amenable to restoration of water to the land. Proximity to urban growth area may result in increased land costs.

Costs: Costs to purchase land, conduct investigations, obtain permits and design and construct the necessary control structures or containment systems are estimated to range from $3.4 to 12.2 million dollars, although smaller cost ranges exist for different configurations. The largest costs of restoration using natural inflow are associated with land acquisition and the potential requirement of a dike or embankment. Revenues from Wetland Mitigation Banking may be possible, though the exact costs would require a financial study.

Additional Data Needs:

- Improved data on the physical properties of the subsurface and hydrogeologic conditions in and around Saltese Flats so that infiltration and groundwater movement can be quantified.
- Investigate the timing and effect of water stored and infiltrated at Shelley Lake and Saltese Flats on Spokane River Flows, could include modeling.
- Physical delineation of the wetlands.

Next Steps:

- Engage regulators to build support for the project and define physical boundaries based on development and planning goals.
- Clarify a sustainable wetland structure and function for Saltese Flats.
- Clarify the balance of storage objectives streamflow augmentation, wetland restoration, water quality, etc.
- Determine a sponsor (agency or group that will champion effort through investigation, design and construction as well as supply/obtain funding).
- Develop a public outreach plan to gain early support for the project.

6.3.2 Saltese Flats Restoration with addition of Reclaimed Water

Objectives: To discharge reclaimed water to the site to aid in restoration. To augment low summer stream flow in the Spokane River between July and October through return flow of infiltrated water. To restore structure and function in the currently degraded wetlands system. To improve water quality of discharge water from Saltese Flats.

Benefits: Sizeable storage volume to retain flows into the summer. Increase in groundwater discharge potential to the Spokane River in the Sullivan Road gaining reach. Increase in wildlife refuge area. Increase in availability of public open space and wildlife viewing in an increasingly urban area. Environmental education potential. Prevention of discharge of treated waste water directly the river.

Additional benefits derived from the generation of reclaimed water over that of direct discharge to the Spokane River or direct recharge to groundwater are increased wetland habitat and Spokane River flow augmentation through natural recharge and managed releases; and potentially less restrictive treatment requirements than that of direct discharge to the Spokane River or percolation to groundwater.

Drawbacks: Existing land owners may not be amenable to restoration of water to the land with reclaimed water. Additional wastewater treatment may be required above conventional treatment. Proximity to an urban growth area will likely cause land costs to be high.

Costs: Costs to purchase land, conduct investigations, obtain permits and design and construct the necessary control structures or containment systems are estimated to range from $4.5 to 13.3 million dollars. Conveyance costs were estimated using an estimated distance from the SCRTP to the Flats and are approximately $30 million dollars. Revenues from Wetland Mitigation Banking may be possible, though the exact costs would require a financial study.

Additional Data Needs:

- Improved data on the physical properties of the subsurface and hydrogeologic conditions in and around Saltese Flats so that infiltration and groundwater movement can be quantified.
- Investigate the timing and effect of water stored and infiltrated at Shelley Lake and Saltese Flats on Spokane River Flows, could include modeling.
- Physical delineation of the wetlands.
- Water quality and flow characteristics of the reclaimed water stream.

Next Steps:

- Engage regulators to build support for the project, to define compliance standards, and clarify physical boundaries based on development and planning goals.
- Clarify a sustainable wetland structure and function for Saltese Flats.
- Clarify the balance of storage objectives for design purposes; objectives may include reclaimed water inflow, streamflow augmentation, wetland restoration, water quality, etc.
- Determine a sponsor (agency or group that will champion effort through investigation, design and construction as well as supply/obtain funding).
- Develop a public outreach plan to gain early support for the project.
- Develop a communication and permitting strategy to address potential permitting issues and ensure that all procedural requirements are met.

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TABLES

Volume Necessary to Meet Objectives
(in Acre-Feet)

	Little Spokane River near Dartford		Spokane River at Spokane	
	2 months	**4 months**	**2 months**	**4 months**
Junior Water Rights [1]	1,047	1,561	n/a	n/a
20-year growth: Projected Impact on Streamflow	1,721	3,471	6,620	13,080
Full Inchoate Water Right Use: Projected Impact on Streamflow	2,097	4,751	25,645	51,290
New Water Right Applications	4,731	9,539	8,775	17,693

Notes:

1) Junior Water Rights are reported are for 2 and 3 month period rather than 2 and 4 months because Lowest Instream Flow Level is applied for a 3 month period. Calculated by assuming Qi rate is used continuously for the period shown.

2) Projected impacts of 20-year growth and Full Inchoate use are predicated values from the Mike SHE Model of the Little and Middle Spokane River.

Availability of Excess Surface Water for Storage
(cfs)

	Little Spokane River near Dartford			Spokane River at Spokane		
Exceedance Flow	**10%**	**50%**	**90%**	**10%**	**50%**	**90%**
October	227	72	ND	1,711	78	0
November	279	106	ND	5,176	1,002	0
December	483	191	ND	15,507	3,515	0
January	793	271	64	16,362	4,172	7
February	1,057	456	28	18,800	6,379	0
March	1,885	904	81	24,495	9,862	1,480
April	1,889	1,182	97	36,553	20,544	9,269
May	1,772	777	119	50,587	31,283	12,188
June	1,155	316	31	42,276	19,960	3,805
July	525	182	0	12,768	2,444	121
August	126	61	0	1,648	0	0
September	82	51	0	578	0	0

Notes:
ND = No Data

TABLE 2-2

Surface Water Storage Options

		Current				Additional 20 ft of Dam Height			Additional 40 ft of Dam Height		
Dams	**WRIA**	**Crest Length (ft)**	**Height (ft)**	**Max Storage (AF)**	**Normal Storage (AF)**	**Crest Length (ft)**	**Additional Storage (AF)**	**Crest Length/Additional Capacity Ratio**	**Crest Length (ft)**	**Additional Storage (AF)**	**Crest Length/Additional Capacity Ratio**
Ponderosa Lake Dam	55	412	55	710	357	560	2,090	0.3	750	6,630	0.1
Newman Lake Flood Control Dam[1]	57	8,400	10	11,300	8,700	8,500	35,040	0.2	8,600	81,120	0.1
Chain Lake[2]	55	-	-		-	600	2,939	0.2	-	-	-
Horseshoe Lake[3]	55	-	-	-	-	2,600	14,660	0.2	2,800	45,880	0.1
Lake of the Woods						112	494	0.2	777	2,221	0
Trout Lake[4]	55	-	-	-	-	1,100	3,831	0.3	2,340	12,489	0.2
Wetlands	**WRIA**					**Area (ac)**	**Volume[5] (AF)**				
Saltese Flats	57					1,270	2540				
Newman Lake	57					700	1400				
WRIA 55	55					920	1840				

Notes:

1) 1st contour was 33 feet above lake, 20 and 40 ft surface area uses this contour.
2) 1st contour was 33 feet above lake surface elevation and would flood Burlington Northern Railroad, therefore storage shown assumes 15 feet elevation increase.
3) 1st contour was 30 feet above lake, 20 and 40 ft surface area uses this contour.
4) Adding 40 feet would require the construction of two dams to prevent flooding of Lost Lake, Horseshoe Lake, etc. One dam at the southern end would be 1,600 foot long, and the dam near the north end of the lake would be about 740 foot long.

TABLE 3-1

Summary of Municipal Well Yields and Aquifer Transmissivity

Well Owner/ID	**TD** (feet)	**Static Water Level** (ft bgs)	**Typical Yield** (gpm)	**Specific Capacity** (gpm/ft)	**Transmissivity**[3] (ft^2/day)
WWD #2 – 8A1	NA	49	700	43.8	87,600
WWD #2 – 8A2	220	47	4,000	120	240,000
WWD #2 – 8B	235	36	5,000	200	400,000
WWD #2 – Shady Slope	130	30	Inactive[2]	13.5	27,000
SCWD #3 – Pine River Park	204	16.5[1]	475	72.7[1]	145,400
SCWD #3 – former Washington WPC well	119	NA	450	NA	NA

(1) Measured when drilled, 1961

(2) Drilled in 1999-2000

(3) Estimated based on T (gpd/ft) = 2000 (gpd/ft) x specific capacity (gpm/ft); (Driscoll, 1986)

TABLE 3-2

Lower Sand and Gravel Aquifer Transmissivities in the Vicinity of Mead

	Map Key	Location		Total Depth (ft)	Land Elevation (ft msl)	Depth to Water (ft bgs)	Approx. Water Elevation (ft bgs)	Saturated thickness (ft)	Pumping rate (gpm)	Specific Capacity (gpm/ft)	Est. Transmissivity (gpd/ft)	Notes
Wells in/near the Gap												
WA Water & Power	1	T26N/R43W	Sec. 10	189	1,900	92	1,808	19	650	46.4	92,857	
Somerlot	2	T26N/R43W	Sec. 3	180	1,850	115	1,735	95	20	1.1	2,222	Airtest, top of screen at 133'
Thompson	3	T26N/R43W	Sec. 3	160	1,910	132	1,778	28	20	10.0	20,000	
SCWD #3	4	T26N/R43W	Sec. 3	180	1,875	116	1,759	20+	1,200	53.9	107,865	
Baump	5	T26N/R43W	Sec. 3	175	1,890	69	1,821	50	12	1.7	3,429	
Hunt	6	T26N/R43W	Sec. 3	185	1,880	139	1,741	<10	40	1.0	2,000	Airtest, top of screen at 179'
Goodwin	7	T26N/R43W	Sec. 3	180	1,880	160	1,720	10+	100	5.0	10,000	Airtest, no perfs
Bailey	8	T26N/R43W	Sec. 11	180	1,870	135	1,735	42+	15	0.4	750	Airtest, top of screen at 175'
Davis	9	T26N/R43W	Sec. 11	165	1,870	124	1,746	10?	30+	0.9	1,818	Airtest, top of screen at 157'
Martin	10	T26N/R43W	Sec. 10	105	1,890	80	1,810	16	5-10	0.4	800	Airtest, based on Q=10 gpm
Howerton	11	T26N/R43W	Sec. 11	187	1,900	156	1,744	31	9	NA	-	
Brown	12	T26N/R43W	Sec. 11	197	1,880	150	1,730	34	30	0.8	1,538	Airtest, top of screen at 189'
Blake	13	T26N/R43W	Sec. 11	147	1,885	106	1,779	21	15	0.4	857	Airtest, top of screen at 141'
Benson	14	T26N/R43W	Sec. 11	223	1,885	97	1,788	?	30	0.2	476	Airtest, no perfs
Pacific Securities	15	T26N/R43W	Sec. 11	160	1,880	120	1,760	23	10-15	0.6	1,120	Airtest, based on Q=15 gpm
WA Water & Power	16	T26N/R43W	Sec. 10	203	1,885	145	1,740	58	550+	NA	-	
Booker	17	T26N/R43W	Sec. 11	214	1,880	118	1,762	47	3	NA	-	
Upham	18	T26N/R43W	Sec. 11	178	1,880	135	1,745	55+	25	0.7	1,316	Airtest, top of screen at 173'
Selby	19	T26N/R43W	Sec. 11	135	1,890	60	1,830	15+	50	NA	-	
Fox Milling	20	T26N/R43W	Sec. 10	247	1,900	163	1,737	?	25	0.6	1,111	

Source: WA Ecology Well Log Database (Nov-04)
NA - none available
Transmissivity estimated based on: T (gpd/ft) = 2000 x specific capacity (gpm/ft) (Driscoll, 1986)

Whitworth Water District #2 Selected Wells Water Quality Summary

Parameter Name	Main Hillyard Trough - Candidate Source Wells: Well 1 Average (mg/L*)	Well 1A Average (mg/L*)	Well 2A Average (mg/L*)	Well 2B Average (mg/L*)	Well 3B Average (mg/L*)	Well 4 Average (mg/L*)	**Selected WWD Average (mg/L*)**	Boese and Buchanan, 1996 # (mg/L)
BARIUM	0.03	0.033	0.03	0.037	0.04	0.585	**0.07**	-
CADMIUM	-	0.004 $	-	0.004 $	0.004 $		**0.004**	-
CHLORIDE	3.25	3.9	2.74	6.95	3.2	7.29	**4.31**	5.44
CHROMIUM	-	0.054 $	0.036 $	0.052 $	-	-	**0.047**	-
CONDUCTIVITY (umhos/cm)	269	318	245	285	341	360	**299**	381
FLUORIDE	0.12	0.065	0.037	0.058	0.041	0.06	**0.07**	-
HARDNESS	156	161	140	139.5	155	181	**156**	183
IRON	0.071	-	-	0.015 $	0.019 $		**0.035**	0.77
NITRATE-N	2.04	1.97	-	1.62	1.65	2.54	**2.19**	-
SILVER	-	0.021 $	0.018 $	0.015	-	-	**0.018**	-
SODIUM	4.14	5.09	3.05	2.88	3.64	6.44	**3.88**	-
SULFATE	13.05	14	15.8	11.4	13.13	18.97	**13.6**	-
TDS-TOTAL DISSOLVED SOLIDS	148	196	141.5	148	193	216.5	**168**	-
TOTAL NITRATE/ NITRITE	3.56	1.81	1.22	2.98	1.54	2.65	**2.25**	0.59
TURBIDITY (NTU	-	0.13	0.34	0.11	0.11	0.395	**0.21**	-

Parameter Name	NE Branch Hillyard Trough - Candidate Receiving Wells: Well 8A1 One measurement (mg/L*)	Well8A2 One measurement (mg/L*)	Well 8B One measurement (mg/L*)	**Selected WWD Average (mg/L*)**	Boese and Buchanan, 1996 % (mg/L)
BARIUM	0.051	-	0.73	**0.39**	-
CADMIUM	-	-	-	-	-
CHLORIDE	7.86	-	11.7	**9.78**	4.92
CHROMIUM	-	-	-	-	-
CONDUCTIVITY (umhos/cm)	403	-	473	**438**	374
FLUORIDE	0.155	-	0.188	**0.17**	-
HARDNESS	207	-	243	**225**	219
IRON	-	-	-	-	1.72
NITRATE-N	1.31	2.62	3.09	**2.34**	-
SILVER	-	-	-	-	-
SODIUM	8.28	-	9.28	**8.78**	-
SULFATE	13.9	-	16.7	**15.3**	-
TDS-TOTAL DISSOLVED SOLIDS	256	-	261	**259**	-
TOTAL NITRATE/ NITRITE	1.31	-	3.09	**2.2**	1.00
TURBIDITY (NTU	-	-	-	-	-

$ = parameter had only one recorded detection

- = No average value could be determined from available data

= wells located in T26N, R43E

% = wells located in T27N, R43E

All other IOC parameters were either non-detect or were detected in less than three of the selected WWD wells
All SOC values were less than State Reporting Limits
All VOC values were less than State Reporting Limits except Well 1 (7/12/2001) TCE = 0.6 ug/L (MCL = 5 ug/L).

Water quality data was queried from WDOH database, current as of December 2002

TABLE 4-1

Current Surface Water Rights on Beaver and Buck Creeks

Control Number	Document Type	Purpose Code	Business	Priority Date	Annual Quantity (AF)	TRS	Source Name	Tributary Name
S3-132926CL	Claim Long Form	ST	BOISE CASCADE CORP			T31N/R43E-31	BUCK CREEK	
S3-132927CL	Claim Long Form	ST	BOISE CASCADE CORP			T31N/R43E-31	BUCK CREEK	
S3-132928CL	Claim Long Form	ST	BOISE CASCADE CORP			T31N/R42E-35	BUCK CREEK	
S3-064114CL	Claim Long Form	ST	WN. ST. DEPT. NAT. RSO.			T31N/R42E-36	SPRING	
S3-064116CL	Claim Long Form	ST	WN. ST. DEPT. NAT. RSO.			T31N/R42E-36	STREAM	
S3-064117CL	Claim Long Form	ST	WN. ST. DEPT. NAT. RSO.			T31N/R42E-36	STREAM	
R3-01484CWRIS	Certificate	FS RE	BAKER KEDRIC	7/14/1967	356.78	T30N/R42E-13	BEAVER CREEK	WEST BRANCH LITTLE SPOKANE RIVER

Purpose of Use Codes:

ST Stock Watering
FS Fish propagation
RE Recreation and beautification

TABLE 4-2

Stream flow Available for Storage (acre-feet) on Beaver and Buck Creeks (Dec - Apr)

Water Year	Beaver Creek		Buck Creek
	Detaining 100%	Detaining 50%	Detaining 50%
1994	353	177	757
1995	2,225	1,113	5,362
1996	1,800	900	4,323
1997	2,483	1,241	6,181
1998	2,173	1,087	5,350
1999	2,093	1,046	5,400
Average	1,855	927	4,562

Beaver Creek and Buck Creek Dam Details

Reservoir	**Reservoir Capacity** (ac-ft)	**Embankment (Dam) Height** (ft)	**Dam Length** (ft)	**Approx. Embankment Volume** (cu. yd.)
Beaver Creek (50%)	1,175	25	Top = 880 ft. Bottom = 600 ft.	67,000
Beaver Creek (100%)	1,932	40	Top = 1,600 ft. Bottom = 600 ft.	332,000
Buck Creek	4,590	85	Top = 800 ft. Bottom = 400 ft.	585,000

1. Embankment volume assumes a 2H:1V upstream and a 3H:1V downstream.
2. Assume 5-foot freeboard above desired water storage volume and 20-foot wide top.

Beaver Creek Streamflow Augmentation Capacity from Various Volumes of Storage

Sustainable Duration of Discharge (Days)	Detaining 50% of Flow (Dec - Apr)		Detaining 100% of Flow (Dec - Apr)	
	Starting with 1,175 AF Storage Volume (Beginning Full -Avg Year)	Starting with 170 AF Storage Volume (Beginning Partially Full - Dry Year)	Starting with 1,932 AF Storage Volume (Beginning Full -Avg Year)	Starting with 330 AF Storage Volume (Beginning Partially Full - Dry Year)
	Discharge (cfs)			
30	20	3	32	6
40	15	2	24	4
50	12	2	19	3
60	10	1	16	3
70	8	1	14	2
80	7	1	12	2
90	7	1	11	2

TABLE 4-5

Buck Creek Streamflow Augmentation Capacity from Various Volumes of Storage

Sustainable Duration of Discharge (Days)	Detaining 50% (Dec - Apr)	
	Starting with 4,590 AF Storage Volume (Beginning Full -Avg Year)	Starting with 710 AF Storage Volume (Beginning Partially Full -Dry Year)
	Discharge (cfs)	
30	80	12
40	60	9
50	48	7
60	40	6
70	34	5
80	30	4
90	27	4

TABLE 4-6

Planning Level Costs for Beaver and Buck Creek Dam Sites

Cost Type	**Cost at Beaver Creek Site (detaining 50%)**	**Cost at Beaver Creek Site (detaining 100%)**	**Cost at Buck Creek Site**
Land Acquisition	$160,000	$182,000	$225,000
Site Investigation	$150,000	$180,000	$275,000
Permitting	$750,000 - $1,000,000	$750,000 - $1,000,000	$750,000 - $1,000,000
Feasibility Study/Engr. Design	$300,000	$400,000	$600,000
Dam Construction	$2,500,000	$10,000,000	$17,000,000
Potential Mitigation	$1,000,000 - $5,000,000	$1,000,000 - $5,000,000	$1,000,000 - $5,000,000
Total (millions of dollars)	$4.19 - $9.11	$11.84 - $16.76	$19.18 - $24.10

Annual Operations and Maintenance	$40,000/year	$45,000/year	$50,000/year

Note: planning level costs -subject to change

FEMA 10-, 50-, 100- and 500-year Peak Discharges

	Drainage Area (Acres)	Peak Discharge (cfs)			
		10-yr	50-yr	100-yr	500-yr
Saltese Creek at Steen Rd (RM 7.1)	15,488	65	215	316	531
Saltese Creek at Barker Road	13,952	31	66	81	101

Source: FEMA, 1992

TABLE 5-2

Summary of Surface Water Rights

Document Number	Document Type	Purpose of Use	Last Name	First Name	Business	Priority Date	Instantaneous Quantity (cfs)	Annual Quantity (AF)	Acres Irrigated	Domestic Units	TRS	Source Name	Tributary Name
S3-22944CWRIS	Certificate	FR, IR			FINNEY ROBERT A	4/9/74	0.12	71	23.55	6	T24N/R45E-04	SALTESE CREEK	
R3-*15215C	Certificate	IR	DOSSER	G		12/29/58		51	70		T25N/R45E-33	QUINNAMOSE CREEK/Storage	SHELLEY LAKE
R3-*19042CWRIS	Certificate	IR			DERUWE D	5/26/65		71	23.5	55	T24N/R45E-04	SALTESE CREEK	SHELLEY LAKE
S3-*11818CWRIS	Certificate	IR			COURCHAINE G	11/5/1952	0.6		45		T25N/R45E-32	UNNAMED SPRING	SALTESE CREEK
S3-*11968CWRIS	Certificate	IR			DERUWE F	1/13/53	0.38			25	T24N/R45E-04	UNNAMED STREAM	QUINNAMOSE CREEK
S3-*12061CWRIS	Certificate	IR			DERUWE F	2/11/53	0.8			55	T24N/R45E-04	SALTESE CREEK	QUINNAMOSE CREEK
S3-*12061CWRIS	Certificate	IR			DERUWE F	2/11/53	0.8			55	T24N/R45E-04	MAUSER CREEK	QUINNAMOSE CREEK
S3-*15216ACCWRIS	Certificate	IR			DOSSER G A	12/29/1958	1	210	70		T25N/R45E-33	QUINNAMOSE CREEK	SHELLEY LAKE
S3-*15216ACCWRIS	Certificate	IR			DOSSER G A	12/29/1958	1	210	70		T25N/R45E-33	UNNAMED SOURCE	SHELLEY LAKE
S3-01092CWRIS	Certificate	IR			MORRISON MILLAR A	8/9/1968	3	553	190		T25N/R45E-29	UNNAMED SOURCE	SALTESE CREEK
S3-22969CWRIS	Certificate	IR			BARRY JAMES E	4/16/74	0.02	10.5	3.5	1	T24N/R45E-04	UNNAMED SPRING	
S3-161717CL	Claim Long Form	DG IR			SALTESE FARM SYNDICATE			450	150		T25N/R45E-28	QUINNAMOSE CRK	
S3-041948CL	Claim Long Form	IR ST	CORIGLIAKE	BENJAMIN L.				60	20		T25N/R45E-31	SPRING	
S3-154030CL	Claim Long Form	IR ST	SMITH	THOMAS S				150	50		T25N/R45E-33	CREEK	
S3-030111CL	Claim Long Form	ST	CARSTENS	DELBERT				1			T25N/R45E-27		
S3-030112CL	Claim Long Form	ST	CARSTENS	DELBERT				1			T25N/R45E-27		
S3-030113CL	Claim Long Form	ST	CARSTENS	DELBERT				1			T25N/R45E-27		
S3-049440CL	Claim Short Form	DG	GORDON	ROBERT A.							T24N/R45E-04	SPRING	
S3-049442CL	Claim Short Form	DG	GORDON	ROBERT A.							T24N/R45E-04	SPRING	
S3-161706CL	Claim Short Form	DG IR ST			SALTESE FARM SYNDICATE			2			T25N/R45E-28	SPRING	
S3-161707CL	Claim Short Form	DG IR ST			SALTESE FARM SYNDICATE			2			T25N/R45E-28	SPRING	
S3-161708CL	Claim Short Form	DG IR ST			SALTESE FARM SYNDICATE			2			T25N/R45E-28	SPRING	
S3-161710CL	Claim Short Form	DG IR ST			SALTESE FARM SYNDICATE			2			T25N/R45E-28	SPRING	
S3-134148CL	Claim Short Form	ST	DURGIN	W C							T24N/R45E-04	STREAM	
								1847					

Source: s Application Tracking System Database (WRATS), December, 2003

Notes: Claims do not generally have quatities recorded. If irrigated acres was provided, an assumption of 3 AF/Acre was applied to develop an annual quantity. Assumptions are detailed in the Phase 2 - Level 1 Technical Assessment, Golder, 2001

Purpose of Use Codes

ST	Stock watering
DG	Domestic general
FR	Fire protection
IR	Irrigation
MU	Domestic municipa
DM	Domestic multiple
CI	Commercial and Industrial manufacturin
DS	Domestic single

TABLE 5-3

Summary of Groundwater Rights

Document Number	Document Type	Purpose of Use	Last Name	First Name	Business	Priority Date	Instantaneous Quantity (gpm)	Annual Quantity (AF)	Acres Irrigated	TRS	Source Name
G3-24967CWRIS	Certificate	DM			W M Land Corporation	7/2/1976	300	200		T25N/R45E-31	WELL
G3-*04179C	Certificate	IR			Charles M. Rice & Sons	12/12/1955	700	480	120	T25N/R44E-24	WELL
G3-28731	Certificate	IR			J & J Drilling Inc	1/29/1990	300	224	65	T25N/R45E-32	WELL
G3-071166CL	Claim Long Form	DG	DERUME	DALE W.						T24N/R45E-04	A WELL
G3-080811CL	Claim Long Form	DG	FINNEY	ROBERT A.						T24N/R45E-04	WELL
G3-008957CL	Claim Long Form	DG IR	PARKINSON	FRED				6	3	T25N/R45E-31	
G3-013387CL	Claim Long Form	DG IR	POE	WILLIAM S.				15	5	T25N/R45E-20	
G3-161713CL	Claim Long Form	DG IR			SALTESE FARM SYNDICATE			2		T25N/R45E-28	AQUIFER LAYER
G3-161714CL	Claim Long Form	DG IR			SALTESE FARM SYNDICATE			2		T25N/R45E-33	AQUIFER LAYER
G3-161715CL	Claim Long Form	DG IR			SALTESE FARM SYNDICATE			2		T25N/R45E-33	AQUIFER LAYER
G3-161716CL	Claim Long Form	DG IR			SALTESE FARM SYNDICATE			2		T25N/R45E-33	AQUIFER LAYER
G3-011424CL	Claim Long Form	DG IR ST	LINDSEY	GUY E.				3	1	T25N/R45E-31	
G3-041947CL	Claim Long Form	DG IR ST	CONGLIAND	BENJAMN L.				60	20	T25N/R45E-31	WELL
G3-093678CL	Claim Long Form	DG ST	DEISHL	GEORGE A				27	9	T25N/R45E-34	WELL
G3-106039CL	Claim Long Form	DG ST	MORRISON	MILLAR A				2		T25N/R45E-19	WELL
G3-106040CL	Claim Long Form	DG ST	MORRISON	MILLAR A				2		T25N/R45E-29	WELL
G3-106041CL	Claim Long Form	DG ST	MORRISON	MILLAR A				2		T25N/R45E-29	WELL
G3-036744CL	Claim Short Form	DG	LADD	DEAN & GEORGE				2		T25N/R45E-29	
G3-106065CL	Claim Short Form	DG IR	BECHT	HELEN				2		T25N/R45E-27	
G3-139431CL	Claim Short Form	DG IR	PARKINSON	FRED				2		T25N/R45E-31	
G3-143087CL	Claim Short Form	DG IR	CALDWELL	WILLIAM A				2		T25N/R45E-20	
G3-044311CL	Claim Short Form	DG ST	WALKER	FRANCIS R.				2		T25N/R45E-19	
G3-084955CL	Claim Short Form	DG ST	ASTER	CHARLES M.				2		T25N/R45E-31	
G3-060752CL	Claim Short Form	ST DG	NESTOSS	LESTER H.						T24N/R45E-04	
G3-070213CL	Claim Short Form	ST DG	NESTOSS	WILLIAM O.						T24N/R45E-04	
G3-126380CL	Claim Short Form	ST DG	NESTOSS	OSCAR H						T24N/R45E-04	
Source: s Application Tracking System Database (WRATS), December, 2003								1041			

Notes: Claims do not generally have quatities recorded. If irrigated acres was provided, an assumption of 3 AF/Acre was applied to develop an annual quantity. Assumptions are detailed in the Phase 2 - Level 1 Technical Assessment, Golder, 2001

Purpose of Use Codes:

ST	Stock watering	MU	Domestic municipal
DG	Domestic general	DM	Domestic multiple
FR	Fire protection	CI	Commercial and Industrial manufacturing
IR	Irrigation	DS	Domestic single

TABLE 5-4

Storage Volume Summary - Natural Flows

Conditions	Configuration	Maximum Available Volume	Surface Area	Stored Volume in Flats in July	Average Surface Discharge Rate assuming, July - Oct release	Average Discharge Rate to Groundwater, July - Oct	Net Average Discharge (surface + groundwater discharge), July - October	Average Loss to Evaporation July - Oct
		AF	acres	AF	cfs	cfs	cfs	cfs
Dry	1 - Inundation to Elevation 2055 feet	11,417	1,237	3,244	1	11	11	5
	2 - Inundation to Elevation 2055 within Critical Areas	8,609	895	3,955	4	10	15	4
	3 - Preservation of Existing System	1,790	895	n/a	n/a	n/a	n/a	n/a
							0	
Average	1 - Inundation to Elevation 2055 feet	11,417	1,237	5,367	6	14	20	6
	2 - Inundation to Elevation 2055 within Critical Areas	8,609	895	6,205	12	12	24	5
	3 - Preservation of Existing System	1,790	895	n/a	n/a	n/a	n/a	n/a
							0	
Wet	1 - Inundation to Elevation 2055 feet	11,417	1,237	8,375	16	17	32	7
	2 - Inundation to Elevation 2055 within Critical Areas	8,609	895	8,609	21	14	35	6
	3 - Preservation of Existing System	1,790	895	n/a	n/a	n/a	n/a	n/a

Notes:

1) Stored Volume in Flats in July indicates the volume expected to be available for potential release during the low flow period
2) Average Discharge Rate is the total volume available in July represented as a discharge rate applied continuously over a 4 month period, accounting for losses.
3) It is assumed that evaporation and infiltration in Configuration 3 will be equivalent or greater than any inflow that occurs.

TABLE 5-5

Current and Potential Point Source Dischargers to the Spokane River

Name	Annual Volume (AF)	Average Monthly Rate (cfs)	Distance from Flats (mi)	Type of Discharge	Notes
Liberty Lake Sewer District	540	0.7	3.5	Domestic	The plant is permitted to treat up to 1,120 AF annually.
Honeywell-Johnson	20	0.0	5.0	Industrial	
Kaiser Trentwood	23,340	32	5.8	Industrial	
Inland Empire Paper	44,335	61	8.0	Industrial	
Proposed Spokane County Regional Treatment Plant (SCRTP)	11,170 - 22,411	15 - 31	11	Domestic	The SCRTP would discharge at the lower rate until 2020. By 2050, it is expected to be operating at full capacity.

Reclaimed Water Criteria for Discharge to Wetlands [1]

General Critera	
Signs and other idenification indicating the use of reclaimed water	
Protect human health	
Prevent the creation of odors, slimes and+A48 other aesthetically displeasing deposits	
500 ft Buffer between perimeter of wetlands and potable water supply wells	
Wetland delineated in accordance with with the manual adopted by Ecology	
Hydraulic Criteria	
Hydraulic Loading Rate	
Wetland Category I	Not permitted
Wetland Category II	Less than 2 cm/day[2]
Wetland Category III and IV	Less than 3 cm/day[2]
Average Monthly Water Level	
An increase of less than 10 cm over background water levels	
Water Quality Criteria	
Class A Reclaimed Water	Reclaimed water must be at all times oxidized, coagulated, filtered, disinfected wastewater. Adequate disinfection should result in a 7-day mean of total number coliform organisms that does not exceed 2.2 per 100 mL and a total that does not exceed 23 per 100 mL in any one sample.
BOD	< 30 mg/L mean monthly
TSS	< 30 mg/L mean monthly
Turbidity	2 NTU mean monthly, 5 NTU in any sample
Dissolved Oxygen	Shall contain dissolved oxygen
Average Annual Limits	
BOD_5	20 mg/L
TSS	20 mg/L
Total Kjeldahl Nitrogen	3 mg/l as Nitrogen
Total Phosphorous	1 mg/L as Phosphorous
Un-ionized ammonia	Must meet WA Surface Water Chronic Toxicity Standards
Metals	Less than WA Surface Water Standards
Average Annual Mass Loadings	
BOD5	5 kg/ha/d
TSS	9 kg/ha/d
Total Nitrogen	1.2 kg/ha/d
Total Phosphorous	0.2 kg/ha/d
Groundwater Criteria	
Perform hydrogeologic evaluation to determine potential impacts on groundwater	
Maintain existing groundwater quality	
Biological Criteria	
Maintain existing beneficial uses of the wetlands	
Biological Parameters	
Vegetation cover or dominance	Reduced by less than 25% overall and less than 50% at any individual station
Plant diversity	
Macroinvertebrates	
Amphibians	
Fish	
Birds	
Threatened or endangered species	

Notes:

1) Criteria may vary based on site specific conditions (such as the existence of water quality problems or breeding amphibians, among others) or if it is demonstrated that net environmental benefits will be derived or unacceptable responses will not occur from the application of reclaimed water.

2) Relative to background conditions.

Wells Within 500 feet of Saltese Flats, Elevation 2055

Well ID	Owner	Location	Well Type	Well Depth
Well Elevation 2055 feet				
154932	JOHN FECHNER	T24 R45E S5	W	200
156768	MIKE PORTER	T24 R45E S5	W	460
162515	SALTESE SYNDICATE L. L. C.	T25 R45E S28	W	560
162619	SALTESE SYNDICATE	T25 R45E S28	W	520
158791	SALTESE FARM SYNDICATE	T25 R45E S29	W	84
154435	JERRY JOHNSON	T25 R45E S32	W	171
162635	GREG WILSON	T25 R45E S32	W	55
155203	JORGEN, CASEY, SMITH, ETAL	T25 R45E S33	W	242
156057	LOGAN JORGENS	T25 R45E S33	W	160
156058	LOGAN JORGENS	T25 R45E S33	W	85
156059	LOGAN JORGENS	T25 R45E S33	W	100
156060	LOGAN JORGENS	T25 R45E S33	W	400
156061	LOGAN JORGENS	T25 R45E S33	W	100
156062	LOGAN JORGENS	T25 R45E S33	W	160
156063	LOGAN JORGENS	T25 R45E S33	W	120
330516	TODD RIGBY	T25 R45E S33	W	378
330567	TODD RIGBY	T25 R45E S33	W	378
333064	LOGAN JORGENS	T25 R45E S33	W	100
336574	BABS RIGGS	T25 R45E S33	W	280
Shelley Lake				
150527	CHAS. RICE & SONS	T25 R44E S24	W	127
161849	BEN SIMPSON & CONWAY MCDONALD	T25 R44E S24	W	46

Source: Ecology on-line well log database. http://www.ecy.wa.gov/welllog, October, 2004.
Note: Not all wells may be used for drinking water supply purposes, and may be exempt from consideration of the 500-foot set-back requirement.

Application of Reclaimed Water Hydraulic and Hydrologic Criteria to Saltese Flats

Conditions	Configuration	Maximum Available Volume	Surface Area	Potential Reclaimed Water Inflow Calculated from Hydraulic Loading Criteria[1], shown as Annual Average Volume and Annual Average Flow		Potential Reclaimed Water Inflow Calculated from Water Level Criteria[2], shown as Average Monthly Volume and Average Monthly Flow		Additional Storage Space Available for Reclaimed Water, shown as Annual Volume and Average Annual Flow	
		AF	Acres	AF	cfs	AF	cfs	AF	cfs
Dry	1 - Restoration to Elevation 2055 feet	11,417	1,237	44,439	61	406	7	7,995	11
	2 - Restoration to Elevation 2055 within Critical Areas	8,609	895	32,153	44	287	5	4,654	6
	3 - Preservation of Existing System	1,790	895	32,153	44	287	5	-	-
		-	-						
Average	1 - Restoration to Elevation 2055 feet	11,417	1,237	44,439	61	406	7	6,049	8
	2 - Restoration to Elevation 2055 within Critical Areas	8,609	895	32,153	44	287	5	2,404	3
	3 - Preservation of Existing System	1,790	895	32,153	44	287	5	-	-
		-	-						
Wet	1 - Restoration to Elevation 2055 feet	11,417	1,237	44,439	61	406	7	3,042	4
	2 - Restoration to Elevation 2055 within Critical Areas	8,609	895	32,153	44	287	5	-	-
	3 - Preservation of Existing System	1,790	895	32,153	44	287	5	-	-

Notes:

1) Compliance with maximum annual average hydraulic loading rate of 3 cm/day calculated as the ratio of average annual flow rate of reclaimed water to the effective wetted area of the wetland (wetted area is assumed to be equal to the maximum surface area).

2) Average monthly water level elevations under the reclaimed water wetland hydrologic regime are not to increase by more than 10 cm compared to the average pre-augmentation monthly water level.

TABLE 5-9

Groundwater Quality Limits and Summary of Quality of SVRP Aquifer

Parameter	Units	WAC 173-200-040 Groundwater Recharge Criteria	SVRP Aquifer Groundwater
ORGANICS			
1,1 Dichloroethane	mg/L	1.0	<0.5
1,1-Dichloropropene	mg/L		<0.5
1,2-Dibromo-3-chloropropane	mg/L		<0.5
1,1,1,2 - Tetrachloroethane	mg/L		<0.5
1,1,1-Trichloroethane	mg/L	200	<0.5
1,1,2 - Trichloroethane	mg/L		<0.5
1,1,2,2 - Tetrachloroethane	mg/L		<0.5
1,1-Dichloroethylene	mg/L		<0.5
1,2 - Dichlorobenzene	mg/L		<0.5
1,2 Dibromoethane	mg/L	0.001	<0.5
1,2 Dichloroethane	mg/L	0.5	<0.5
1,2 Dichloropropane	mg/L	0.6	<0.5
1,2 Dimethylhydrazine	mg/L	60	
1,2 Diphenylhydrazine	mg/L	0.09	
1,2,3 - Trichlorobenzene	mg/L		<0.5
1,2,3 - Trichloropropane	mg/L		<0.5
1,2,4 - Trichlorobenzene	mg/L		<0.5
1,2,4 - Trimethylbenzene	mg/L		<0.5
1,3 - Dichloropropane	mg/L		<0.5
1,3 Dichloropropene	mg/L	0.2	
1,3-Dichlorobenzene			<0.5
1,3,5 - Trimethylbenzene	mg/L		<0.5
1,4 Dichlorobenzene	mg/L	4.0	<0.5
1,4 Dioxane	mg/L	7	
2-Chlorotoluene			<0.5
2 Methoxy-5-nitroaniline	mg/L	2	
2 Methylaniline	mg/L	0.2	
2 Methylaniline hydrochloride	mg/L	0.5	
2,2 - Dichloropropane	mg/L		<0.5
2,3,7,8-Tetrachlorodibenzo-p-dioxin	mg/L	0.0000006	
2,4 Dinitrotoluene	mg/L	0.1	
2,4 Toluenediamine	mg/L	0.002	
2,4,5-TP Silvex	mg/L	10	
2,4,6-Trichlorophenol	mg/L	4	
2,6 Dinitrotoluene	mg/L	0.1	
2-4 D	mg/L	100	
3,3' Dichlorobenzidine	mg/L	0.2	
3,3' Dimethoxybenzidine	mg/L	6	
3,3 Dimethylbenzidine	mg/L	0.007	
4-Chlorotoluene			<0.5
4 Chloro-2-methyl analine hydrochloride	mg/L	0.2	
4 Chloro-2-methyl aniline	mg/L	0.1	
4,4' Methylene bis(N,N'-dimethyl) aniline	mg/L	2	
Acrylamide	mg/L	0.02	
Acrylonitrile	mg/L	0.07	
Aldrin	mg/L	0.005	
Aniline	mg/L	14	
Aramite	mg/L	3	
Azobenzene	mg/L	0.7	
Benzene	mg/L	1.0	<0.5
Benzidine	mg/L	0.0004	
Benzo(a)pyrene	mg/L	0.008	
Benzotrichloride	mg/L	0.007	
Benzyl chloride	mg/L	0.5	
Bis(2-ethylhexyl) phthalate	mg/L	6	
Bis(chloroethyl)ether	mg/L	0.07	

Groundwater Quality Limits and Summary of Quality of SVRP Aquifer

Bis(chloromethyl)ether	mg/L	0.0004	
Bromobenzene	mg/L		<0.5
Bromochloromethane	mg/L		<0.5
Bromodichloromethane	mg/L	0.3	<0.5
Bromoform	mg/L	5.0	<0.5
Bromomethane	mg/L		<0.5
Carbazole	mg/L	5	
Carbon tetrachloride	mg/L	0.3	<0.5
Chlorobenzene	mg/L		<0.5
Chlorodibromomethane	mg/L	0.5	
Chloroethane	mg/L		<0.5
Chloroform	mg/L	7.0	<0.5
Chloromethane	mg/L		<0.5
Chlorthalonil	mg/L	30	
cis - 1,2 - Dichloroethylene	mg/L		<0.5
cis - 1,3 - Dichloropropene	mg/L		<0.5
DDT (includes DDE and DDD)	mg/L	0.3	
Diallate	mg/L	1	
dibromochloromethane (THM)	mg/L		<0.5
Dibromomethane	mg/L		<0.5
Dichlorodifluoromethane (CFC-12)	mg/L		<0.5
Dichloromethane	mg/L		2.11
Dichlorvos	mg/L	0.3	
Dieldrin	mg/L	0.005	
Direct Black 38	mg/L	0.009	
Direct Blue 6	mg/L	0.009	
Direct Brown 95	mg/L	0.009	
Endrin	mg/L	0.2	
Epichlorohydrin	mg/L	8	
Ethyl acrylate	mg/L	2	
Ethylbenzene	mg/L		<0.5
Ethylene dibromide	mg/L	0.001	
Ethylene thiourea	mg/L	2	
Fluorotrichloromethane (CFC-11)	mg/L		<0.5
Folpet	mg/L	20	
Furazolidone	mg/L	0.02	
Furium	mg/L	0.002	
Furmecyclox	mg/L	3	
Heptachlor	mg/L	0.02	
Heptachlor Epoxide	mg/L	0.009	
Hexachlorobenzene	mg/L	0.05	
Hexachlorobutadiene	mg/L		<0.5
Hexachlorocyclohexane	mg/L	0.05	
Hexachlorocyclohexane (alpha)	mg/L	0.001	
Hexachlorodibenzo-p-dioxin, mix	mg/L	0.00001	
Hydrazine/Hydrazine sulfate	mg/L	0.03	
Isopropylbenzene	mg/L		<0.5
Lindane	mg/L	0.06	
m/p - Xylenes	mg/L		<0.5
Methoxychlor	mg/L	100	
Mirex	mg/L	0.05	
n - Butylbenzene	mg/L		<0.5
n - Propylbenzene	mg/L		<0.5
Napthalene	mg/L		<0.5
Nitrofurazone	mg/L	0.06	
N-Nitrosodiethanolamine	mg/L	0.03	
N-Nitrosodiethylamine	mg/L	0.0005	
N-Nitrosodimethylamine	mg/L	0.002	
N-Nitroso-di-n-butylamine	mg/L	0.02	
N-Nitroso-di-n-propylamine	mg/L	0.01	
N-Nitrosodiphenylamine	mg/L	17	
N-Nitroso-N-methylethylamine	mg/L	0.004	
N-Nitrosopyrrolidine	mg/L	0.04	

Groundwater Quality Limits and Summary of Quality of SVRP Aquifer

o - Xylene	mg/L		<0.5
o-Chloronitrobenzene	mg/L	3	
o-Phenylenediamine	mg/L	0.005	
o-Toluidine	mg/L	0.2	
p - Isopropyltoluene	mg/L		<0.5
p,a,a,a-Tetrachlorotoluene	mg/L	0.004	
PAH	mg/L	0.01	
PBBs	mg/L	0.01	
PCBs	mg/L	0.01	
p-Chloronitrobenzene	mg/L	5	
Propylene oxide	mg/L	0.01	
sec - Butylbenzene	mg/L		<0.5
Styrene	mg/L		<0.5
tert - Butylbenzene	mg/L		<0.5
Tetrachloroethylene	ug/L	0.8	<0.5
Toluene	mg/L		<0.5
Toxaphene	mg/L	0.08	
trans - 1,2 - Dichloroethylene	mg/L		<0.5
trans - 1,3 - Dichloropropene	mg/L		<0.5
Trichloroethylene	mg/L	3.0	<0.5
Trimethyl phosphate	mg/L	2	
Vinyl Chloride	mg/L	0.02	<0.5
INORGANICS			
Alkalinity	mg/L as CaCO3		29.7
Aluminum	mg/L		0.0
Ammonia	mg/L as N		na
un-ionized Ammonia (a)	mg/L		
Antimony	mg/L		0.0003
Arsenic (b)	mg/L	0.05	0.001
Barium	mg/L	1.0	0.026
Beryllium	mg/L		0.0001
Cadmium (b)	mg/L	0.01	0.001
Calcium	mg/L		11.7
Chloride	mg/L	250.0	1.4
Chlorine Residual	mg/L		
Chromium	mg/L	0.05	0.002
Chromium - Hexavalent (b)	mg/L		
Chromium - Trivalent (i)	mg/L		
Copper (b)	mg/L	1.0	0.003
Cyanide	mg/L		na
Dissolved Oxygen	mg/L		1.2
Fluoride	mg/L	4.0	1.5
Iron	mg/L	0.3	0.4
Lead (b)	mg/L	0.05	0.001
Magnesium	mg/L		3.7
Manganese	mg/L	0.05	0.010
Mercury (s)	mg/L	0.002	0.001
Nickel (b)	mg/L		0.0004
Nitrate (as N)	mg/L	10.0	0.755
Total Kjeldahl Nitrogen (as N)	mg/L		
NO_2/NO_3	mg/L		0.439
Total Phosphorous (as P)	mg/L		
Potassium	mg/L		1.3
Selenium	mg/L	0.01	0.001
Silicon	mg/L		5.2
Silver (b)	mg/L	0.05	0.0004
Sodium	mg/L		2.1
Sulfate	mg/L	250.0	5.6
Thallium	mg/L		0.00004
Zinc (b)	mg/L	5.0	0.016
PHYSICAL PARAMETERS			

Groundwater Quality Limits and Summary of Quality of SVRP Aquifer

Color	color units	15	na
Corrosivity		noncorrosive	
Foaming Agents	mg/L	0.5	
Hardness	mg/L as CaCO3		36
Odor	threshold odor units	3	
pH		6.5 - 8.5	7.2
Total Dissolved Solids	mg/L	500.0	61
Turbidity	NTU		6.3
BOD 5	mg/L		
MICROORGANISMS			
Total Coliform Bacteria	cfu/mL	1/100	
RADIONUCLIDES			
Gross Alpha Particle Activity	pCi/L	15.0	
Gross Beta Activity	pCi/L	50	
Radium 226 & 228	pCi/L	5	
Radium-226	pCi/L	3.0	
Strontium-90	pCi/L	8	
Tritium	pCi/L	20000	

Sources:

SVRP Aquifer Groundwater Quality Data was obtained from Spokane County. Monitoring data for organics was averaged from data at two wells: Vera Water and Power, Well 8 (5423J01) and Well 9 (5423J02) measured on 11/19/2001 and 12/27/2001. Monitoring data for inorganics was average from data at the following wells: 5508M01 Barker Road Centennial Trail North, 5508M02 Barker Road Centennial Trail South, 5517D05 Mission & Barker monitoring well at CID 4, 5518R01 CONSOLIDATED IRRIG DIST 19, Site 2A, 5423J01 Vera Water and Power Well 8, and 5423J02 Vera Water and Powe, Well 9. In general sampling started in 1998 and has continued with samples being taken every three months, though it may vary from well to well.

Notes:

a The listed fresh water criteria are based on unionized or total ammonia concentrations, while those for marine water are based on total ammonia concentrations. Tables for the conversion of total ammonia to un-ionized ammonia for freshwater can be found in the USEPA's Quality Criteria for Water, 1986. Criteria concentrations based on total ammonia for marine water can be found in USEPA Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA440/5-88-004, April 1989.

Groundwater Quality Limits and Summary of Quality of SVRP Aquifer

Notes Table 5-9 (continued):

b These ambient criteria in the table are for the dissolved fraction. The cyanide criteria are based on the weak acid dissociable method. The metals criteria may not be used to calculate total recoverable effluent limits unless the seasonal partitioning of the dissolved to total metals in the ambient water are known. When this information is absent, these metals criteria shall be applied as total recoverable values, determined by back-calculation, using the conversion factors incorporated in the criterion equations. Metals criteria may be adjusted on a site-specific basis when data are made available to the department clearly demonstrating the effective use of the water effects ratio approach established by USEPA, as generally guided by the procedures in USEPA Water Quality Standards Handbook, December 1983, as supplemented or replaced by USEPA or ecology. Information which is used to develop effluent limits based on applying metals partitioning studies or the water effects ratio approach shall be identified in the permit fact sheet developed pursuant to WAC 173-220-060 or 173-226-110, as appropriate, and shall be made available for the public comment period required pursuant to WAC 173-220-050 or 173-226-130(3), as appropriate. Ecology has developed supplemental guidance for conducting water effect ra

c A 1-hour average concentration not to be exceeded more than once every three years on the average.

d A 4-day average concentration not to be exceeded more than once every three years on the average.

e A chlorine residual of at least 0.5 mg/L shall be maintained in the reclaimed water during conveyance from the reclamation plant to the use area unless waived by the Departments of Health and Ecology.

f Shall not exceed the numerical concentration calculated as follows:

g Unionized ammonia concentration for waters where salmonid habitat is an existing or designated use:

$0.80 \div (FT)(FPH)(RATIO)$

where:	RATIO =	13.5 for $7.7 \leq pH \leq 9$
	RATIO =	$(20.25 \times 10^{(7.7-pH)})/(1+ 10^{(7.4-pH)})$; $6.5 \leq pH \leq$
	FT =	1.4; $15 \leq T \leq 30$
	FT =	$10^{[0.03(20-T)]}$; $0 \leq T \leq 15$
	FPH =	1; $8 \leq pH \leq 9$
	FPH =	$(1 + 10^{(7.4-pH)})/1.25$; $6 \leq pH \leq 8.0$

Total ammonia concentrations for waters where salmonid habitat is not an existing or designated use and other fish early life stages are absent:

Chronic criterion = $(0.0557)/(1 + 10^{7.688-pH}) + ((2.487)*(1.45 \times 10^{0.028(25-A)}))/(1 + 10^{pH-7.688})$

where: A = the greater of either T (temperature in degrees Celsius) or 7.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

Total ammonia concentration for waters where salmonid habitat is not an existing or designated use and other fish early life stages are present:

Chronic criterion = $(0.0557)/(1 + 10^{7.688-pH}) + ((2.487)*(B^{)}))/(1 + 10^{pH-7.688})$

where: B = the lower of either 2.85, or $1.45 \times 10^{0.028 \times (25-T)}$. T = temperature in degrees Celsius.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on the average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

g $\leq (0.944)(e(1.128[\ln(hardness)]-3.828))$ at hardness = 100. Conversion factor (CF) of 0.944 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.136672 - [(ln hardness)(0.041838)].

h $\leq (0.909)(e(0.7852[\ln(hardness)]-3.490))$ at hardness = 100. Conversions factor (CF) of 0.909 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.101672 - [(ln hardness)(0.041838)].

i Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total-recoverable chromium.

j Salinity dependent effects. At low salinity the 1-hour average may not be sufficiently protective.

k The conversion factor used to calculate the dissolved metal concentration was 0.982.

l The conversion factor used to calculate the dissolved metal concentration was 0.962.

m $\leq (0.316)e^{(0.8190[\ln(hardness)] + 3.688)}$

n $\leq (0.860)e^{(0.8190[\ln(hardness)] + 1.561)}$

o $\leq (0.960)(e^{(0.9422[\ln(hardness)] - 1.464)})$

p $\leq (0.960)(e^{(0.8545[\ln(hardness)] - 1.465)})$

q $\leq (0.791)(e^{(1.273[\ln(hardness)] - 1.460)})$ at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

r $\leq (0.791)(e^{(1.273[\ln(hardness)] - 4.705)})$ at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

s If the four-day average chronic concentration is exceeded more than once in a three-year period, the edible portion of the consumed species should be analyzed. Said edible tissue concentrations shall not be allowed to exceed 1.0 mg/kg of methylmercury.

t The conversion factor used to calculate the dissolved metal concentration was 0.85.

u These criteria are based on the total-recoverable fraction of the metal.

v $\leq (0.998)(e^{(0.8460[\ln(hardness)] + 3.3612)})$

w $\leq (0.997)(e^{(0.8460[\ln(hardness)] + 1.1645)})$

x An instantaneous concentration not to be exceeded at any time.

y $\leq (0.85)(e^{(1.72[\ln(hardness)] - 6.52)})$

z $\leq (0.978)(e^{(0.8473[\ln(hardness)] + 0.8604)})$

aa $\leq (0.986)(e^{(0.8473[\ln(hardness)] + 0.7614)})$

Monitoring Requirements for the Use of Reclaimed Water in Saltese Flats

Parameter	Sample Type & Frequency
Hydraulic Criteria	
Flow Rate	Continuous Recording
Water Level Elevation	Continuous Recording
Water Quality Criteria (Wetlands)	
Biochemical Oxygen Demand	24-hour composite, collected at least weekly
Total Suspended Solids	24-hour composite, collected at least weekly
Total Coliforms	Grab, collected at least daily
Kjeldahl Nitrogen	24-hour composite, collected weekly
Total Ammonia-Nitrogen	24-hour composite, collected weekly
Total Phosphorus	24-hour composite, collected weekly
Metals: Arsenic, Cadmium, Copper, Lead, Mercury, Nickel, Zinc	24-hour composite, collected weekly
Water Quality Criteria (Class A Reclaimed Water)	
Biochemical Oxygen Demand	24-hour composite, collected at least weekly
Total Suspended Solids	24-hour composite, collected at least daily[1]
Total Coliforms	Grab, collected at least daily
Turbidity	Continuous Recording
Dissolved Oxygen	Grab, collected at least daily
Groundwater Criteria	
SVRP Aquifer Quality[2]	To be determined
Groundwater Recharge Criteria[3]	To be determined
Biological Criteria	
Vegetation cover, plant diversity, macroinvertebrate biomass, amphibian species, fish biomass & species, bird density & species, threatened/endangered density & species	Once per year during 1st, 2nd, 4th, 6th, 8th & 10th growing seasons

Notes:
1) May be reduced for project generating Class A reclaimed water.
2) Monitoring is required to determine that the use of reclaimed water does not degrade the quality of SVRP Aquifer.
3) Required if sufficient recharge from Saltese Flats to SVRP occurs.

Source: Water Reclamation and Reuse Standards, Washington State Departments of Ecology and Health, 1997

TABLE 5-11

Planning Level Costs for Saltese Flats Restoration

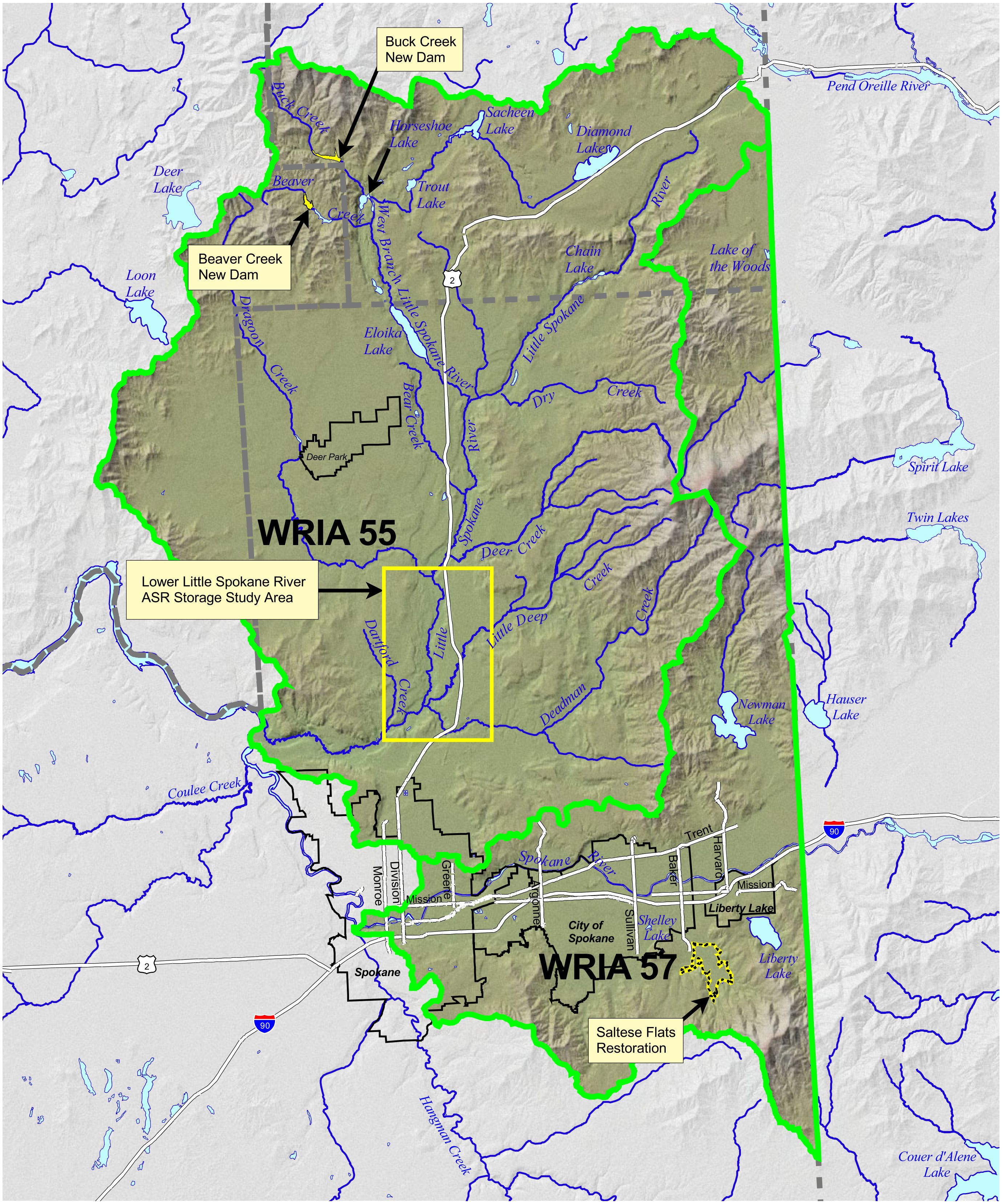
	Design using Natural Inflows			Design using Reclaimed Water		
	Configuration 1	Configuration 2	Configuration 3	Configuration 1	Configuration 2	Configuration 3
Land acquisition[1]	$10,200,000	$3,200,000	$3,200,000	$10,200,000	$3,200,000	$3,200,000
Site Investigation	$100,000	$200,000	$50,000	$500,000	$500,000	$500,000
Permitting	$75,000 - $750,000	$75,000 - $1,000,000	$25,000 - $250,000	$500,000 - $1,500,000	$500,000 - $1,500,000	$500,000 - $1,500,000
Design and Construction	$900,000	$7,800,000	$100,000	$1,100,000	$8,000,000	$300,000
Conveyance Costs [5]				$30,100,000	$30,100,000	$30,100,000
Total (millions of dollars)	$11.3 -$ 11.9	$11.2 - $12.2	$3.4 - $3.6	$42.4 - $43.4	$42.3 - $43.3	$34.6 - $35.6

Annual Operation, Maintenance and Monitoring	$75,000/year	$150,000/yer	$50,000/year	$125,000/year	$200,000/year	$100,000/year

Notes:

1) Land Acquisition costs were assumed to average $4,000 per acre due to the fact that the majority of wetland acreage required will be agricultural land without significant development potential. A 20% transaction cost for land is included
2) Site Investigations include all costs related to assessment of the wetlands boundaries and characteristics, as well as any investigation required for construction purposes. Site Investigations for reclaimed water inflows would require additional hydrogeologic evaluation as well as more stringent wetland characterization
3) Permitting costs can vary widely depending on the regulatory environment, public response to the project and agenvy involvement.
4) Design and Construction costs primarily include any design or construction costs associated with engineered systems such as the dike, and outlet control structure. Design is estimted as approximately 30% of construction costs
5) Conveyance Costs were estimated using average capital cost estimates developed for two outfall alternatives for the planned SCRTP (HDR, 2004). These costs do not take into account specific routes or conditions that may be encountered. Average outfall capital costs are $518/linear foot.
6) Costs are planning level and are subject to change

FIGURES



LEGEND

- Roads
- WRIA Boundary
- Municipal Boundary
- County Boundary
- Lake
- River

0 6

Scale 1" = 6 Miles

Map Projection:
Washington State Plane
North Zone, NAD 83, Feet

Source: WSDOE, NWI
Spokane County, DNR

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Storage Assessment Overview

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Drawn: RMT	Revision: 3	Date: Oct. 06, 2004	Figure: 1 - 1

013137245100_062104.apr

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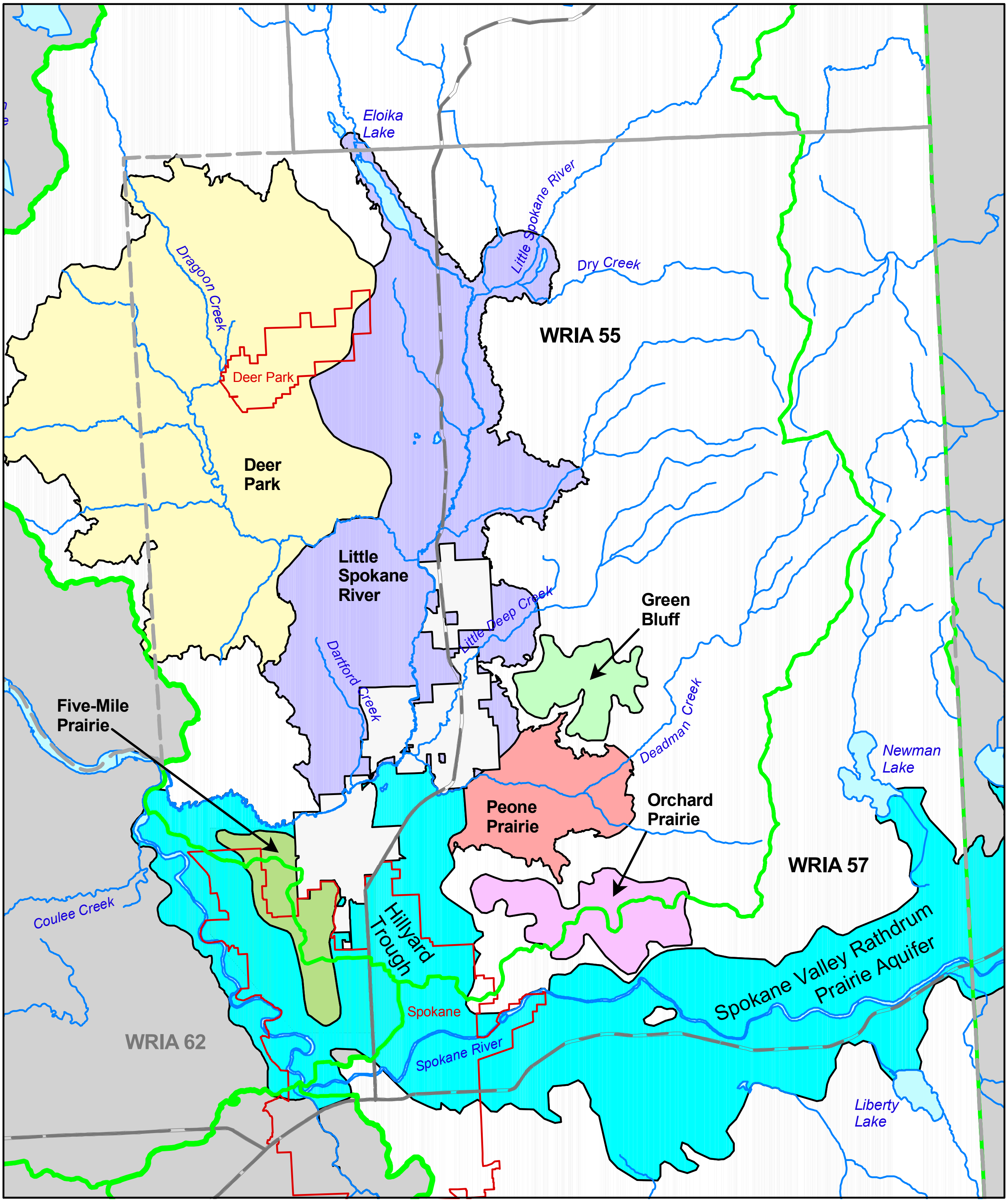

This figure was originally produced in color.
Reproduction in black and white may result in loss of information.

LEGEND

- WRIA Boundaries
- Cities
- Counties
- Roads
- Rivers and Streams
- Whitworth WD #2

N

0 2 4 Miles

Scale 1" = 4 Miles

Map Projection: Washinton State Plane North Zone, NAD83 Datum

Original Data Source: Washington Department of Ecology, Spokane County

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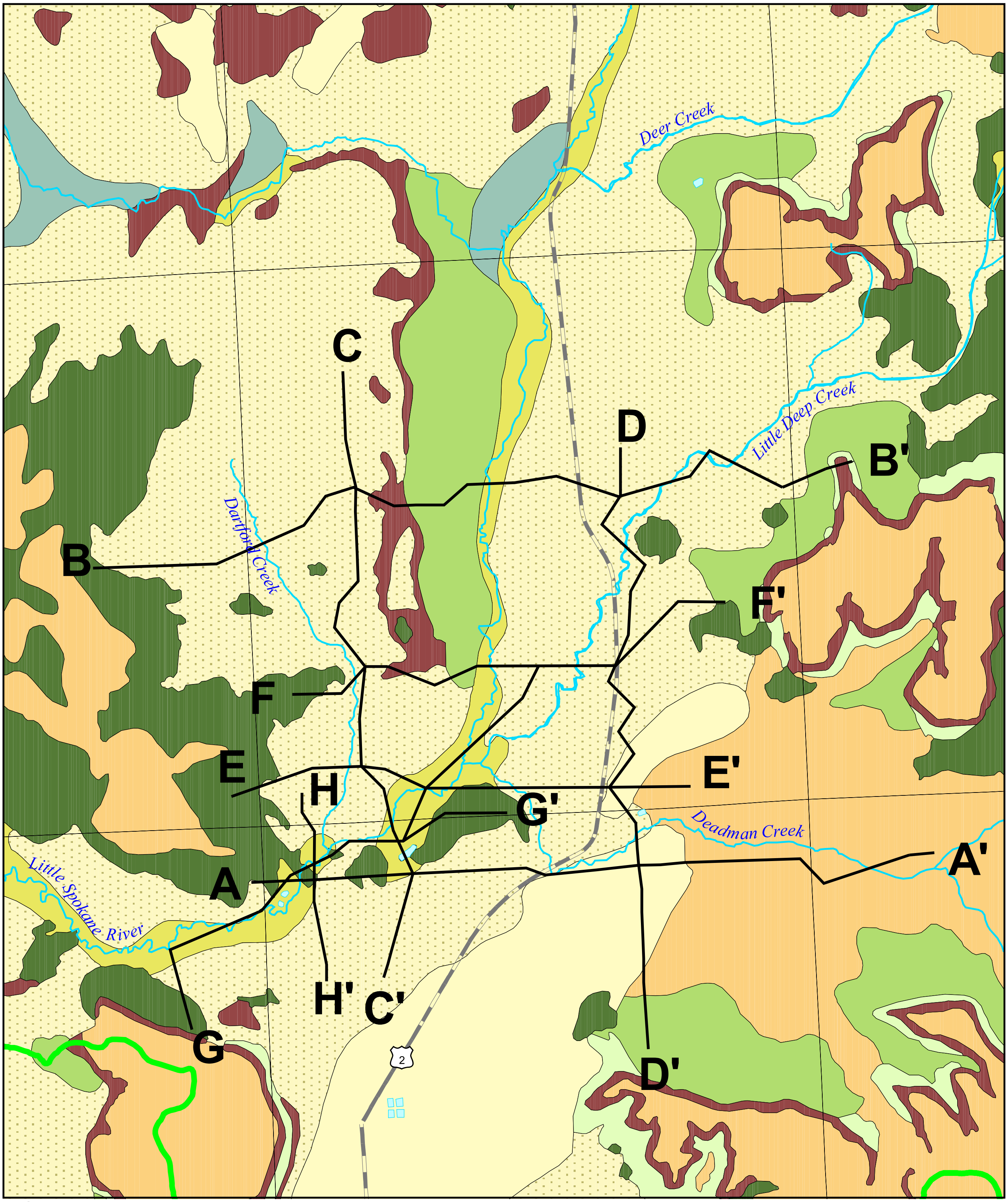
Regional Aquifer Delineations

Drawn: KAV	Rev: 2	Date: Nov. 3, 2004	Figure: 3-1

01313720014330_100404.apr



LEGEND

WRIA Boundaries	Qal	Alluvium
Sections	Qmn	Mass Wasting Deposits
Rivers and Streams	QL	Loess
Roads	Qfg	Flood Deposits, Gravel
	Qs	Undifferentiated Sediments
Cross Sections	Qgd	Glacial Deposits
	TL	Latah
	TW/Tgr	Basalt
	B	Crystalline Basement

N

0 1 8,000

Scale 1" = 8,000 Feet

Map Projection: Washinton State Plane North Zone, NAD83 Datum

Original Data Source: Washington State DNR, Department of Ecology; USGS; Emcon (1992), Boere & Buchanan, (1996), CH2MHill (1998)

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

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Surficial Geology and Locations of All Cross Sections

Drawn: KAV	Rev: 3	Date: Nov. 5, 2004	Figure: 3-2

01313720014330_100404.apr

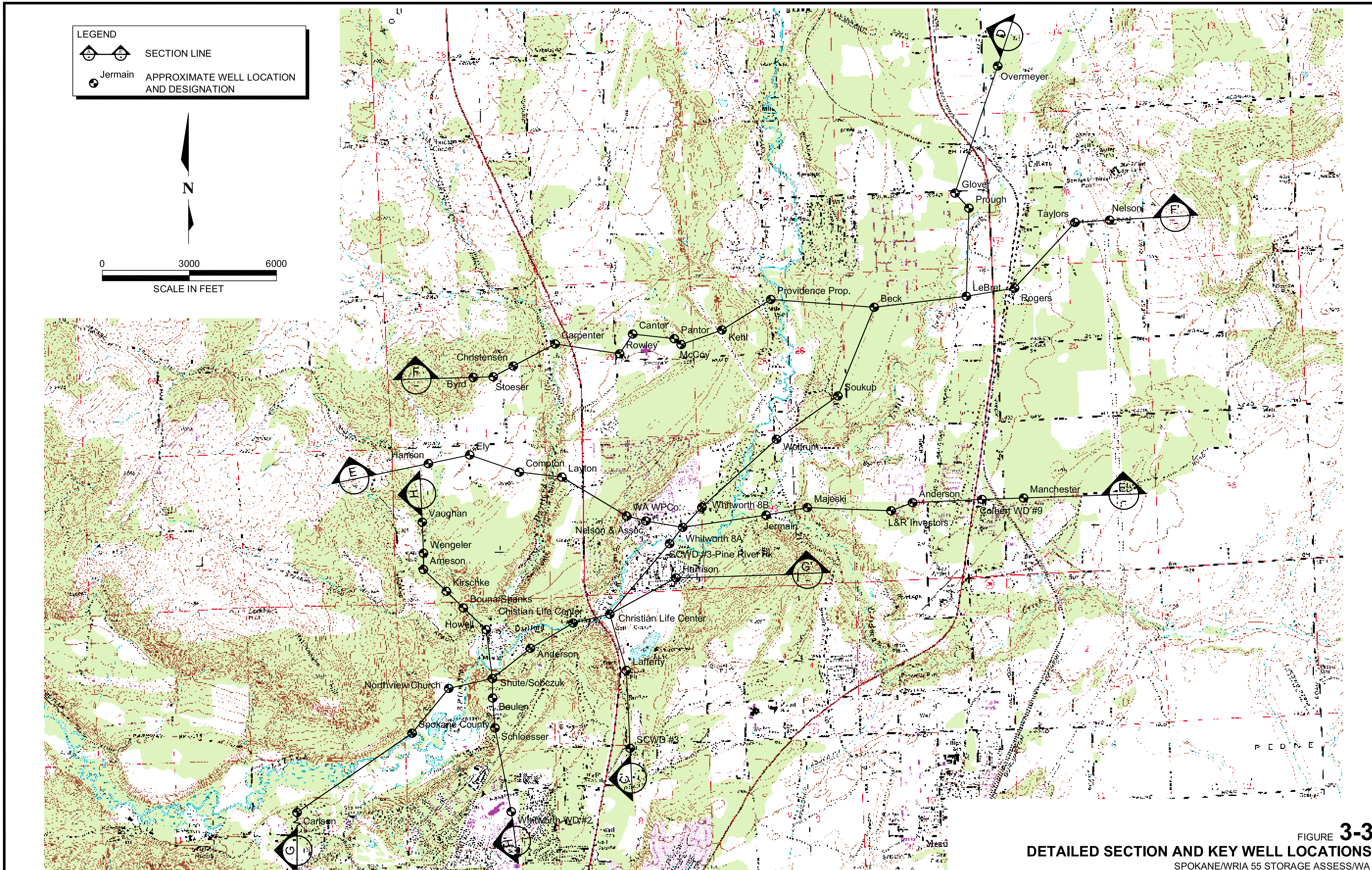
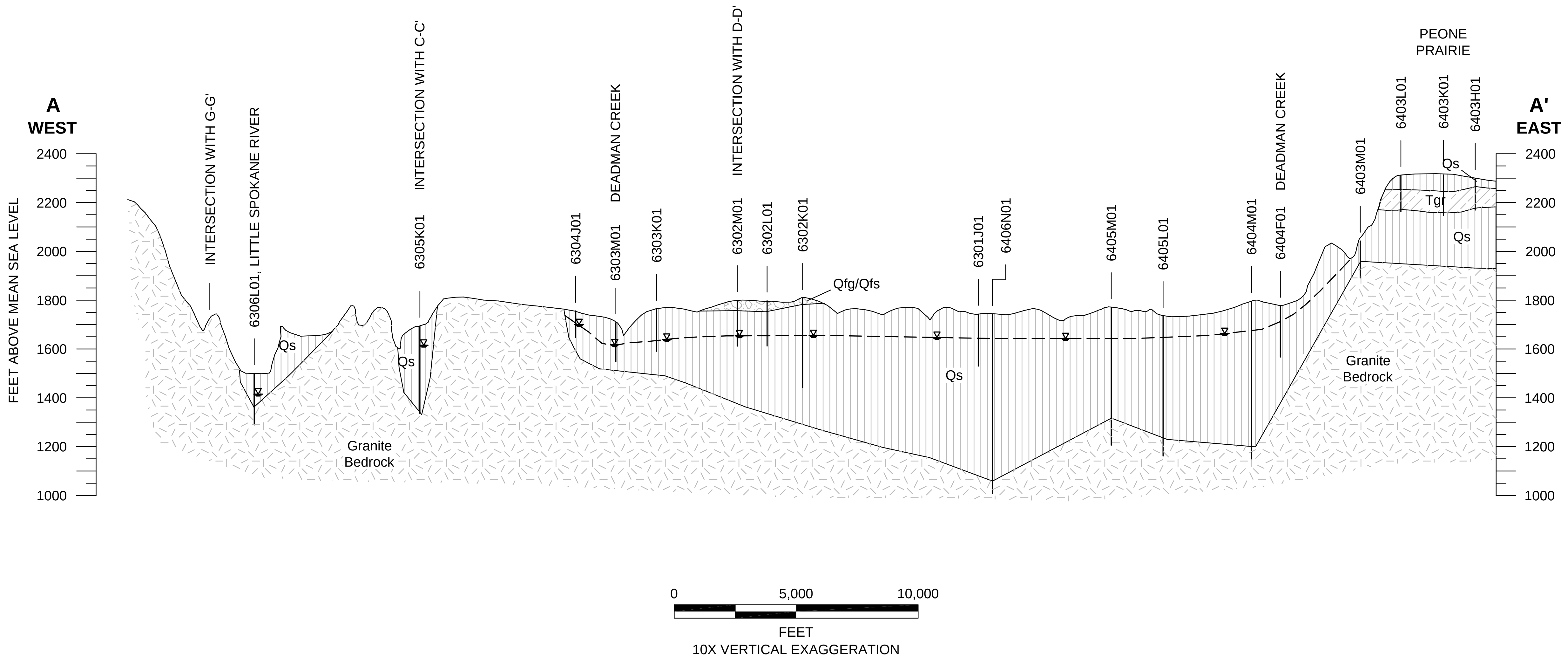


FIGURE **3-3**

DETAILED SECTION AND KEY WELL LOCATIONS

SPOKANE/WRIA 55 STORAGE ASSESS/WA



LEGEND

Qs - UNDIFFERENTIATED SEDIMENTS

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

DATA SOURCE: AQUIFER DELINEATION OF A PORTION OF NORTH SPOKANE COUNTY (BOESE AND BUCHANAN, 1996).

FIGURE **3-4**

CROSS-SECTION A-A'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

01313720014330F03.dwg | Layout: A-A' | Modified: 11/29/2004, 15:24 | Plotted: 11/29/2004, 15:58

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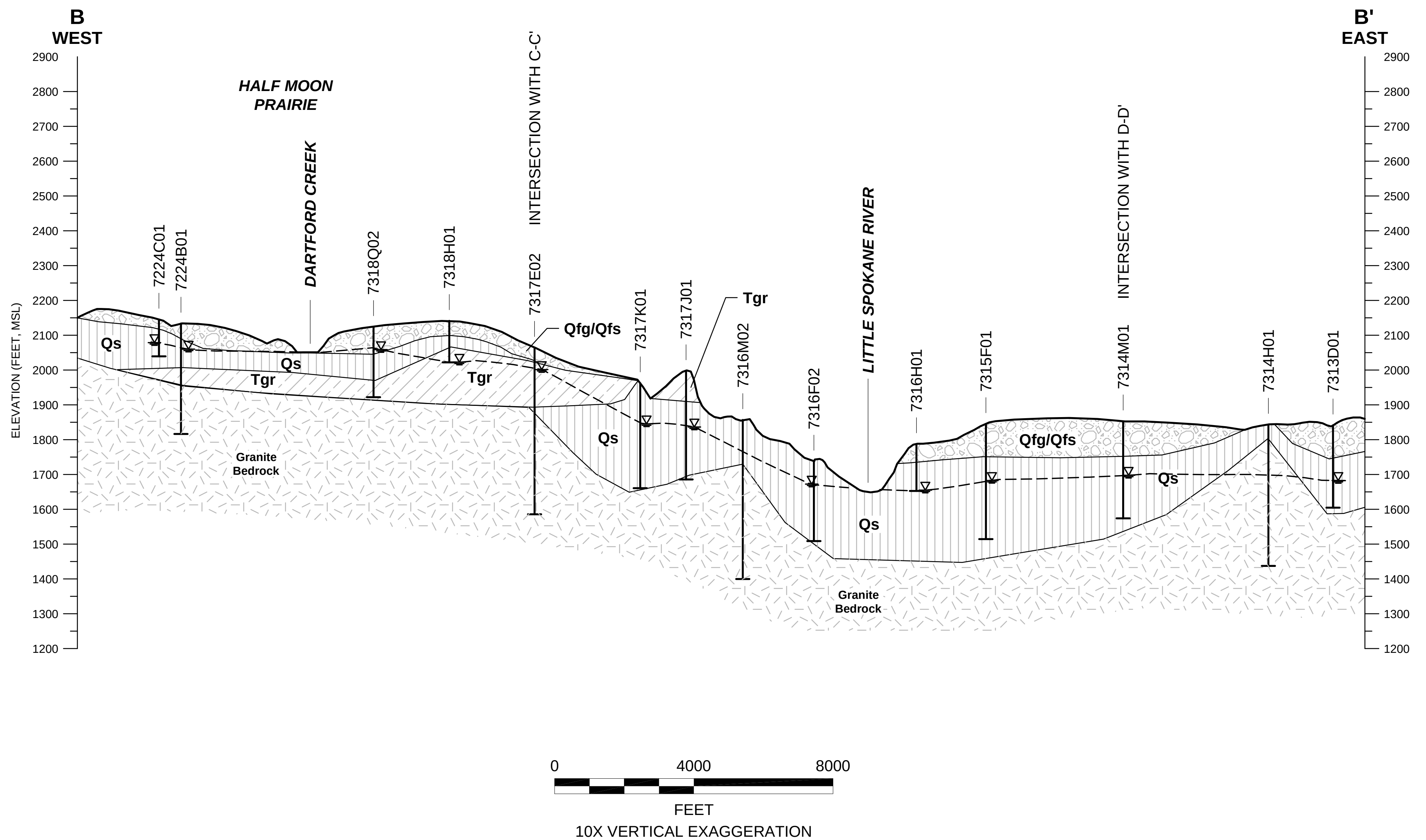

LEGEND

Qs - UNDIFFERENTIATED SEDIMENTS

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

DATA SOURCE: AQUIFER DELINEATION OF A PORTION OF NORTH SPOKANE COUNTY (BOESE AND BUCHANAN, 1996).

FIGURE **3-5**

CROSS-SECTION B-B'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Drawing file: 01313720014330F01.dwg Nov 29, 2004 – 3:59pm

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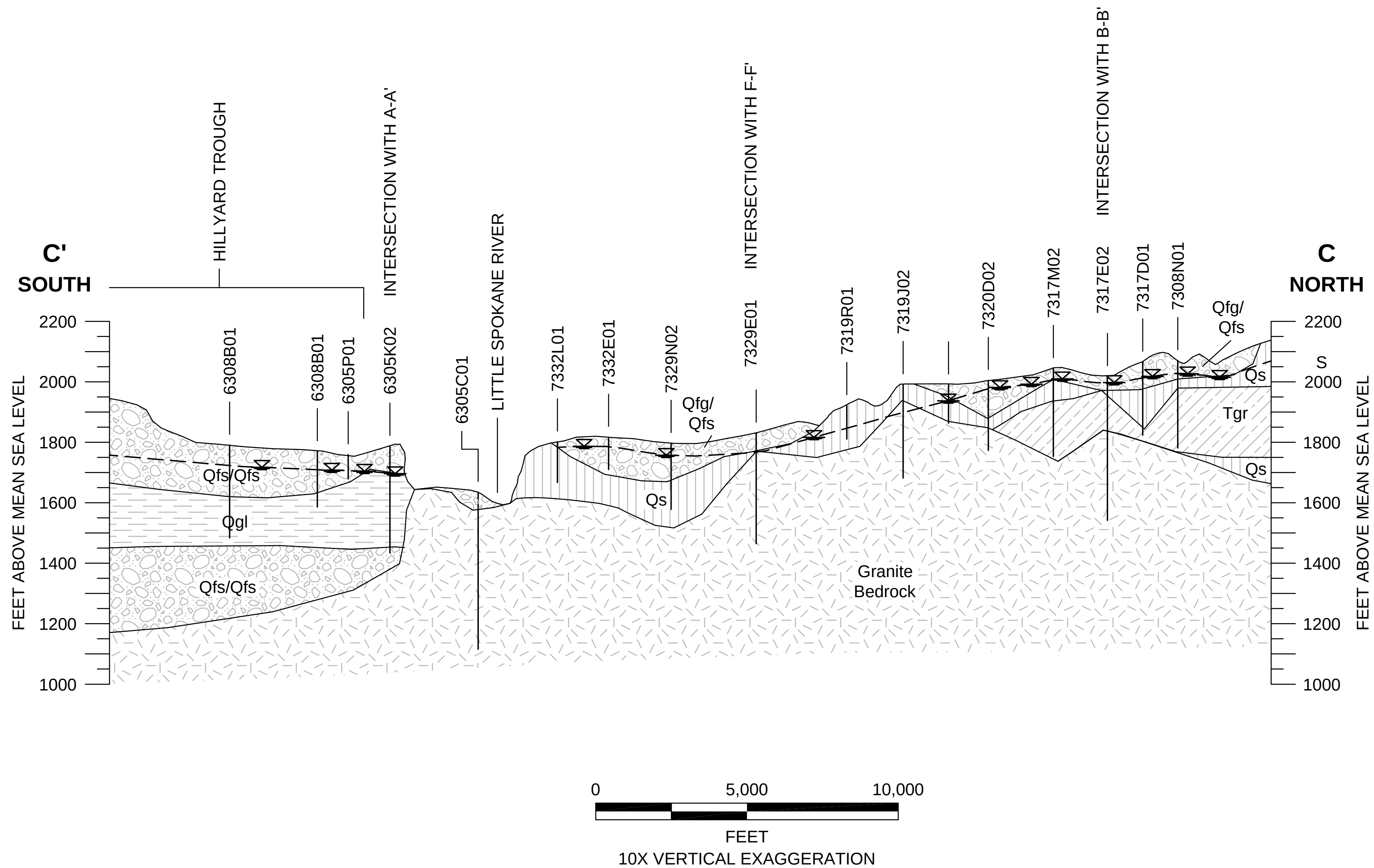


LEGEND

Qgl- QUATERNARY GLACIAL LACUSTRINE

Qs - UNDIFFERENTIATED SEDIMENTS

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

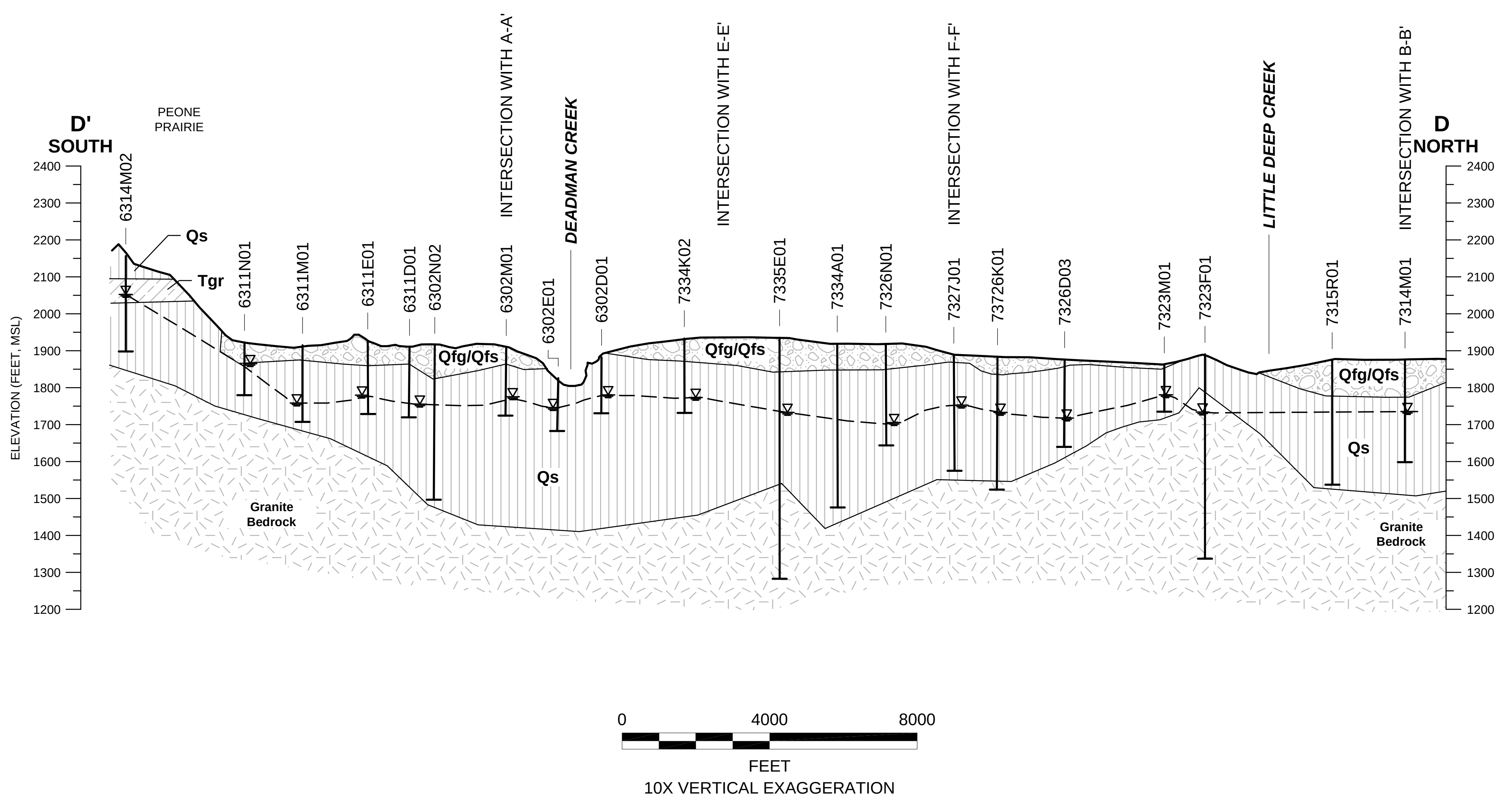
DATA SOURCE: AQUIFER DELINEATION OF A PORTION OF NORTH SPOKANE COUNTY (BOESE AND BUCHANAN, 1996).

FIGURE **3-6**

CROSS-SECTION C-C'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Golder Associates



LEGEND

Qs - UNDIFFERENTIATED SEDIMENTS

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

DATA SOURCE: AQUIFER DELINEATION OF A PORTION OF NORTH SPOKANE COUNTY (BOESE AND BUCHANAN, 1996).

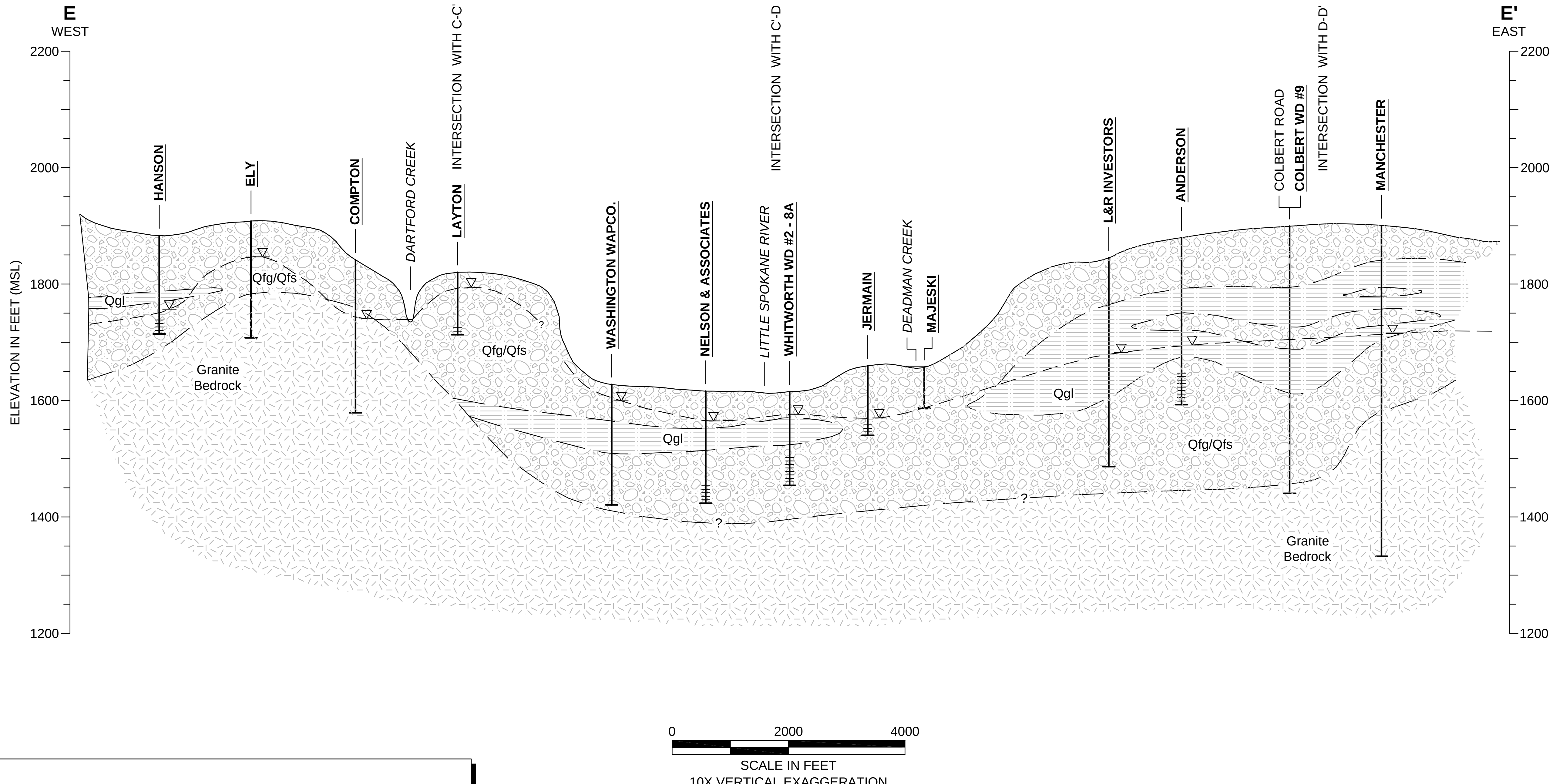
FIGURE **3-7**

CROSS-SECTION D-D'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Drawing file: 01313720014330F02.dwg Nov 29, 2004 – 4:00pm

Golder Associates



LEGEND

ELY — WELL ID (OWNER)

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SCREENED INTERVAL (WHERE KNOWN)

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

Qgl- QUATERNARY GLACIAL LACUSTRINE

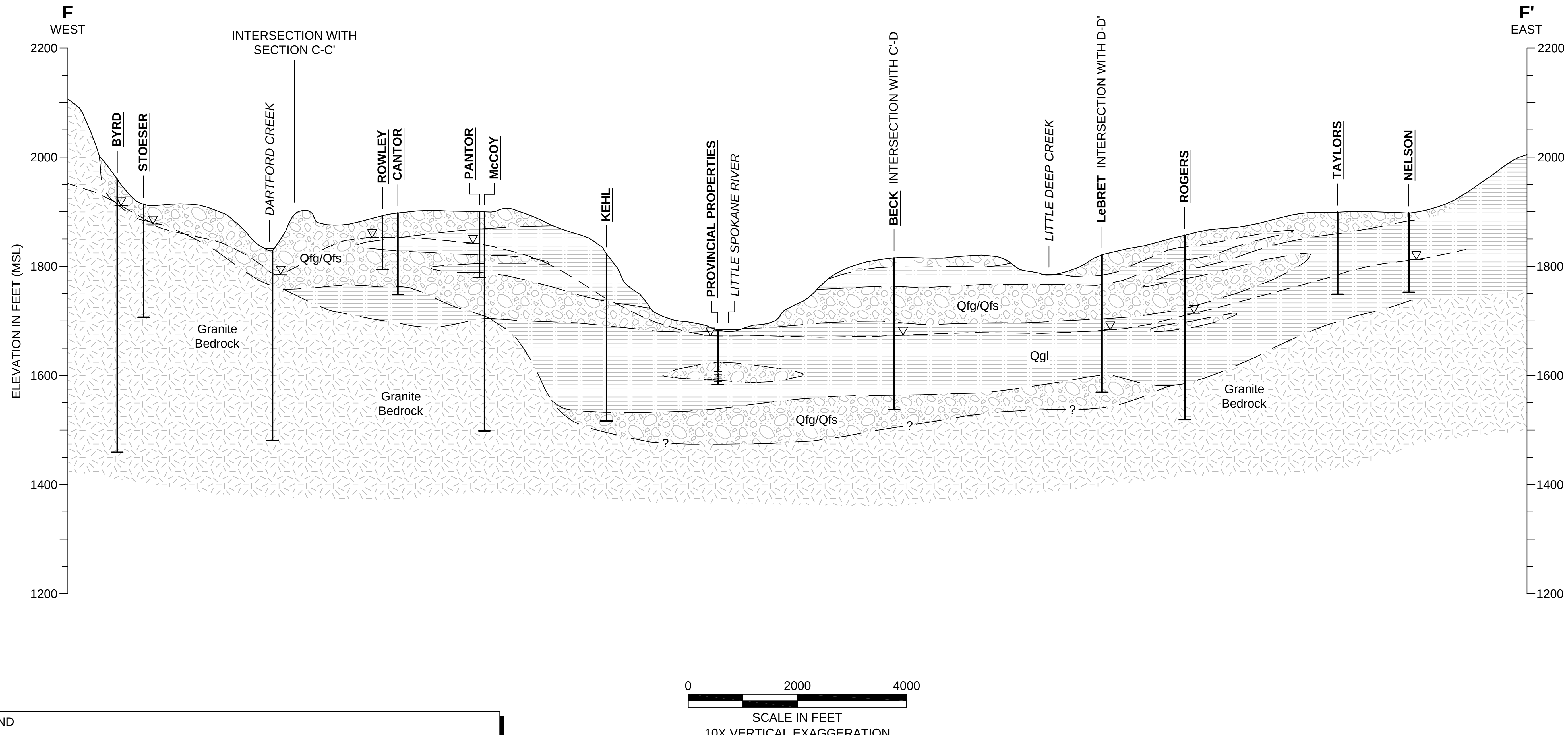
SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

FIGURE **3-8**

CROSS-SECTION E-E'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Golder Associates



LEGEND

ELY — WELL ID (OWNER)

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SCREENED INTERVAL (WHERE KNOWN)

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

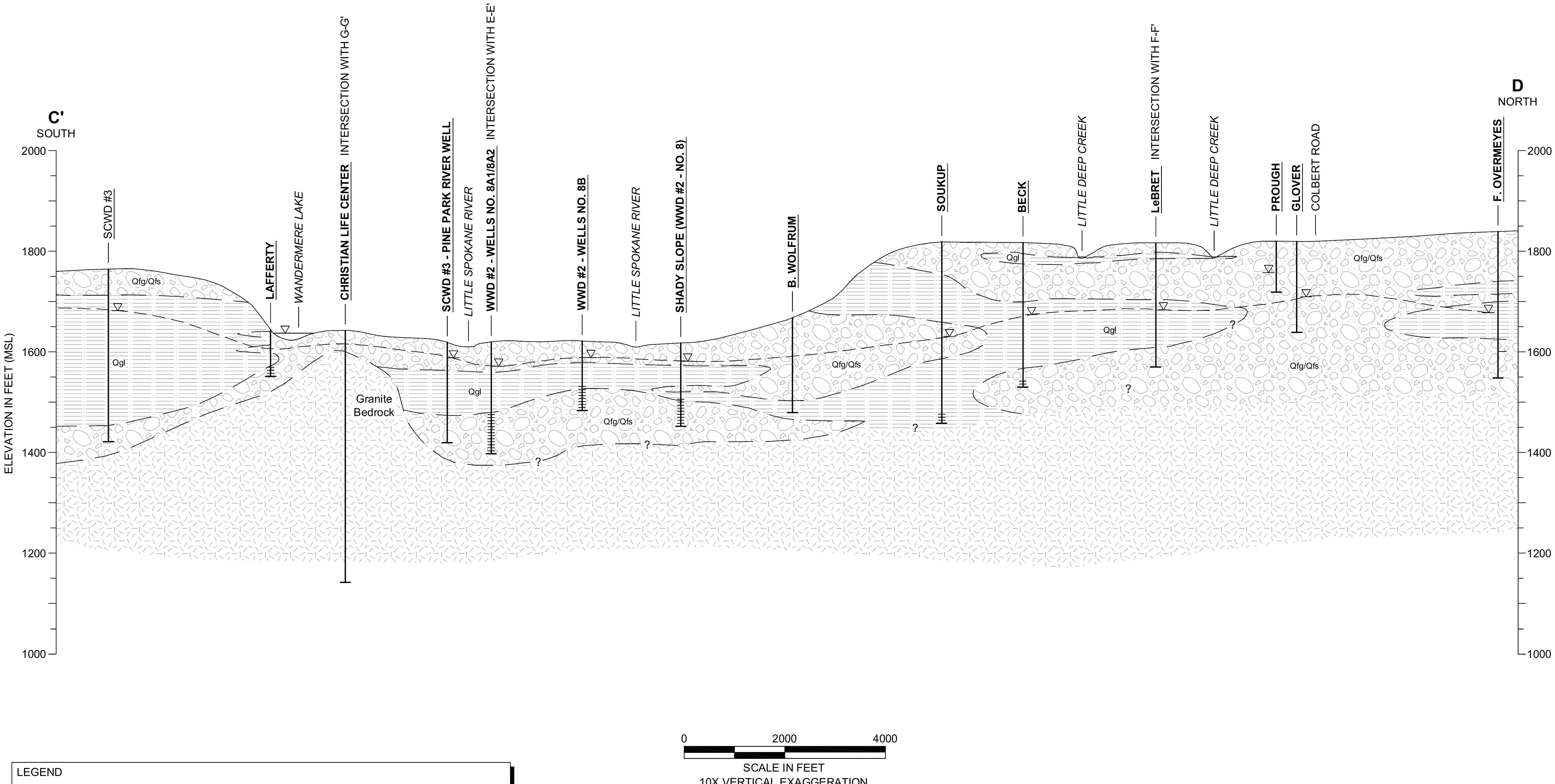
Qgl- QUATERNARY GLACIAL LACUSTRINE

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

FIGURE **3-9**

CROSS-SECTION F-F'

SPOKANE/WRIA 55 STORAGE ASSESS/WA



LEGEND

ELY — WELL ID (OWNER)

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SCREENED INTERVAL (WHERE KNOWN)

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

Qgl- QUATERNARY GLACIAL LACUSTRINE

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

FIGURE **3-10**

CROSS-SECTION C'-D

SPOKANE/WRIA 55 STORAGE ASSESS/WA

01313720014330F04.dwg | Layout: Layout3 | Modified: 12/22/2004, 10:02 | Plotted: 12/22/2004, 10:05

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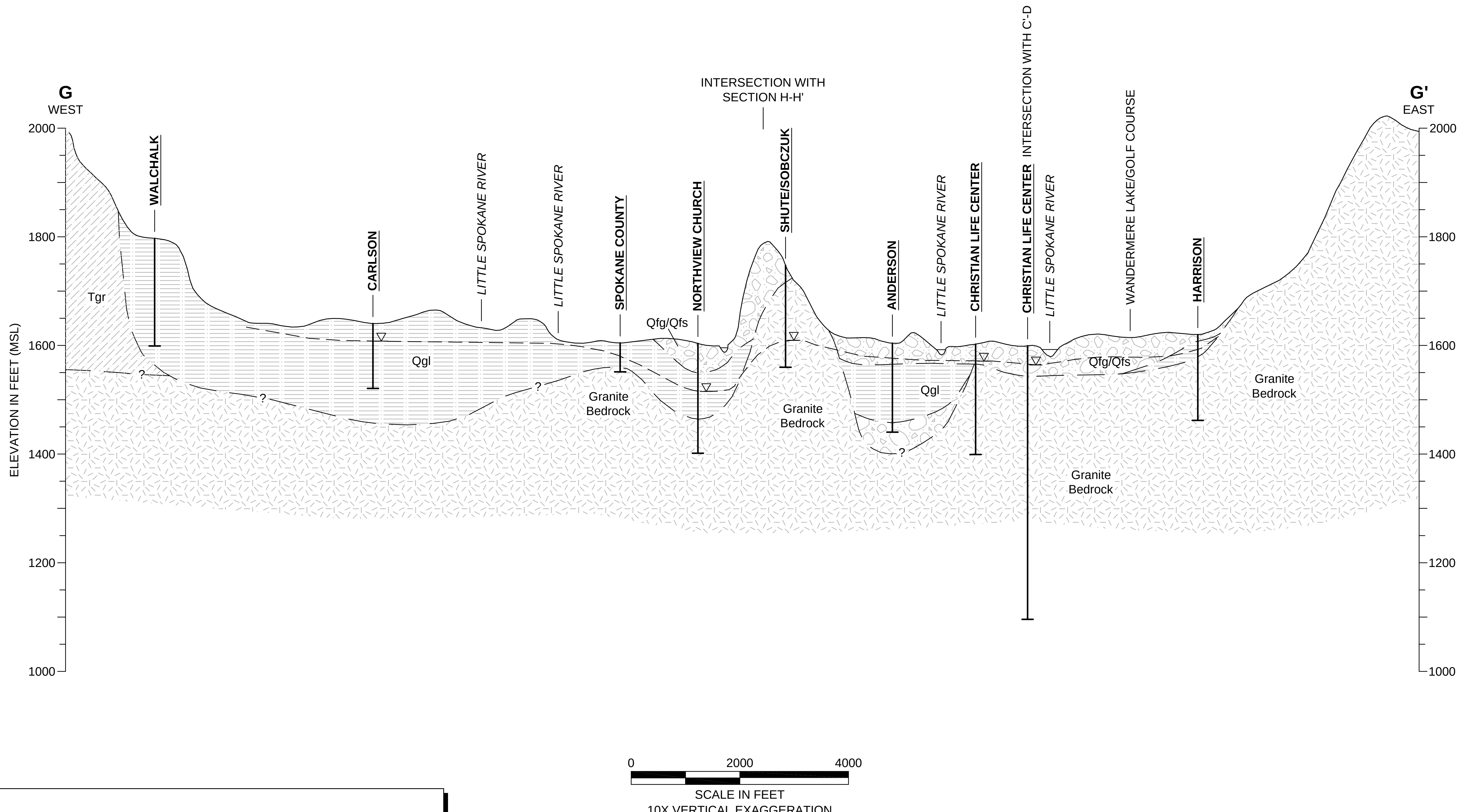


LEGEND

ELY — WELL ID (OWNER)

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SCREENED INTERVAL (WHERE KNOWN)

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

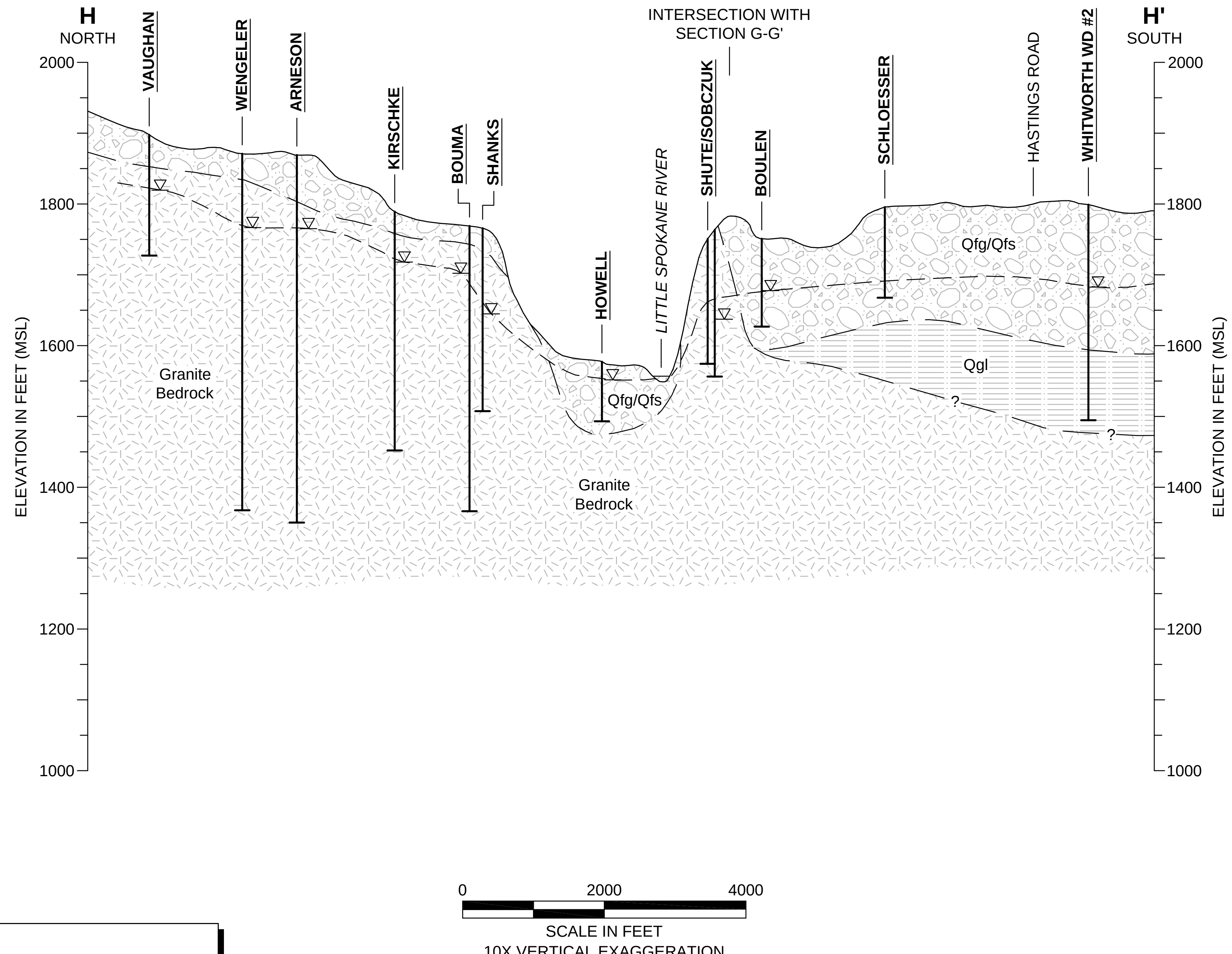
Qgl- QUATERNARY GLACIAL LACUSTRINE

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

FIGURE **3-11**

CROSS-SECTION G-G'

SPOKANE/WRIA 55 STORAGE ASSESS/WA



LEGEND

ELY — WELL ID (OWNER)

INFERRED PIEZOMETRIC SURFACE (BASED ON DRILLER'S LOG DEPTHS TO STATIC WATER)

SCREENED INTERVAL (WHERE KNOWN)

Qfg/Qfs - QUATERNARY FLOOD GRAVEL/SAND

Tgr - BASALT

Qgl- QUATERNARY GLACIAL LACUSTRINE

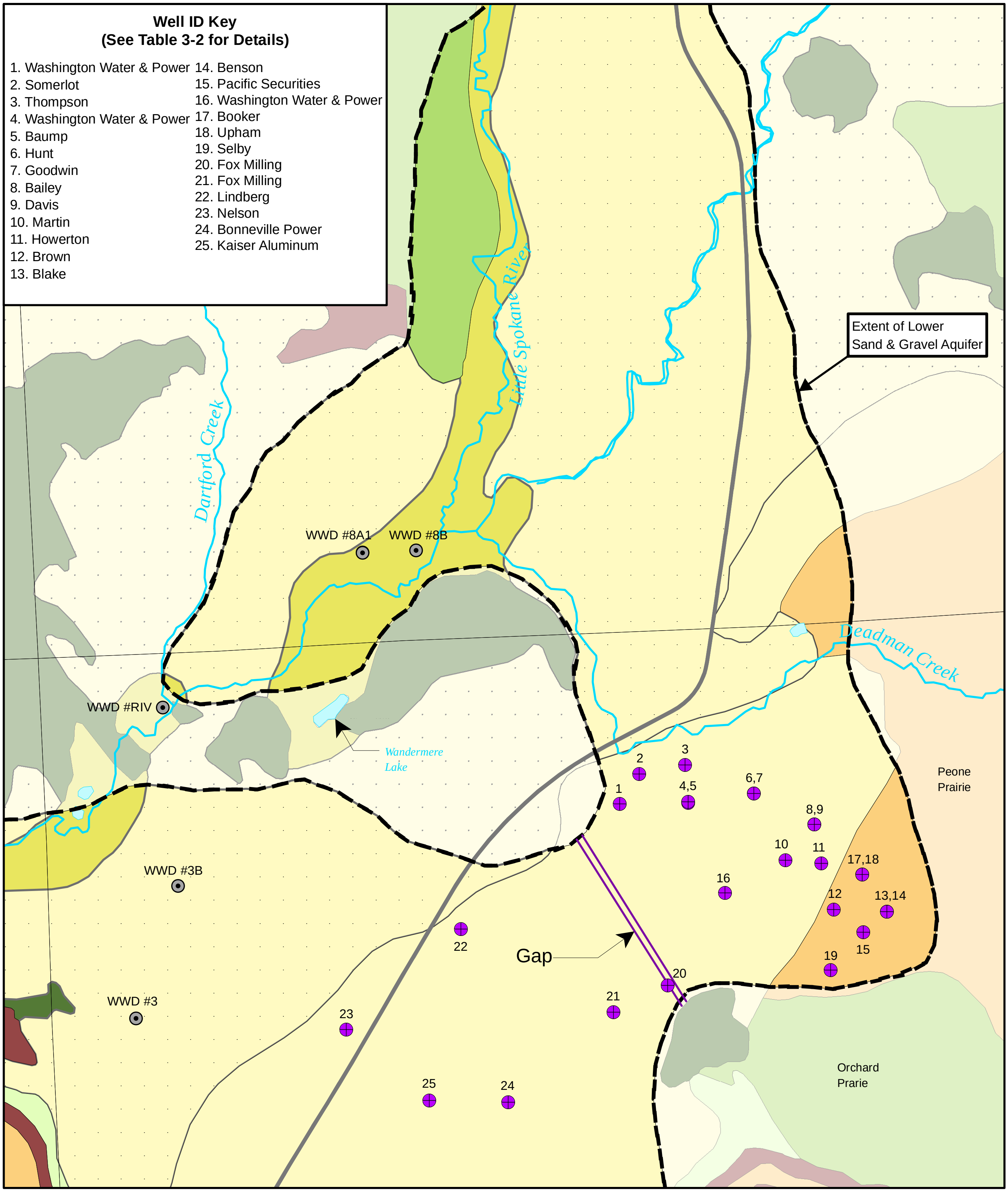
SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

FIGURE **3-12**

CROSS-SECTION H-H'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Golder Associates



LEGEND

B	Crystalline Basement	Whitworth WD#2 Production Wells
Qal	Alluvium	Private Wells (See Table 3-xx for details)
Qfg	Flood Deposits, Gravel	Roads
Ql	Loess	Rivers and Streams
Qmw	Mass Wasting Deposits	Lake
Qs	Undifferentiated Sediments	Sections
Tl	Latah	
Tw/Tgr	Basalt	

0 — 4,000

Scale 1" = 4,000 Feet

Map Projection: Washington State Plane, North Zone, NAD 83, Feet

Source: Washington State DNR, Department of Ecology; USGS; Emcon (1992), Boere & Buchanan, (1996), CH2MHill (1998)

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Extent of the Lower Sand and Gravel Aquifer

Drawn: RMT	Revision: 1	Date: Nov. 29, 2004	Figure: 3-14

01313720014330F01.mxd

Golder Associates

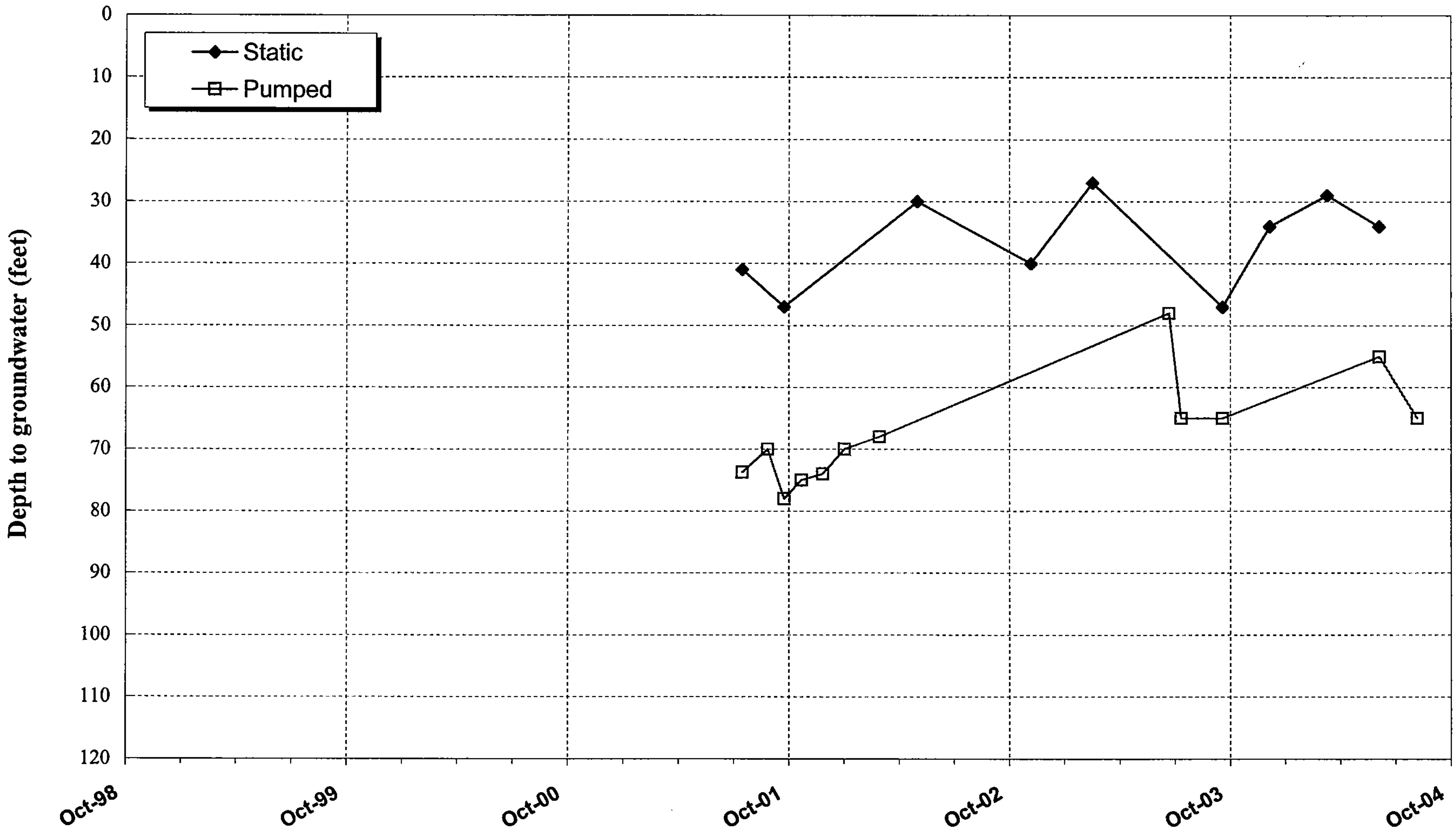


FIGURE 3-15:
Groundwater Hydrograph - Whitworth WD #2 Well No. 8, 1997-2003

WRIA 55 & 57 - Second Step Storage Assessment

Golder Associates

013-1372001.4330 November 29, 2004

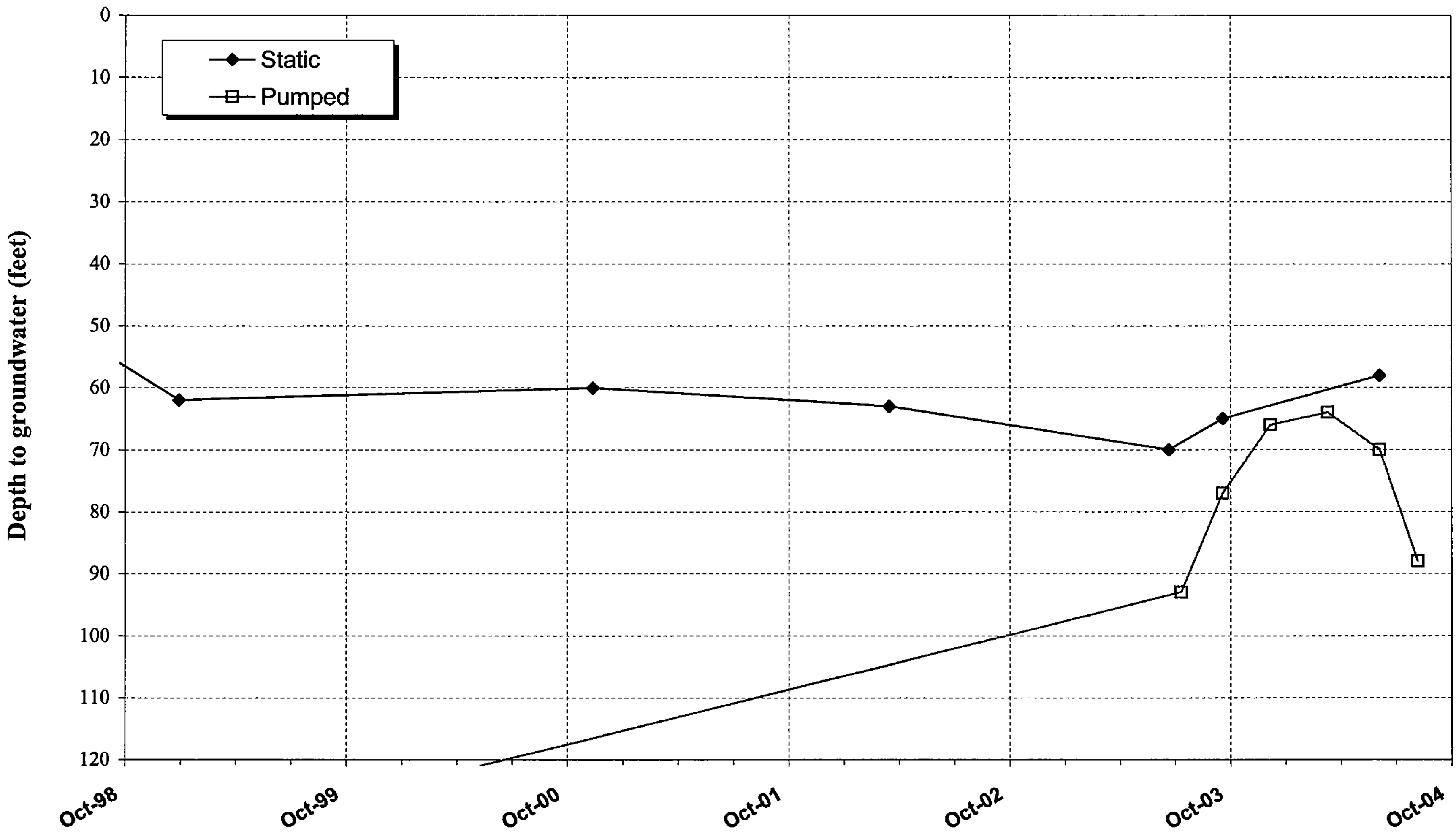


FIGURE 3-16:

Groundwater Hydrograph - Whitworth WD #2 Well No. 8-A1, 1997-2003

Golder Associates

WRIA 55 & 57 - Second Step Storage Assessment

013-1372001.4330 November 29, 2004

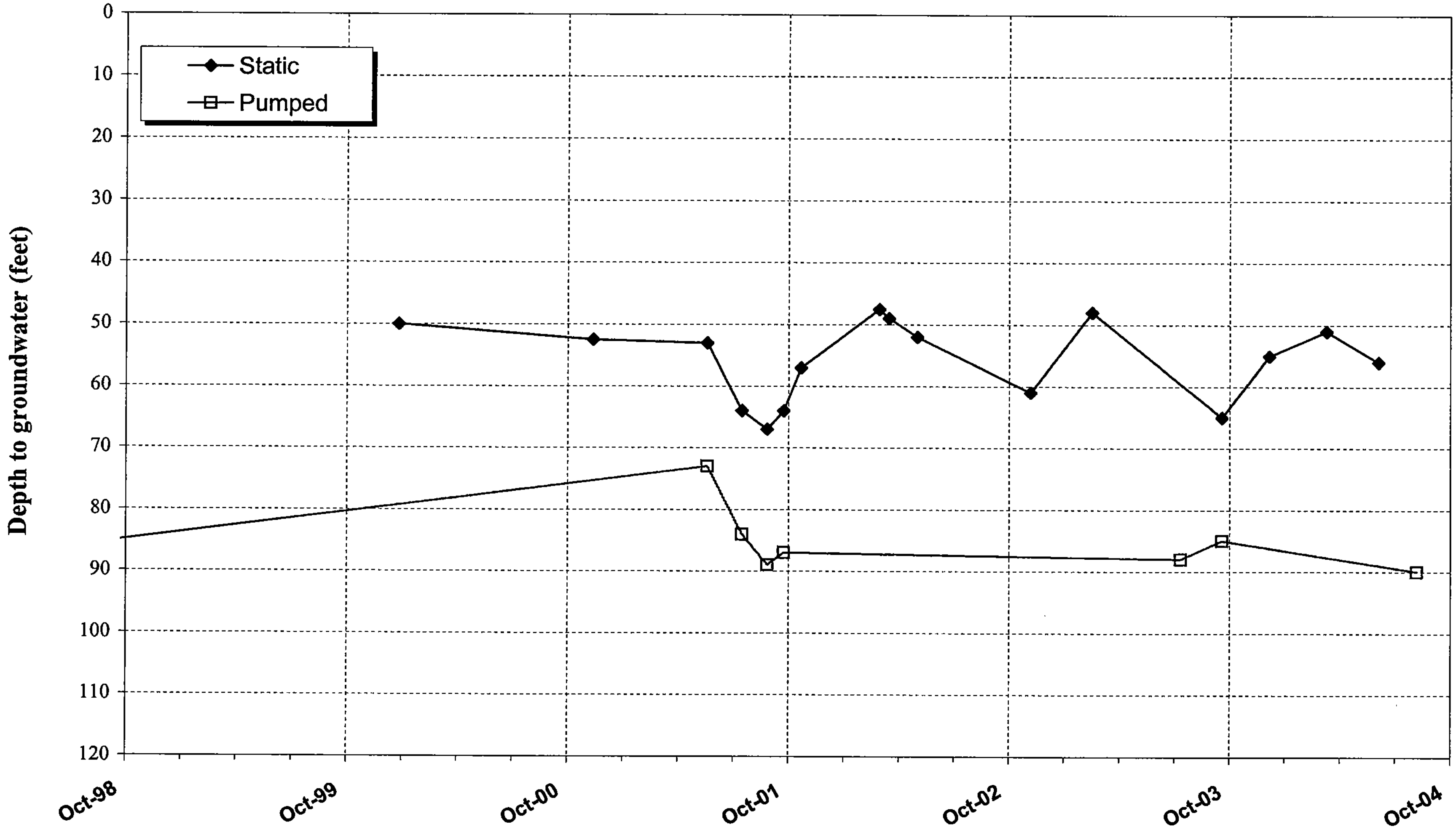


FIGURE 3-17:
Groundwater Hydrograph - Whitworth WD #2 Well No. 8-A2, 1997-2003

Golder Associates

WRIA 55 & 57 - Second Step Storage Assessment

013-1372001.4330 November 29, 2004

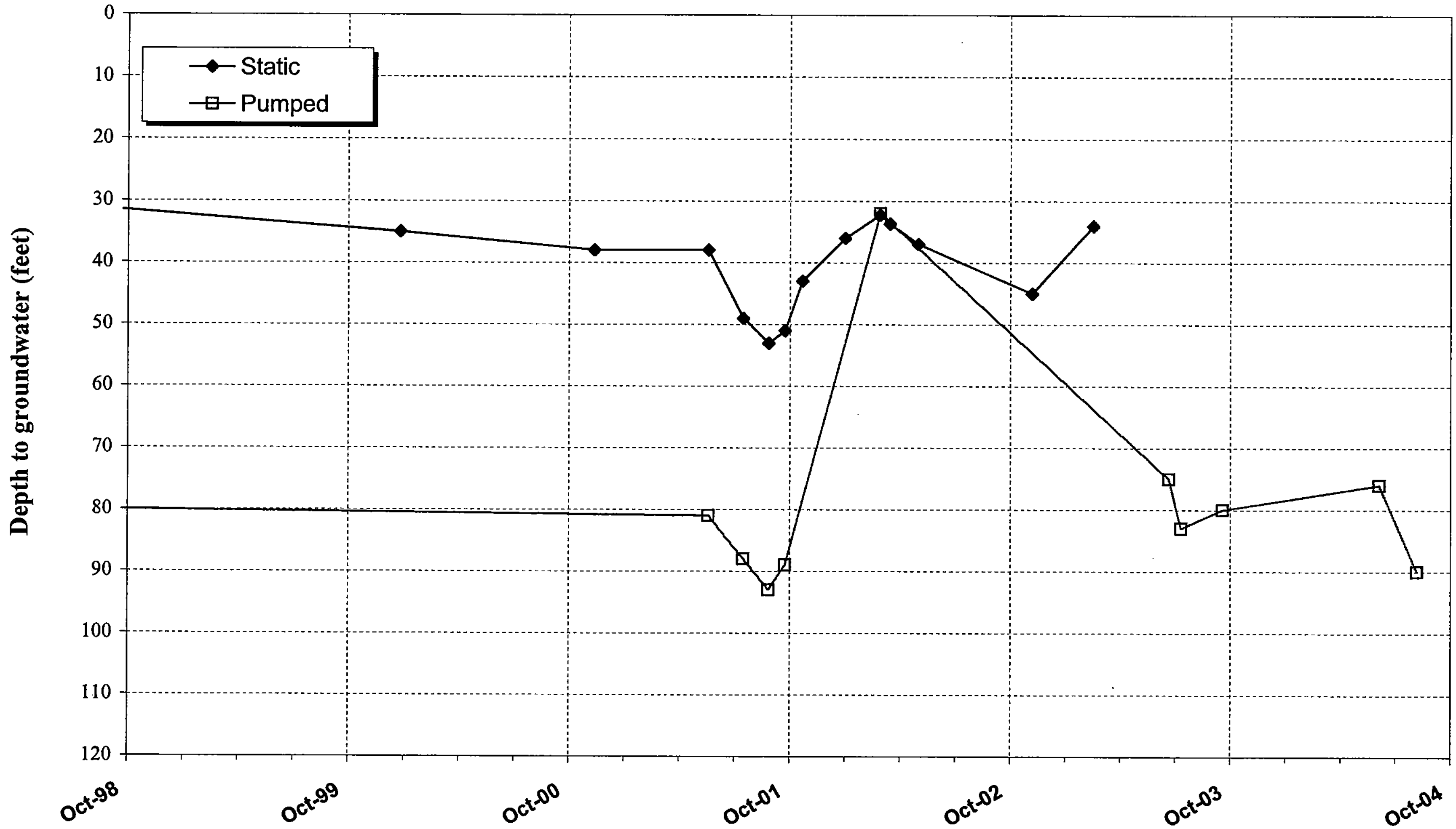
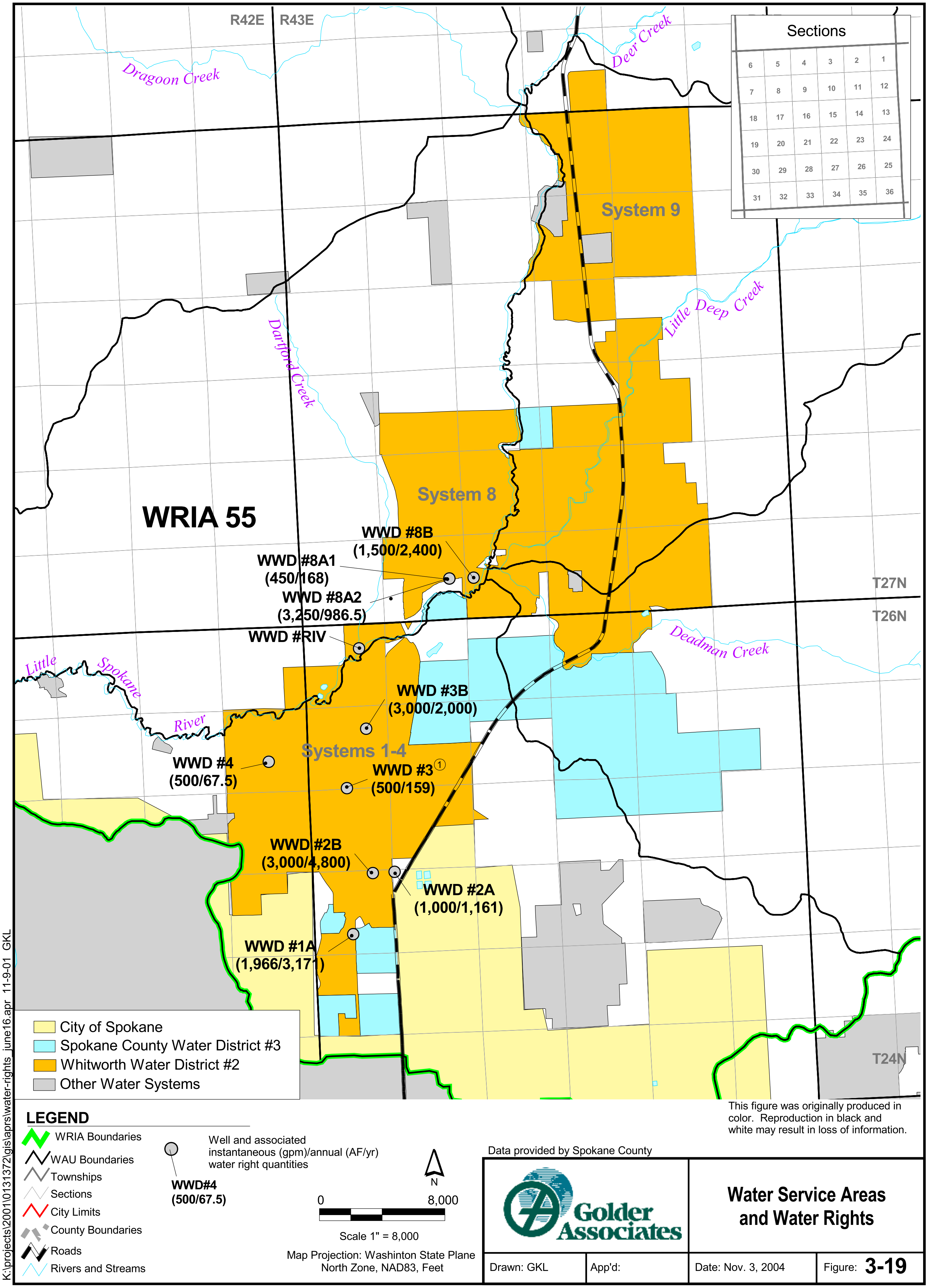


FIGURE 3-18:
Groundwater Hydrograph - Whitworth WD #2 Well No. 8B, 1997-2003

Golder Associates

WRIA 55 & 57 - Second Step Storage Assessment

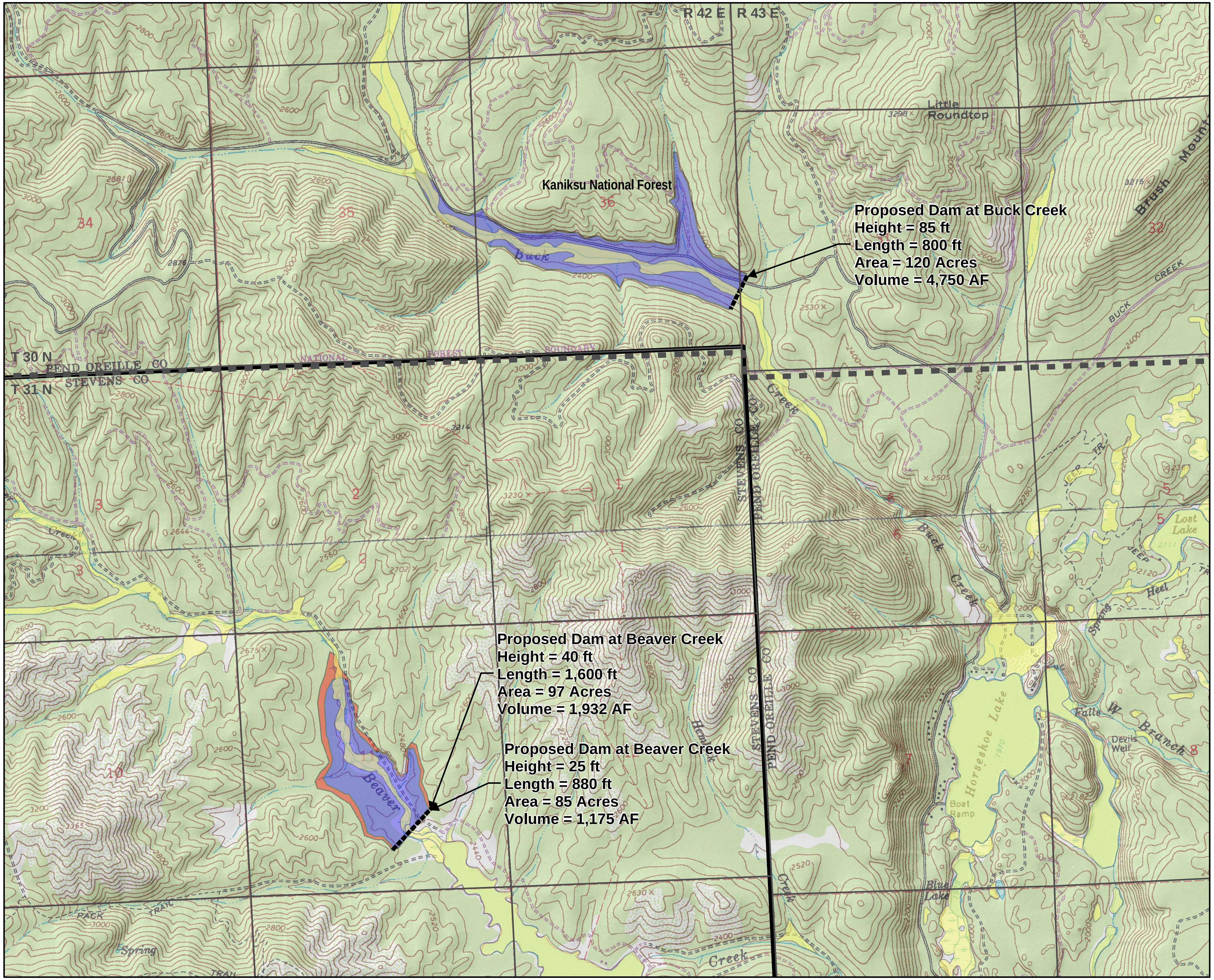
013-1372001.4330 Npvember 29, 2004



Water Service Areas and Water Rights

Figure: 3-19

K:\projects\2001\013-1372\gis\aprs\water-rights june16.apr 11-9-01 GKL



LEGEND

- Proposed Dam Location
- Kaniksu National Forest Boundary
- Township, Range, Section
- Wetlands
- Inundated area storing 50% of mean monthly flow from December to April
- Inundated area storing 100% of mean monthly flow from December to April
- County Line

N

0 2,000
Scale 1" = 2,000 feet

Map Projection: Washington State Plane, North Zone, NAD 83, Feet

Source: WAGDA, Golder Associates

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

Proposed Dam Locations

Spokane/WRIA 55 Storage Assess/WA

Drawn: BBA	Revision: 3	Date: Oct. 13, 2004	Figure: 4-1

01313720014320R0.mxd

Golder Associates

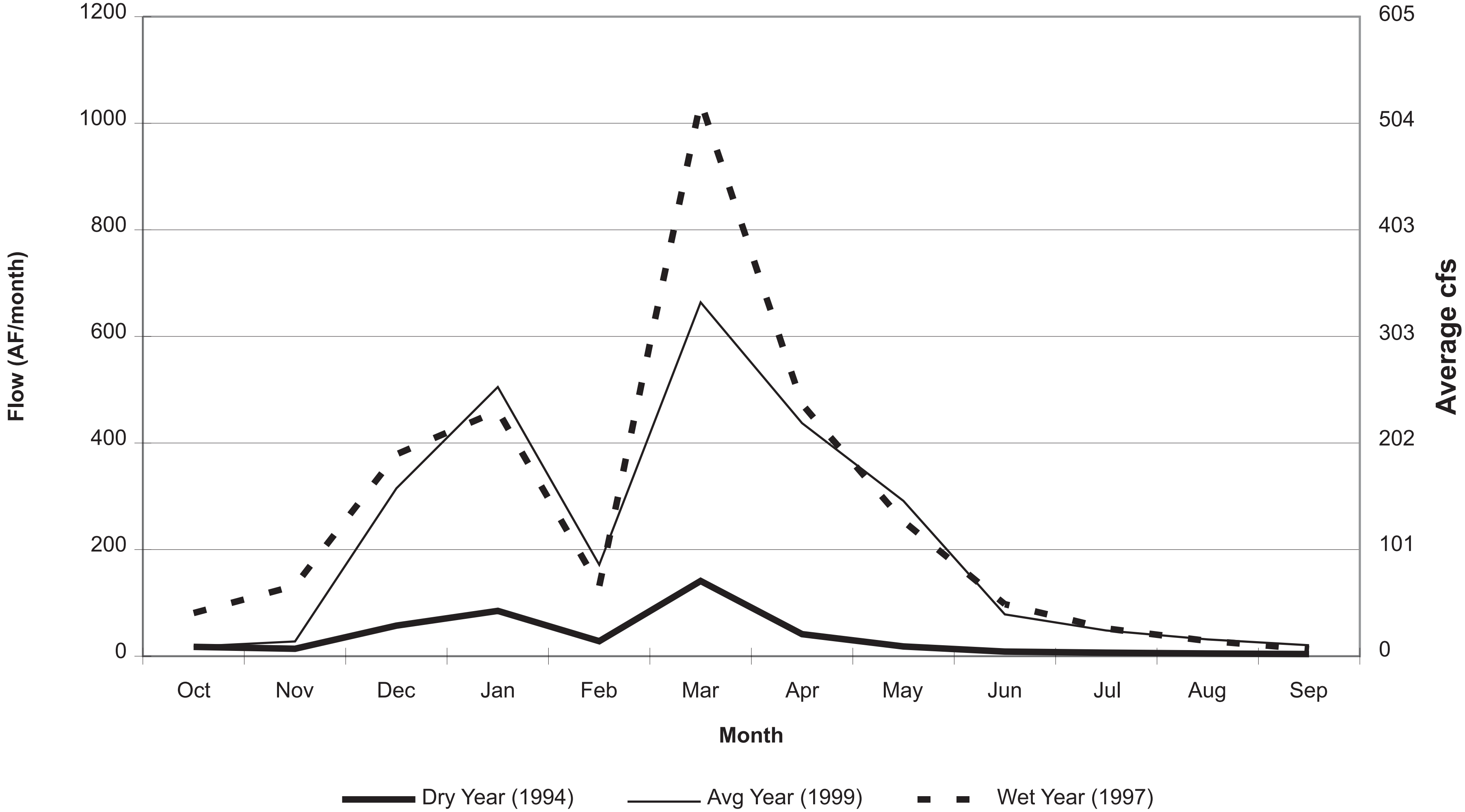


FIGURE **4-2**

SIMULATED BEAVER CREEK TOTAL MONTHLY STREAMFLOW NEAR THE PROPOSED DAM SITE

SPOKANE/WRIA 55 STORAGE ASSESSMENT/WA

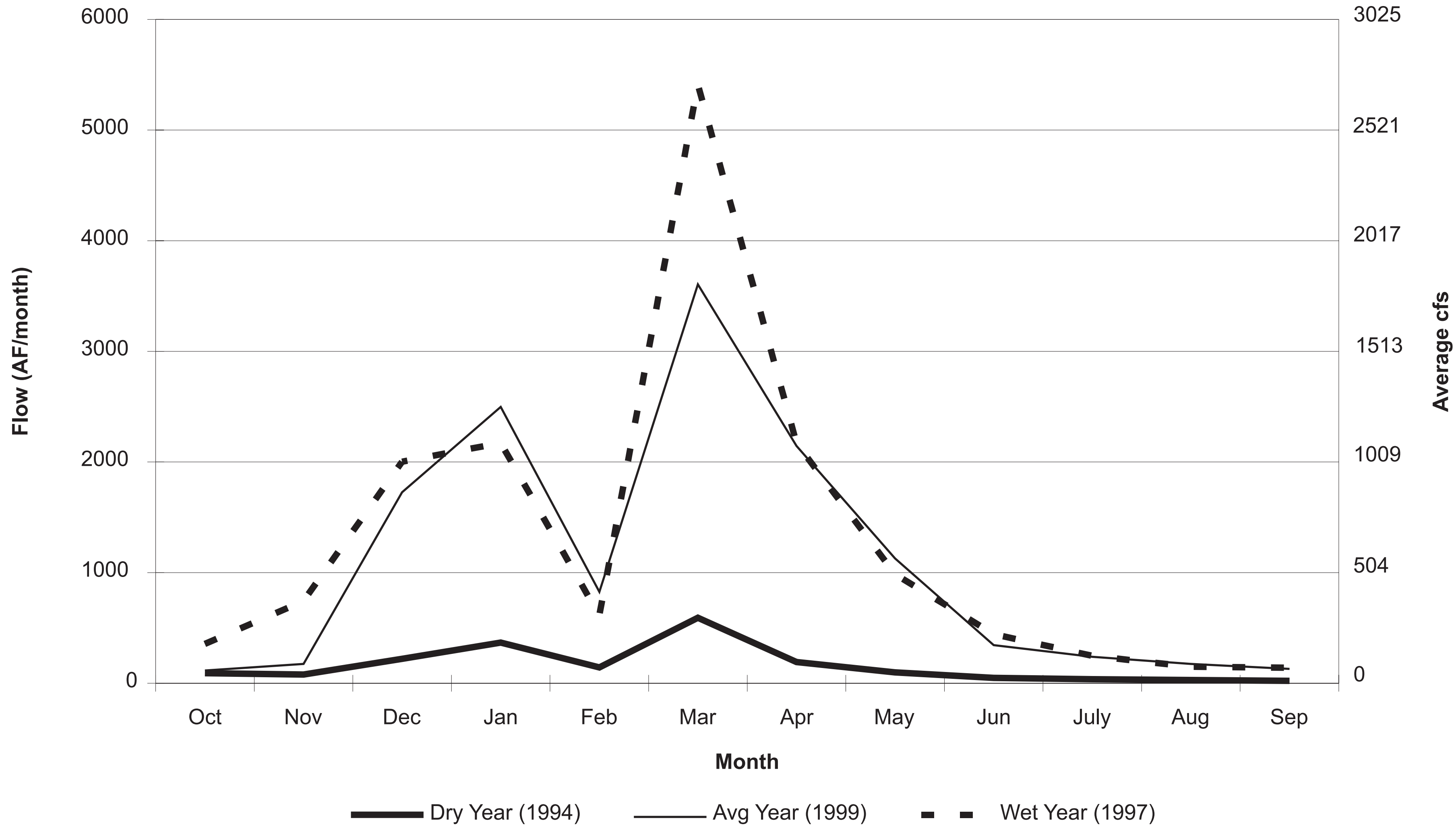
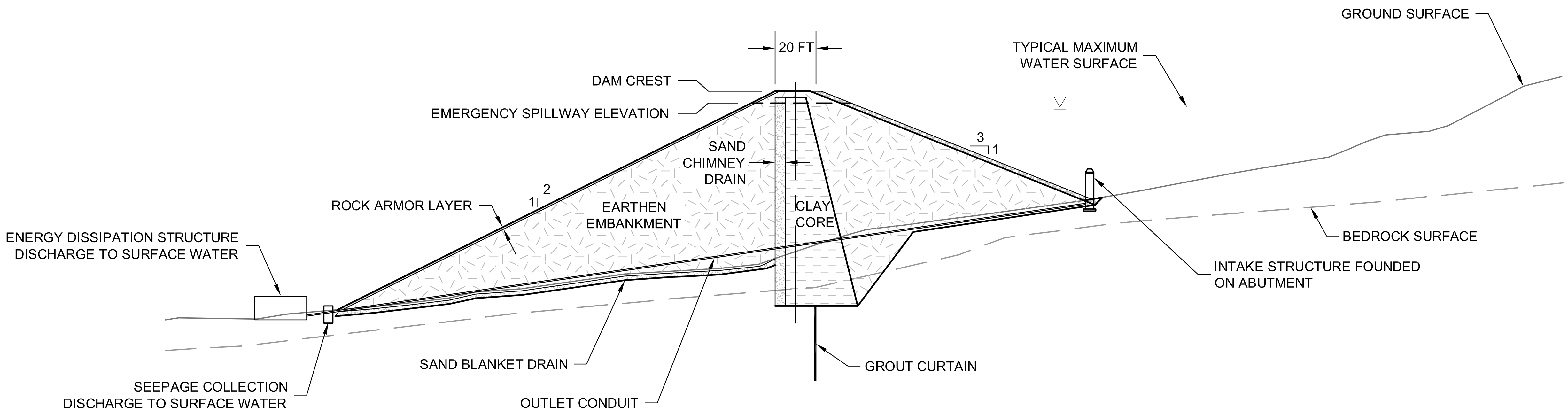


FIGURE **4-3**

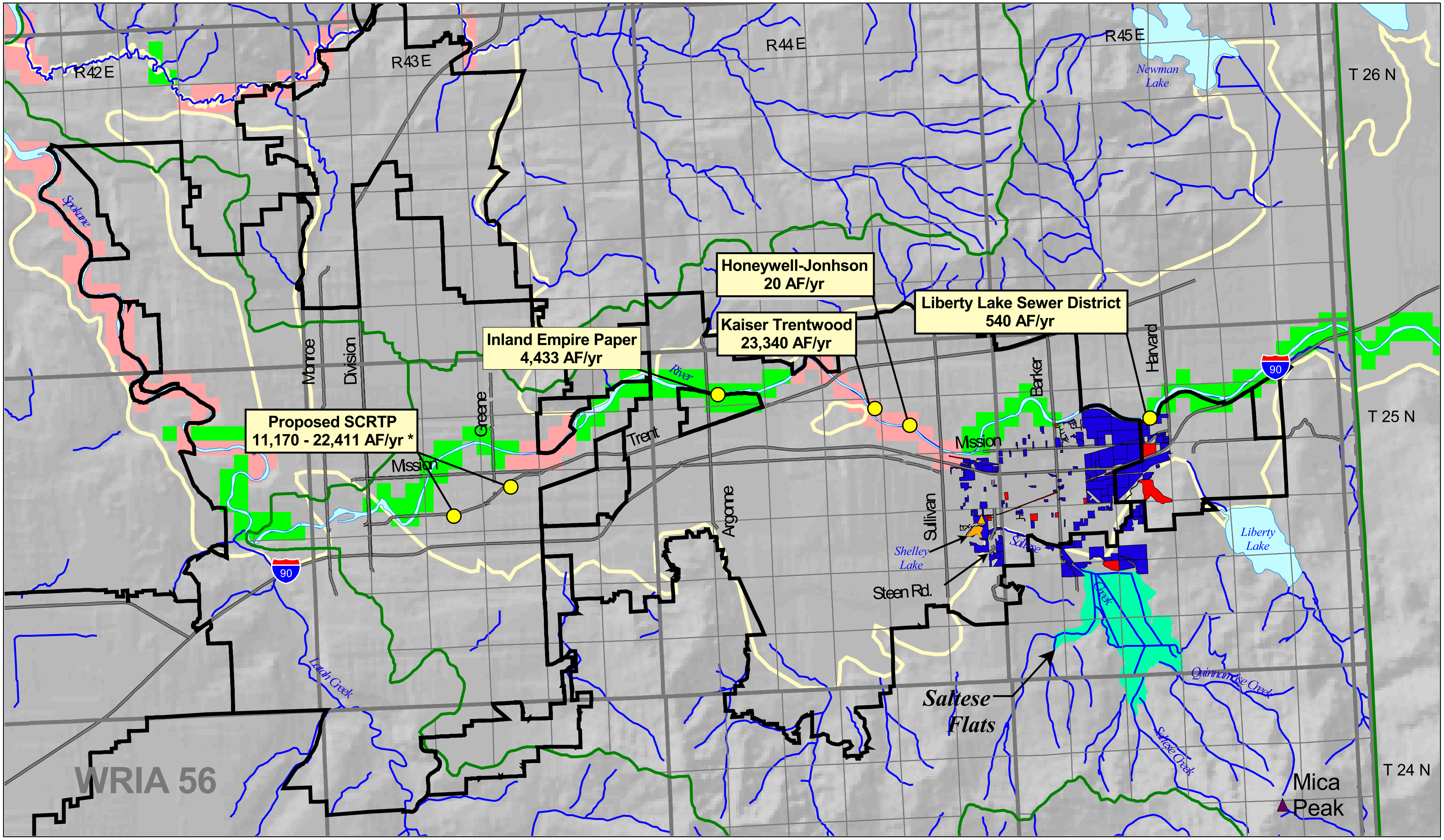
SIMULATED BUCK CREEK TOTAL MONTHLY STREAMFLOW NEAR THE PROPOSED DAM SITE

SPOKANE/WRIA 55 STORAGE ASSESSMENT/WA



A
-
CONCEPTUAL EARTHEN DAM CROSS-SECTION
NOT TO SCALE

FIGURE **4-4**
TYPICAL EARTHEN DAM CROSS-SECTION
SPOKANE/WRIA 55 STORAGE ASSESS/WA



LEGEND

- Current and Proposed Waste Water Discharge
- Rivers
- Streets
- WRIA Boundaries
- Lakes
- Urban Growth Boundary
- Approximate SVRP Aquifer Boundary
- Township
- Section
- Saltese Flats (NWI)
- Saltese Discharge Location
- Gravel Pit / Saltese Discharge Location

Modeled Groundwater - Surface Water Interaction

- Losing
- Gaining

Potential Discharge Parcels

- Public
- Private

0 2.5 Miles

Scale 1" = 2.5 Miles

Map Projection:
Washington State Plane, NAD83,
North Zone, Feet

Source: USGS, WSDOE,
DNR, Spokane County, National Wetlands Inventory
Golder Associates Inc.

* From Spokane County FPA 6/2004

N

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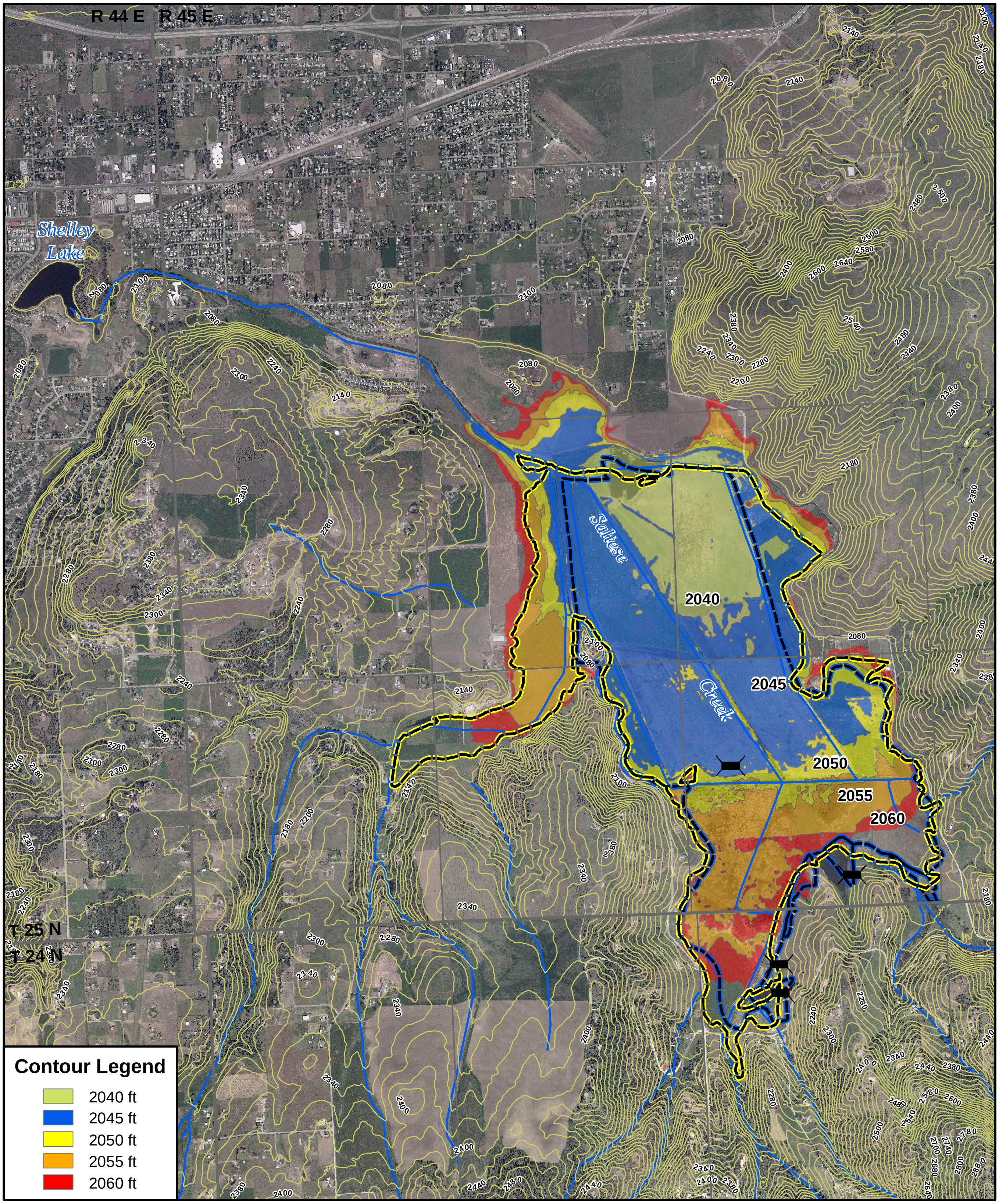
Saltese Flats Storage Overview

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: 5	Date: Dec. 20, 2004	Figure: 5 - 1

01313725100_092004.apr

Golder Associates



LEGEND

- Dam
- Contour (20 ft Interval)
- Watercourses
- Saltese Flats (NWI)
- Saltese Flats (Spokane County)

0 3,000

Scale 1" = 3,000 Feet

N

Map Projection:
Washington State Plane
North Zone, NAD 83, Feet

Source: Spokane County,
Golder Assocaites

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

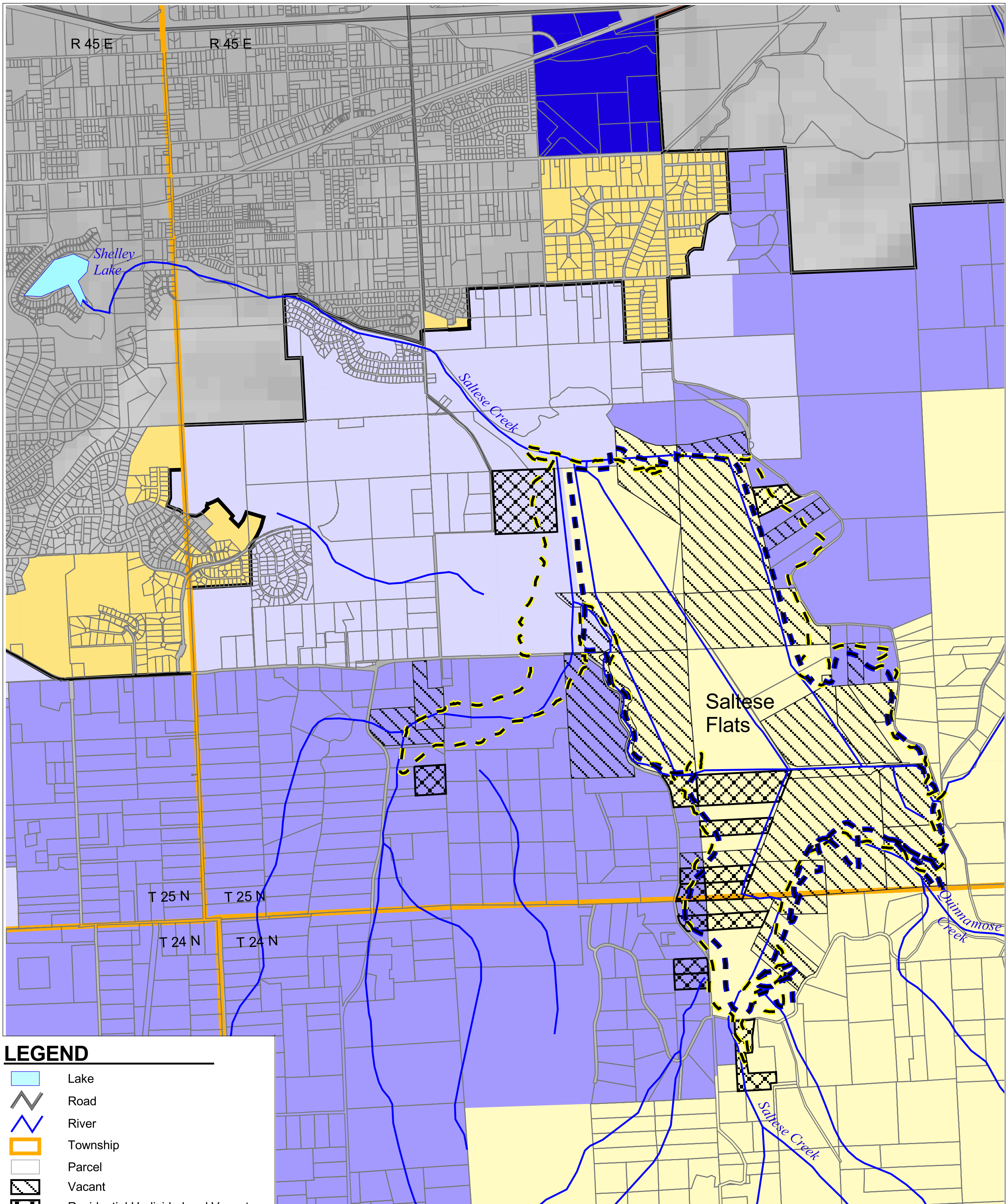
Topography

WRIA 55/Storage Assessment/WA

Drawn: BBA	Revision: 3	Date: Oct. 11, 2004	Figure: 5 - 2

01313725100F5R1.mxd

Golder Associates



This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Map Projection:
Washington State Plane, NAD83,
North Zone, Feet

Source: USGS, WSDOE,
DNR, Spokane County,
Golder Associates Inc.

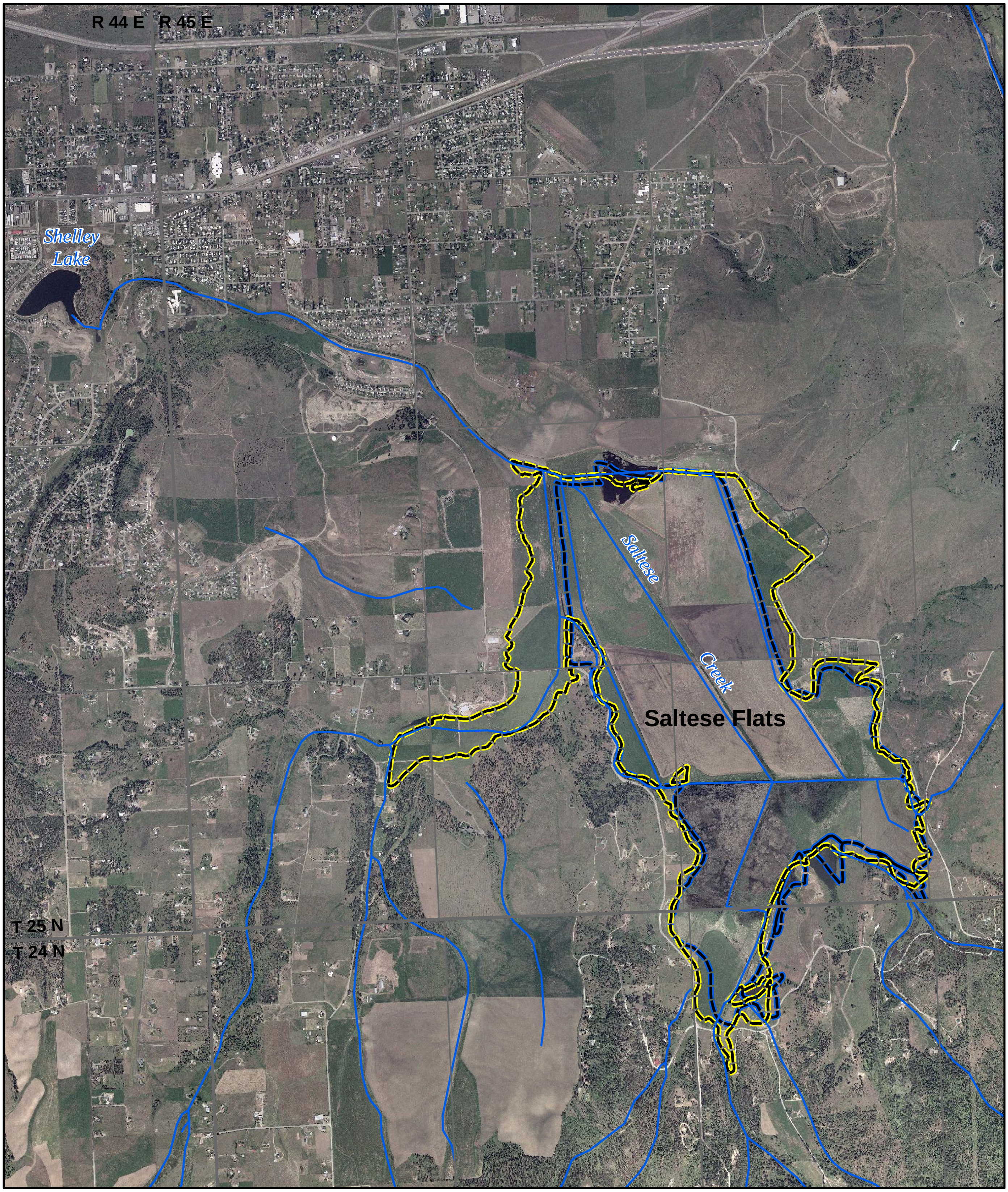
Spokane County Parcels and Zoning

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: 3	Date: Oct. 11, 2004	Figure: 5 - 3

01313725100_092004.apr

Golder Associates



LEGEND

- Watercourses
- Saltese Flats (NWI)
- Saltese Flats (Spokane County)

0 3,000

Scale 1" = 3,000 Feet

Map Projection: Washington State Plane, North Zone, NAD 83, Feet

Source: USGS, WSDOE, WSDOT

AVISTA ortho-photography, July 2003, 6 inch resolution

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Saltese Ortho-Photography (July, 2003)

WRIA 55 & 57/STORAGE ASSESSMENT/WA

Drawn: RMT	Revision: 1	Date: Oct. 11, 2004	Figure: 5 - 4

01313725100F7.mxd

Golder Associates

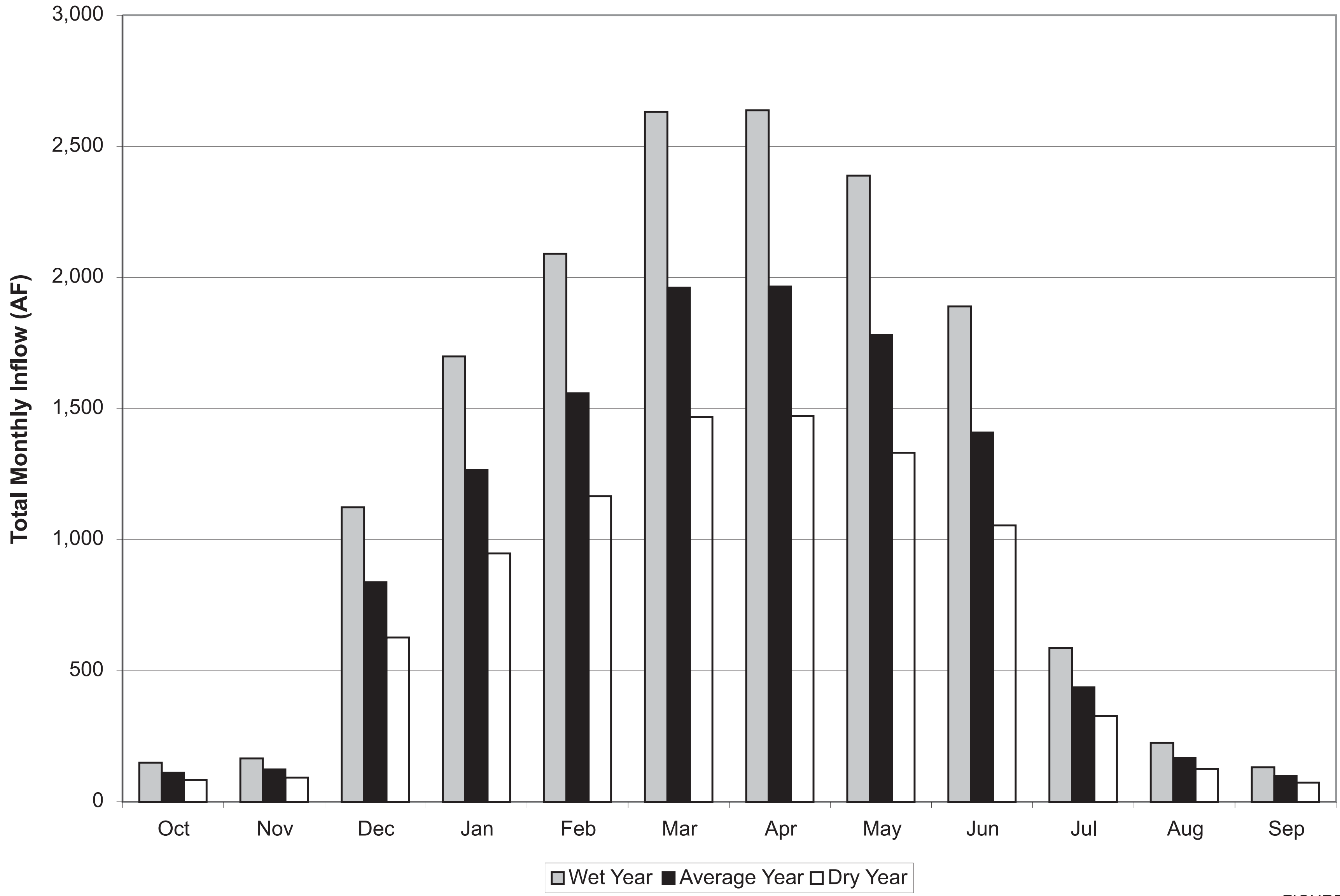


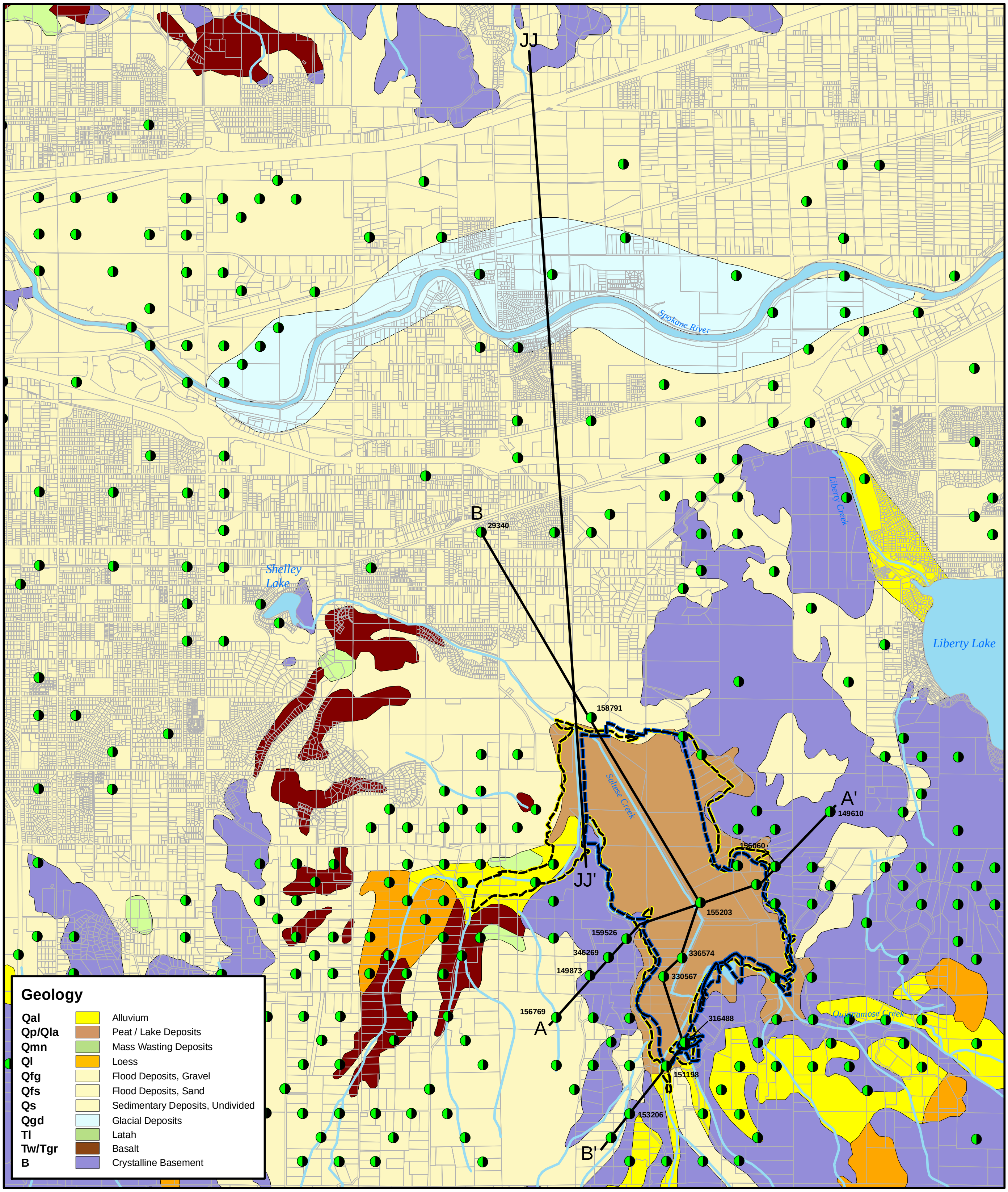
FIGURE **5-5**

PREDICTED TOTAL MONTHLY NATURAL INFLOW HYDROGRAPH

SPOKANE/WRIA 55 STORAGE ASSESSMENT/WA

DRAWING NO. 01313720015320fg01.fh11 DATE 12/14/04 DRAWN BY AMP

Golder Associates



LEGEND

- Wells
- Cross Sections
- Lake or River
- Saltese Flats (NWI)
- Saltese Flats (Spokane County)

0 4,000

Scale 1" = 4,000 Feet

Map Projection:
UTM Zone 11, NAD 27, Feet

Source: USGS, WSDOE, WSDOT
Spokane County, USGS

N

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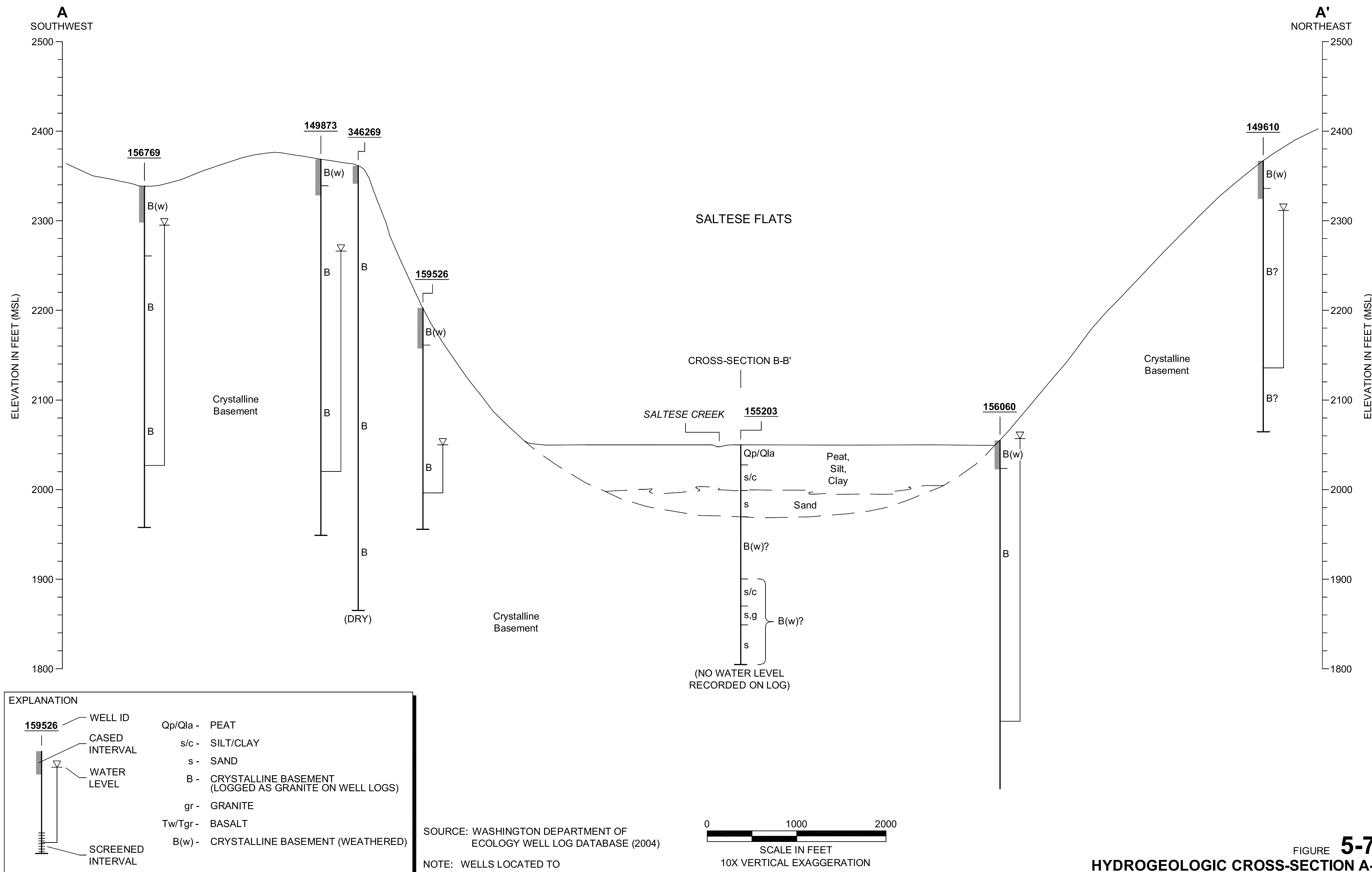
Saltese Flats Geology

Spokane/WRIA 57/Storage Assessment

Drawn: SJG	Revision: 1	Date: Oct 6, 2004	Figure: 5 - 6

01313725100F6.mxd

Golder Associates



SOURCE: WASHINGTON DEPARTMENT OF ECOLOGY WELL LOG DATABASE (2004)

NOTE: WELLS LOCATED TO NEAREST 1/4 - 1/4 SECTION.

FIGURE **5-7a**

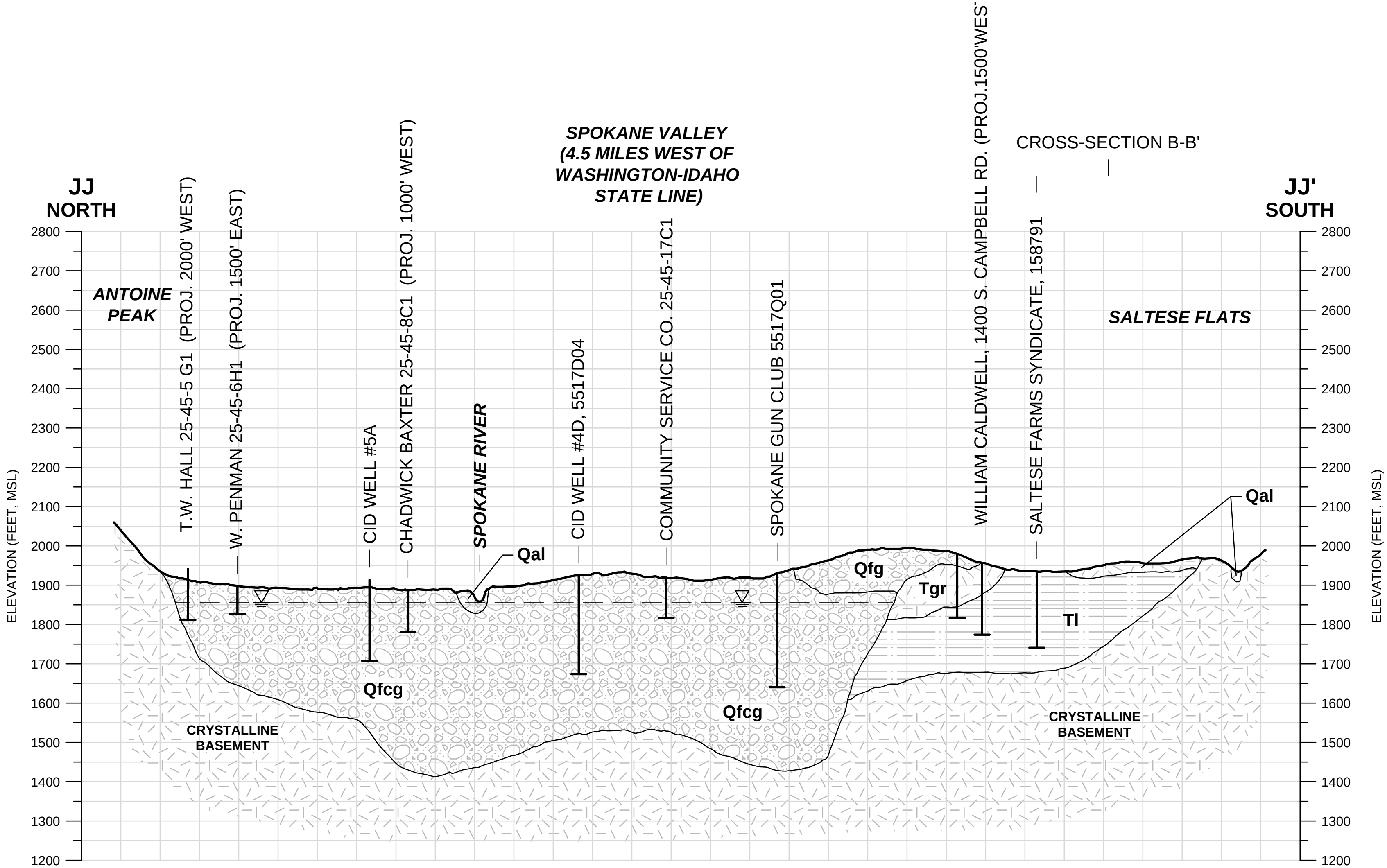
HYDROGEOLOGIC CROSS-SECTION A-A'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

FIGURE **5-7b**

HYDROGEOLOGIC CROSS-SECTION B-B'

SPOKANE/WRIA 55 STORAGE ASSESS/WA



SEE FIGURE 2 FOR LEGEND.

SPECIAL NOTE:
Data concerning the various strata have been obtained at exploration locations only. The interpretation between these locations has been inferred from geological evidence and so may vary from that shown.

DATA SOURCE: DNR 2000 DRAFT SECTION F-F' BASED ON WELL LOG DATA AND REGIONAL GEOLOGY.

0 4000 8000

FEET

10X VERTICAL EXAGGERATION

FIGURE **5-7c**

HYDROGEOLOGIC CROSS-SECTION JJ-JJ'

SPOKANE/WRIA 55 STORAGE ASSESS/WA

01313720015320F02.dwg | Layout: Layout1 | Modified: 11/02/2004, 13:47 | Plotted: 11/03/2004, 08:36

Golder Associates

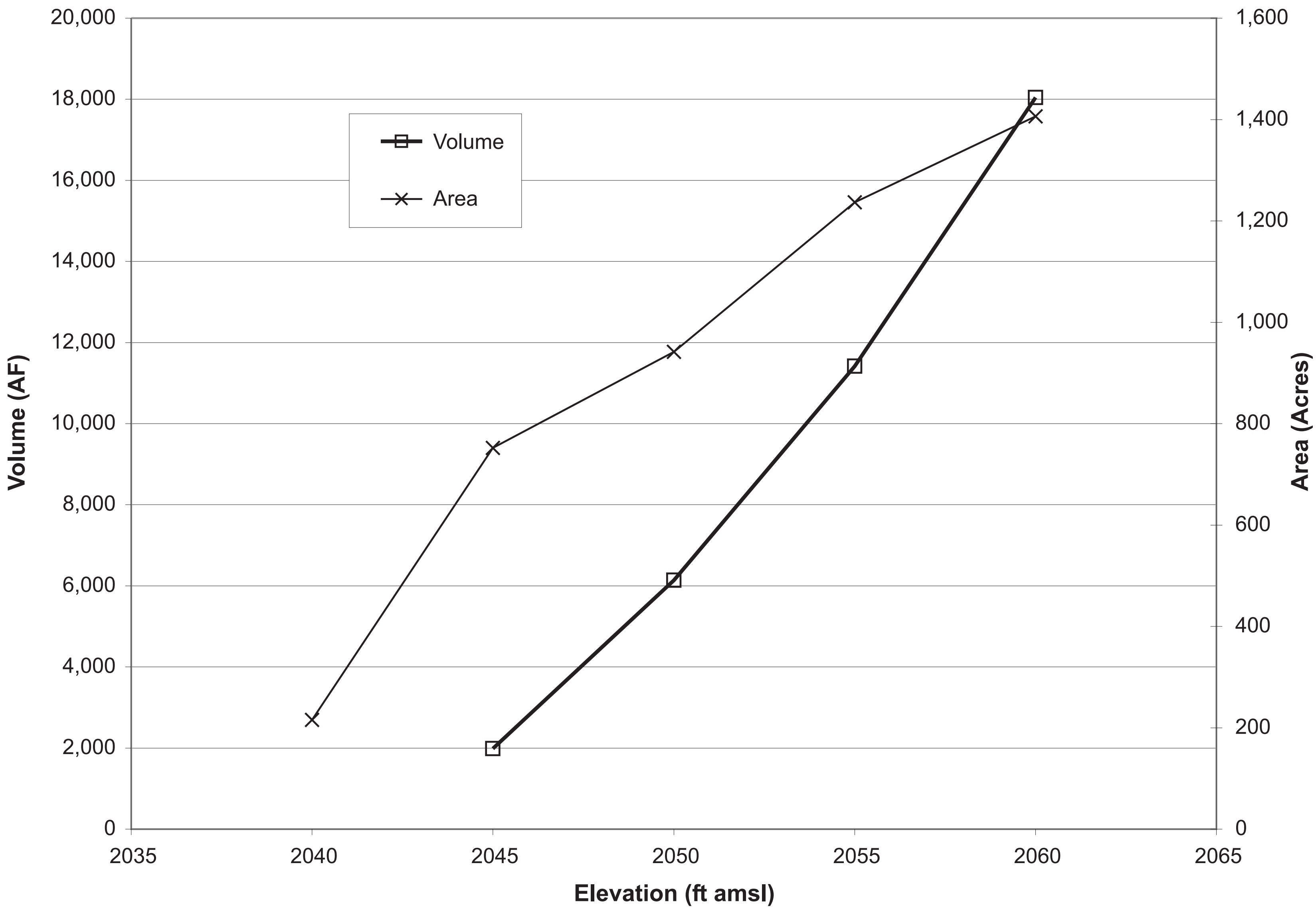


FIGURE **5-8**

VOLUME AND SURFACE AREA VERSUS ELEVATION

SPOKANE/WRIA 55 STORAGE ASSESSMENT/WA

DRAWING NO. 01313720015320fg02.fh11 DATE 12/20/04 DRAWN BY EFS

Golder Associates

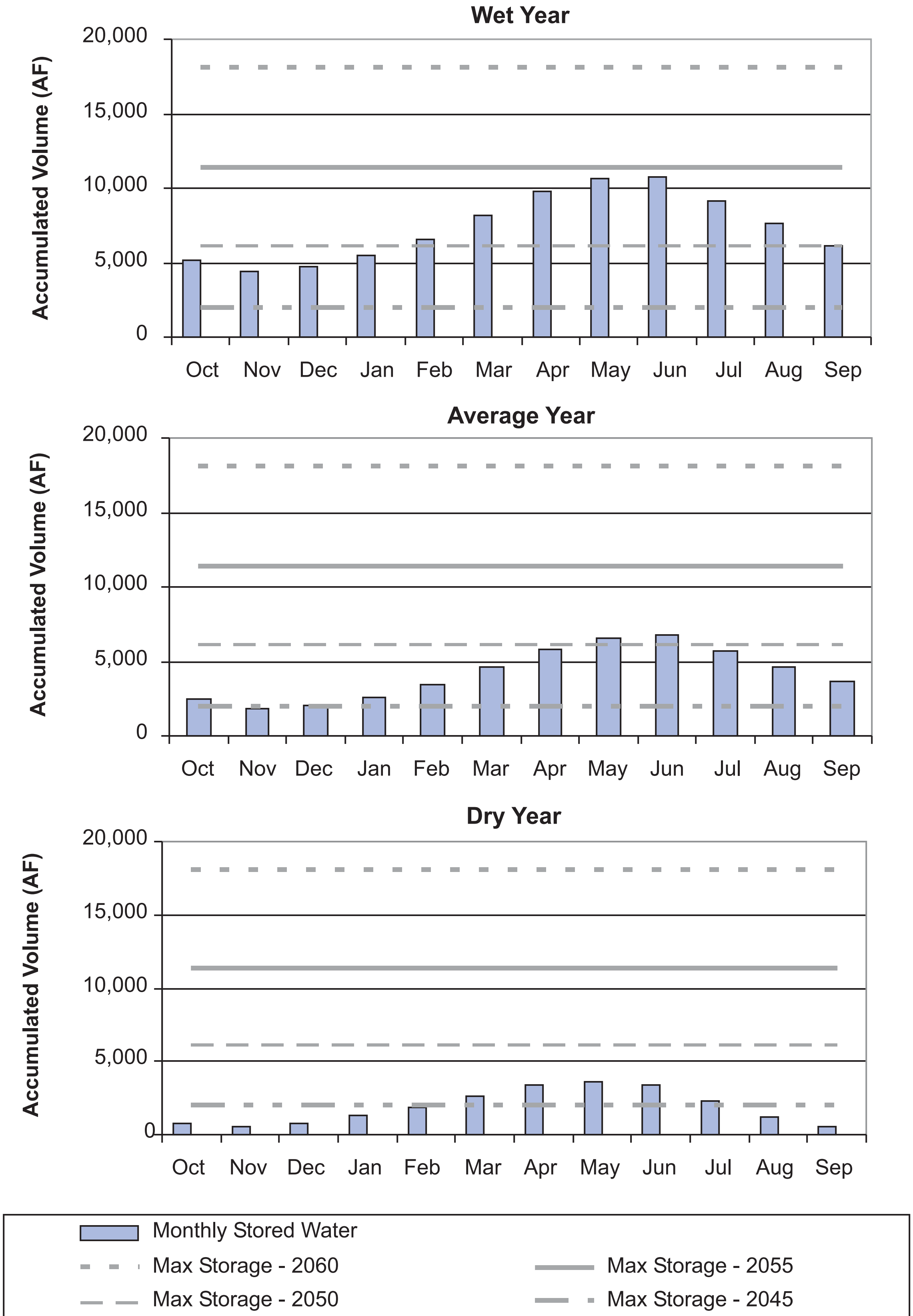


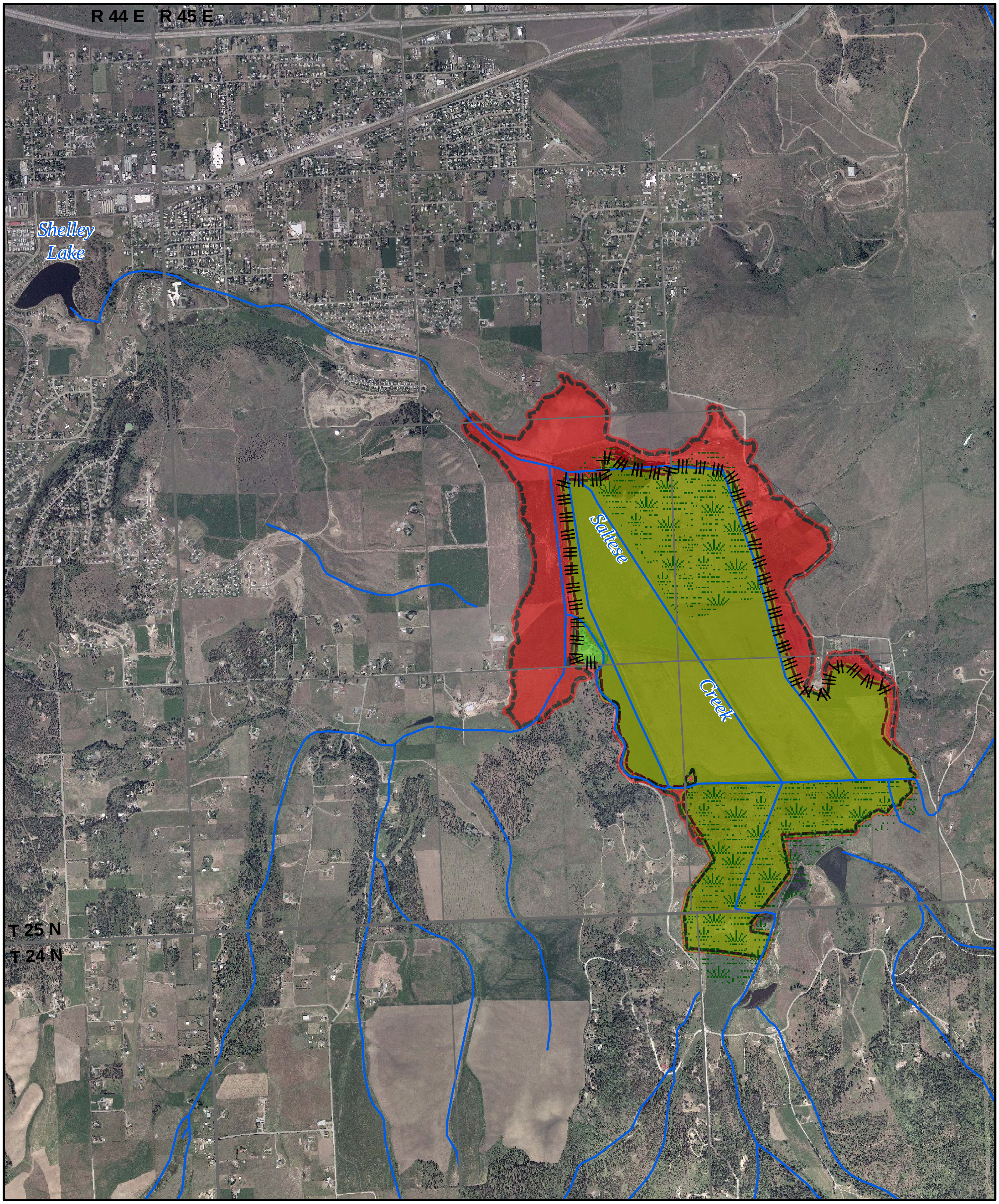
FIGURE **5-9**

MONTHLY STORAGE PROFILE - NATURAL INFLOWS

SPOKANE/WRIA 55 STORAGE ASSESSMENT/WA

DRAWING NO. 01313720015320fg03.fh11 DATE 11/08/04 DRAWN BY EFS

Golder Associates



LEGEND

- Watercourses
- Configuration 2 & Configuration 3
- Configuration 1
- Configuration 2 Embankment
- Existing Marshlands & Ponded Areas

N

0 3,000

Scale 1" = 3,000 Feet

Map Projection:
Washington State Plane
North Zone, NAD 83, Feet

Source: Spokane County,
Golder Assocaites

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Saltese Flats Configuration

WRIA 55/Storage Assessment/WA

Drawn: BBA	Revision: 1	Date: Oct. 12, 2004	Figure: 5 - 10

01313725100F8.mxd

Golder Associates

APPENDIX A

FIRST STEP STORAGE ASSESSMENT – REVISED OCTOBER, 2003

MIDDLE AND LITTLE SPOKANE BASIN (WRIA 55 AND 57)

FIRST STEP
STORAGE ASSESSMENT TECHNICAL MEMORANDUM

Submitted to:

Spokane County
and
WRIA 55 and 57 Planning Unit

Submitted by:

Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, Washington 98052

Distribution:

Copies 5 Spokane County, 2 CDs
Copies 3 Golder Associates Inc.

October 2004 013-1372-001

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1.0 INTRODUCTION AND PURPOSE

The purpose of the storage assessment is to determine the feasibility of storing water during periods of "excess" capacity, for use during periods of limited capacity to mitigate current or future impacts to streamflows, provide new water supply, and/or to improve habitat. This assessment considers the type of storage projects that would be useful in WRIA 55 (Little Spokane Watershed) and WRIA 57 (Middle Spokane Watershed), given the current and future water supply and demand. It includes:

- A general overview of types potential storage, including off-channel and on-channel storage, underground storage, enlargement or enhancement of existing storage;
- A discussion of issues associated with developing storage, including potential environmental effects;
- An inventory of existing storage facilities, available infrastructure, and storage volumes; and,
- An overview of potential storage projects in WRIA 55 and 57

Based on this overview, the Planning Unit will be able to select options and/or areas for more detailed assessment in the second part of the study, in which detailed storage assessments would be conducted.

By convention, storage projects are typically developed in volumetric units, acre feet (AF), or million gallons (MG). Units of AF are used in this report. One AF of water is equivalent to 0.33 MG of water and can sustain a flow of one cubic feet per second (cfs) for approximately half a day, or provide a supply of 0.6 gallons per minute for one year.

1.1 Objectives of the Storage Assessment

RCW 90.82.070 identifies the intended objectives of the storage assessment component of watershed planning:

> "The objective of these strategies is to supply water in sufficient quantities to satisfy the minimum instream flows for fish and to provide water for future out-of-stream uses … and to ensure that adequate water supplies are available for agriculture, energy production, and population and economic growth under the requirements of the state's growth management act, chapter 36.70A RCW. "

Based on the results of Watershed Planning work completed in WRIA 55 and 57 as well as conversations with Spokane County the following specific list of objectives was developed and presented to the Planning Unit in a Memo dated June 8, 2004. These objectives provided a more focused basis from which to evaluate locations, timing, amounts and types of storage as well as determine what types of storage can meet multiple objectives.

The objectives are presented below for each WRIA.

<u>WRIA 55:</u>

1. Offset potential impacts on streamflow from future water supply development under existing water rights.
2. Offset potential impacts on streamflow of future water allocations (new water rights).

3. Prevent the interruption of exercise of junior water right holders during dry years in WRIA 55.
4. Prevent poor quality groundwater from impacting water supply wells in the Deer Park area of WRIA 55.
5. Improve flow-based aquatic habitat (for example flows for passage, and redd coverage) where flow is a potentially limiting factor.
6. Improve flow related surface water quality problems.

<u>WRIA 57</u>

1. Offset potential impacts on streamflow from future water supply development under existing water rights.
2. Offset potential impacts on streamflow of future water allocations (new water rights).
3. Use reclaimed water for groundwater recharge in WRIA 57.
4. Improve aquatic habitat through increased flows (for example flows for passage, and redd coverage) where flow is a potentially limiting factor.
5. Improve flow related surface water quality problems.

Objective number five, regarding prevention of poor quality groundwater from impacting Deer Park water supply wells, was ultimately removed due to measured cessation of the problem in recent years.

1.2 Water Storage Task Force

The water storage task force was convened by Ecology in 2000 to examine the role of increasing water storage in water resources management. The report to the legislature provides valuable information on storage and was used as a reference throughout this study.

During the legislative session, the definition of a storage “reservoir” was expanded to include underground formations. This led to the development of permitting for Aquifer Storage and Recovery or “ASR” projects. A 2001 report to the legislature provides information on ASR.

1.3 Water Storage SEPA Elements Related to RCW 90.82

WDOE has addressed six potential water storage alternatives in its programmatic EIS for watershed planning, as described below.

Alternative WP 19: Construct and operate new on-channel storage facilities. Under this alternative, a water storage facility would be created by impounding a river or stream. On-channel storage facilities could include large reservoirs on the mainstem of major rivers as well as small reservoirs on tributary streams. Construction could involve creation of an earthen dam or a concrete dam.

Alternative WP 20: Raise and operate existing on-channel storage facilities. Under this alternative the capacity of an existing on-channel reservoir would be increased by raising or enlarging the impoundment structure.

Alternative WP 21: Construct and operate new off-channel storage facilities. Under this alternative, an impoundment structure, either earthen or concrete, would be created in an upland location. Water would be diverted or pumped from a river to an off-channel location for storage.

Alternative WP 22: Raise and operate existing off-channel storage facilities. Under this alternative the capacity of an existing off-channel reservoir would be increased by raising or enlarging the impoundment structure.

Alternative WP 23: Use existing storage facilities for additional beneficial uses. Operation of a storage facility constructed to provide water for one specific beneficial use or group of uses could be modified to provide water for additional beneficial uses. For example, use of a storage facility originally constructed for municipal water supply could be expanded to supply water for irrigation or to provide additional flows for fish during critical life stages.

Alternative WP 24: Construct and operate artificial recharge/aquifer storage. Aquifer storage and recovery involves introducing water, usually surface water from rivers, into an aquifer through injection wells or through surface spreading and infiltration. The introduced water is stored in the aquifer until needed and then withdrawn from the aquifer through wells for beneficial use. Water to be stored in an aquifer must meet the state's ground water quality standards, Chapter 173-200 WAC.

The programmatic EIS is intended to provide support to development of a watershed plan. Additional SEPA compliance may be needed for the implementation of specific recommendations and individual projects. Such compliance might be satisfied by a SEPA checklist for small projects, although larger projects may require a project EIS. Upon selection by the Planning Unit of options for more detailed evaluation in the second step of this project, requirements for SEPA compliance will be assessed including the applicability of the programmatic EIS, the likelihood of whether a SEPA checklist will be sufficient, and/or whether a project EIS may be required.

2.0 SURFACE WATER STORAGE ALTERNATIVES

This section provides an overview of types of surface water storage alternatives including on-channel and off-channel reservoirs small impoundments and wetlands.

2.1 Reservoirs and Impoundments

There are two types of reservoirs: on-channel and off-channel reservoirs. On-channel reservoirs are situated on the main stem of a river or stream and are filled by the flow from an upstream watershed. Off-channel reservoirs are located completely off a perennial stream channel and are filled by overland flow or pumped from a nearby source.

There are benefits and drawbacks to each reservoir type. Benefits of an on-channel reservoir may include flood control and a plentiful source of water. Drawbacks potentially include being a barrier to fish passage, population and infrastructure relocation, and requirement of large spillways and outlet works, and sediment infilling. Benefits of an off-channel reservoir may include being located in a non-environmentally sensitive area, existing aquatic habitat is not affected, and necessity of smaller spillways and outlet works. Drawbacks may include the need to construct infrastructure to convey water to and from the reservoir, higher construction, operations and maintenance costs, and reservoir leakage/seepage is often a larger problem (Ecology, 2001).

For any reservoir to be successful, it must be located at a site that allows for construction of a safe dam, has a catchment or conveyance infrastructure large enough to reliably refill the reservoir, and provides enough water to be beneficial. Choosing a site can be difficult.

The state Dam Safety Office can exempt dams with less than 10 AF of storage and less than six feet of dam height from more rigorous permitting requirements. The impoundment must be filled with water that is obtained under an existing, valid water right. Development and use of the water from the impoundment does not require a water right holder to change, transfer or amend any existing water right (RCW 90.03.380).

2.2 Wetlands as Storage

Natural and constructed wetlands can provide short-term surface water storage, long-term surface water storage, and maintenance of high water tables. The short-term surface water storage function may include reduced and delayed flood peaks and erosion potential from peak flows, and increased ground water recharge. The long-term surface water storage functions maintain and moderate stream flows helping to maintain fish habitat during dry periods. Trees, root mats, and other wetland vegetation also slow the speed of flood waters and distribute them more slowly over the floodplain, reducing erosion.

Wetlands are generally thought of as small storage solutions but a series of wetlands can store a significant amount of water. The storage capacity of a wetland is determined by the geology, subsurface soil, groundwater levels, topography and vegetation. In general watersheds with wetlands tend to store and distribute streamflow over longer periods resulting in lower levels of peak streamflow and reduced probability of flooding. A relatively low ratio of wetlands acreage to watershed (less than 10 percent) appears sufficient to moderate a watershed's annual hydrograph (Ogawa & Male, 1983; Novitski, 1985; Demissie and Khan, 1993), but also adequate for nutrient removal and sediment detention (Sather, 1992).

A second general conclusion suggests that downstream flood attenuation improves as the wetland area increases within the watershed. Gosselink et al. (1981) determined that the forested riparian wetlands adjacent to the Mississippi during presettlement times had the capacity to store about 60 days of river discharge. With the removal of wetlands through channelization, leveeing and draining, the remaining wetlands have a storage capacity of less than 12 days of discharge, an 80 percent loss of flood storage capacity.

Wetlands can also provide water quality, habitat and food web support. After being slowed by a wetland, sediments can settle out and nutrients that are dissolved in the water are often absorbed by plant roots and microorganisms in the soil.

2.3 Small Impoundments

Small impoundments in natural depressions, oxbows, or small surface ponds can be implemented on a basin-wide basis to meet individual demands. Storage options such as this must be implemented on a basin-wide basis in order to provide the greatest benefit. One manner in which to implement this option is in basins where individual water users, such as agricultural irrigators, use a significant amount of water and their needs can be met partially or in whole by small surface water impoundments. This can reduce water requirements during the agricultural season when water is most scarce. Another implementation used in urban areas is small impoundments or water towers that are used to meet peaking requirements of a water system.

2.4 Overview of Regulatory, Technical and Economic Requirements

Typical technical study needs for a surface water reservoir include:

- Geotechnical Site Investigation: Includes geotechnical test pits or subsurface borings evaluating geology within the impoundment area and around the outlet structure area of the reservoir. Determination of subsurface conditions for foundation of dike structures, subsurface seepage issues (i.e., within the impoundment area and at specific locations), evaluation of requirement of cut-off walls, etc.;
- Site Survey and Land Use Analysis: Options include either land survey or aerial survey of lake perimeter and dam structure area of development of engineering grade topographic data. Data is used for evaluation of land impacts due to increased water surface elevations, and design of dam structure;
- Hydrological Study: Includes assessment of inflow/outflow regime, flood flow, operational rule curves, and carry-over storage;
- Engineering Design of the Dam: Includes all aspects of analysis/evaluation of dam and corresponding wing dikes for raising water levels, as well as subsurface cut-off wall requirements addressing subsurface seepage;
- Securing of Water Rights: To be secured prior to dam design permit application, and may be greatly facilitated if diversions are restricted to high flow periods;
- Permitting of Dam Structure and reservoir: Highly variable but usually involves multiple state and federal permits – may be facilitated if less than 10 AF storage and less than six-foot high; and,
- Construction or Modification of Dam: Geotechnical and design phase will determine final construction requirements.

2.4.1 Treatment and Conveyance Requirements

Surface water storage for direct potable supply requires a full treatment plant to meet safe drinking water standards and is not considered further here because the purpose is assumed to be for environmental benefits and mitigation of impacts caused by existing and/or future water uses. Storage for agricultural supply or streamflow mitigation does not typically require comparable water quality requirements.

Storage facilities may require conveyance infrastructure to supply water to the reservoir and/or conveyance to the area where it's needed. For example a flow of 40 mgd with a peaking capacity of 60 mgd would typically require 42-inch diameter pipelines to convey flow.

2.4.2 Permitting/Legal Constraints

Construction of new surface water storage or expansion of existing facilities would likely involve multiple federal and state agency approvals and can require a lengthy budget, study, and authorization process. The Judy Reservoir expansion, which increased the reservoir from 1,700 AF to 4,500 AF, took 11 months to permit (Ecology, 2001) and cost over $1.3 million (includes planning, permitting, design and legal fees). Potential permits and approvals that may be required include:

- Environmental Review under SEPA or NEPA (State/National Environmental Policy Act; WDOE);
- Joint Aquatic Resource Permits Application (JARPA) which includes Hydraulic Project Approval (WDFW), 401 Water Quality Certification (Ecology), Coastal Zone Management Certification (Ecology or federal permitting agency), US Army Corps of Engineers 404 Permits, U.S. Army Corps of Engineers Section 10 Individual Permit and Shoreline Substantial Development Permit (Local Government)
- Washington Department of Fish and Wildlife mitigation;
- Forest Practices Permit (DNR);
- Water Quality Modification (WDOE);
- Water Rights/Reservoir Permit (WDOE);
- Dam Safety Construction Permit (WDOE);
- County Construction and Land Use permits; and,
- Other local permits.

Dams or reservoirs have a long history of both real and perceived negative environmental impacts. (Ecology, 2001). New dams or expansion of existing dam facilities will introduce additional political complexities with the general public, affected purveyors and local governments, creating both opportunities and challenges. Dams and reservoirs require an extensive public outreach effort, and need to be developed in an open and cooperative environment. Land use and the inherent environmental impacts of constructing a dam can often overwhelm the technical feasibility or benefit of a new or expanded reservoir. However, dams and reservoirs have a proven history in the water supply field, and could play an important role in storing water for both human and ecological needs.

2.4.3 Economics

Comparative cost data for new dam and reservoir projects was assembled for the Water Storage Task Force in 2001. Storage projects ranging from 80 to 800,000 AF were evaluated. Costs reported for dam enlargements ranged from $200/AF for a 500 AF small dam raise in the Methow Basin, to $5,300/AF for the 1,700 AF Judy Reservoir enlargement. Costs for new reservoirs in Washington State ranged from $1,695/AF for the Zintel Canyon Dam to $13,280/AF for the Rosa Wasteway 6 Re-regulation Reservoir. New dams tend to cost more than raising existing dams. As a comparison, free market values for water rights can provide some perspective of the total cost. Water rights have been exchanged for rates of between $600 and $3,000 per AF/yr.

Costs for major conveyance systems vary, and additional engineering analysis is needed to prepare more detailed cost estimates. For example, prices for HDPE (High Density Polyethylene) pipe range from $13 to $67 per linear foot for a 24 to 60 inch pipe and installation costs range from $16 to $76 per linear foot depending on installation environment (Hancor Eastern Washington Rep). Costs for pumps can be well over $100,000 if pumping needs to occur over significant elevation. For example a pump to convey 18,000 gpm, 30 feet in elevation is $100,000 (Beckwith and Kuffel pump representative).

3.0 STORAGE IN WRIA 55/57

This section presents specific information on storage needs in WRIA 55 and WRIA 57, the availability of water in those basins for storage, and finally identifies specific surface water storage options within the watersheds.

3.1 Storage Needs

Quantification of the amount, timing and location of storage needs is necessary to evaluate the relative benefit of specific storage options. At this time the WRIA 55 and 57 planning unit have not specified a single storage need, but have identified through the planning process, several potential purposes for which stored water could be used beneficially. This section summarizes these purposes in terms of storage.

Prevent the interruption of exercise of junior water rights during dry years in WRIA 55

Water rights issued subsequent to the adoption of an instream flow rule (junior water rights) are interruptible during low flow conditions in order to retain water in the river. In the Little Spokane River, during July 1 through September 15, such regulation is triggered when flows at Dartford fall below 115 cfs. In the past junior water rights holder have received a notice of interruption in ten of the past 24 years: 1980, 1981, 1986, 1987, 1989, 1994, 1995, 2001, 2002, and 2003. This is approximately twice as often as might be anticipated given that minimum instream flow regulations were based on flows that were historically met four out of five years.

The total number and quantity allocated to water rights junior to instream flow is shown in Table 2-1. Quantities are grouped by the first compliance point (compliance points are specified in WAC 173-555) that they affect. Figure 2-1 displays the location of the compliance points.

An estimate of the storage volume necessary to prevent junior water right interruption was developed by assuming the instantaneous flow rate for each water right is used continuously and for fully consumptive purposes for two and three months of the low flow period (the low flow period is three months from July 15 to Sep 15). This assumption results in a total storage need of approximately 1,047 and 1,562 AF on the Little Spokane River over the 2 and 3 month period respectively.

Storage for the purpose of mitigating the exercise of junior water rights should be located upstream of the points of exercise of the water rights. The higher in the drainage the delivery point(s) is located, the greater the length of river benefit. Measurement of flows for MISF compliance currently occurs on the Little Spokane River at Dartford, therefore mitigation of impacts on streamflow, at a minimum, must be realized at this point under current enforcement practices.

Offset potential impacts from future water supply development under existing water rights

The impact of water supply development, under existing water rights, was evaluated as part of the Phase 2 Watershed Assessment in two forms: 20-year growth projections and full use of municipal and domestic water rights. Total annual projected water use developed for these two scenarios is shown in Figure 2-2.

The evaluation of impacts of these water use scenarios was carried out using the Mike SHE model of WRIA 55 and 57 as part of the Phase 2 Watershed Assessment. The model predicts changes in streamflow and groundwater levels due to changes in withdrawals and land use over the run (1994 – 1999). Model-predicted streamflow changes were converted to a total volume assuming supplemental storage was used for either a 2 month (August and September) or 4 month (July through October) period. The period was selected based on the general timing of low flows in the watershed. Table 2-2 displays the volume necessary to offset predicted future water use impacts. On the Spokane River between 6,620 and 51,290 AF are necessary to offset future uses, while on the Little Spokane River between 1,721 and 4,751 AF are necessary.

The point of delivery of stored water can be selected to mitigate flows at existing instream flow monitoring points and provide the most benefit of other flow objectives (such as water quality and aquatic habitat). A delivery point higher in the watershed would provide the greatest stream reach of benefit.

Offset potential impacts of future allocations

This objective, to offset potential impacts of future allocations, is closely related to the previous objective. It varies only in that it assumes the storage would be applied to mitigation of impacts caused by allocation of new water rights rather than existing. Or it could be construed to mean that a storage option would be developed specifically in order to gain new rights, such as a storage reservoir used for direct water supply. The volume of future water right allocations is an unknown and unpredictable quantity. Currently portions of WRIA 55 streams are closed to future consumptive appropriations during the summer months (Ch. 173-555 WAC). WRIA 57 is not considered a closed basin. Therefore there is some potential for new water rights to be approved beyond what is currently understood. While the volume of future water right allocations is unknown, current applications for new water rights in WRIA 55 provide some context and are shown in Table 2-3.

Improve flow-based aquatic habitat (for example flows for fish passage) where flow is a potentially limiting factor

Flow based aquatic habitat was evaluated as part of the Little Spokane River Instream Flow Assessment (Golder, 2003). Part of the assessment process involved identifying critical habitat reaches of interest for indicator species (rainbow trout and maintain white fish; Figure 2-1) and include portions of

- Dragoon Creek,
- Little Deep Creek,
- Deer Creek,
- Bear Creek,
- Otter Creek,
- Little Spokane River, and,
- West Branch Little Spokane River.

Reaches of the Little Spokane, River, Deadman, Dragoon and Otter Creek were included as part of the instream flow assessment, and have recommendations for flows which will provide sufficient spawning and rearing habitat area. However, continuous historical gaging records are not available from which to determine the frequency with which these flows are met. Therefore there is no predetermined quantity associated with this option only the recognition that storage options located in basins serving these creeks could supplement flows for aquatic habitat due to either current or future needs, and/or mitigating current and/or future streamflow impacts.

WRIA 57 also contains aquatic habitat that may benefit from increased flows. An instream flow assessment has occurred as part of the Avista Relicensing of Spokane River Hydroelectric Project and will provide insight into discharge levels which provide sufficient flows for spawning in the free-flowing reach above Upriver Dam and downstream of the Monroe Street hydroelectric facility. Results of this report are likely to influence the amount of flow required to be released into the Spokane River from Lake Coeur d'Alene during the controlled period (June – September) under Avista's FERC license.

Improve flow related surface water quality problems

Surface water quality problems exist in several lake and stream reaches of WRIA 55 and 57. Draft State Water Quality Assessment results, summarized in Table 2-4, provide an indication of where these problems exist. Affected reaches are shown by category, where category 5 indicates "303(d)" listings for 2002/2004, category 4 indicates reaches which have or are working on TMDL's or pollution control plans and category 2 indicates reaches that are not listed but are considered of "concern".

The Total Maximum Daily Load (TMDL) development process results in creation of a clean-up plan for parameters of concern. Currently TMDLs have been developed for dissolved metals (cadmium, lead, and zinc), and are being developed for PCBs, total dissolved gas, phosphorus, and biochemical oxygen demand on the Spokane River. Additionally, a use attainability analysis is being completed for the Spokane River and a draft Use Attainability Analysis report is available (CH2MHill, 2004). A TMDL has been approved for chlorine, ammonia-N and total phosphorus on Dragoon Creek.

Therefore while many water quality concerns are being addressed under other processes specifically developed for that purpose it is possible that supplementing streamflow with stored water of suitable quality during low flow periods can, potentially, improve water quality conditions that are exacerbated by low flows. Determination of the amount and delivery point of stored water necessary specifically for water quality purposes must completed on a case by case basis. The success of improving water quality is dependant on the quality and quantity of the stored water released into the stream.

Use reclaimed water for groundwater recharge in WRIA 57

Spokane County is finalizing details for a new regional waste water treatment plant, the Spokane County Regional Treatment Plant (SCRTP). Currently plans for the SCRTP include an outfall location in the Spokane River, but there is interest in reclaiming this water for increased benefit to streamflow augmentation.

The location of the wastewater treatment plant has not yet been finalized, but the two locations being evaluted are in the vicinity of Greene and Mission Street. The planned amount of water availble from this source is projected to be from 10 mgd (~ 15 cfs) to 20 mgd (~ 30 cfs) to meet future capacity needs to the year 2050 (HDR, 2004).

Recharge of surface water to improve groundwater quality in the Deer Park area of WRIA 55

Historical groundwater monitoring in the Deer Park aquifer showed elevated levels of nitrates in both the shallow and deep basalt aquifers. This has been shown to no longer be an issue and was removed from further consideration as an objective.

3.2 Availability of "Excess" Surface Water for Storage

A preliminary estimate of the amount of water available for storage can be determined by defining the amount of flow over the instream flow requirement as "excess" flow which could be withdrawn from the river for storage and beneficial use.

The flow records for the Little Spokane River and the Spokane River were analyzed for the range in volume of "excess" water. This was done by subtracting the minimum instream flow requirement (MISF) from the 10%, 50% and 90% 7-day average exceedance flow at each station. If the exceedance flow was less than the instream flow requirement, then no excess water was available. Differences were then averaged over the month for an average daily volume of "excess" water per month. Exceedance flows represent the probability of a certain flow occurring at a certain location. For example a 90% exceedance flow of 100 cfs on the Little Spokane River at Dartford in August indicates that, historically, nine out of ten times August flow is equal to or greater than 100 cfs.

3.2.1 Spokane River

The Spokane River is the primary surface water body in WRIA 57. Instream flows have not, at this time, been set for the Middle Spokane River Basin. However, the Washington Department of Fish and Wildlife suggested a minimum flow target of 2,000 cfs in 1999 at USGS gage station 12422500, Spokane River at Spokane, based on the minimum streamflow recorded at the Spokane gage prior to the construction of the Post Falls Dam. This value may be affected by Federal Energy Regulatory Committee (FERC) relicensing that is currently occurring for Avista's Spokane River Hydroelectric Project.

Average daily volumes of water in excess of suggested minimum flow targets of 2,000 cfs for the Spokane River at Spokane (12422500) are shown in Figure 3-1. In general there is a large amount of water available during the spring melt, even in dry years. The greatest-volume of water is available between April and June and ranges from approximately 3,800 AF/day (June, 90% curve) in dryer periods, to more than 50,000 AF/day in wet periods (May, 10% curve). Comparison of daily average flow with the 50% exceedance flow indicate the largest volumes, over 20,000 AF/day, are likely to be available in April, May or June, about 10,000 AF/day is likely to be available in March, and over 6,000 AF/day in February.

3.2.2 Little Spokane River

Minimum Instream Flows (MISF) have been established for four points on the Little Spokane River system including the Little Spokane River at Elk, the Little Spokane River at Chattaroy, the Little Spokane River at Dartford, and the Little Spokane River near Dartford (WAC 173-555). The Little Spokane River is primarily gaining throughout its length with the largest gaining reach occurring between the "at" Dartford and "near" Dartford gages due to spring discharge from the SVRP through the Hillyard Trough.

3.2.2.1 Little Spokane River near Dartford, WA

Average daily volumes of water in excess of instream flows for the Little Spokane River near Dartford (12431500) are shown in Figure 3-2. The greatest volumes of water are available between March and May and range from approximately 80 AF/day (March, 90% curve) in dryer periods to more than 1,900 AF/day in wet periods (April, 10% curve).

3.2.2.2 Little Spokane River at Dartford, WA

Average daily volumes of water in excess of instream flows for the Little Spokane River at Dartford (12431000) are shown in Figure 3-3. The greatest volumes of water are available between March and May and range from approximately 8 AF/day (April, 90% curve) in dryer periods to more than 1,800 AF/day in wet periods (April, 10% curve).

3.2.2.3 Little Spokane River at Chattaroy, WA

Average daily volumes of water in excess of instream flows for the Little Spokane River at Chattaroy are shown in Figure 3-4. The greatest volumes of water are available in February through March and range from having no excess water in March (90% exceedance flow) in dryer periods to more than 790 AF/day in wet periods (March, 10% curve).

3.2.2.4 Little Spokane River at Elk, WA

Daily volumes of water for the Little Spokane River at Elk (12427000) are shown in Figure 3-5. The greatest volumes of water are available between March and May and range from approximately 5 AF/day (March, 90% curve) in dryer periods to more than 130 AF/day in wet periods (April, 90% curve).

3.3 Potential Surface Water Storage Alternatives

This section describes the initial assessment completed to develop a list of potential surface storage opportunities WRIA's 55 and 57. The order of assessment started with existing man-made and natural storage before considering new storage, this is due to the fact that the level of effort (in terms of cost, permitting and technical feasibility) generally increases from the former to the latter. In addition public perception of a dam raise may be significantly more positive than that of a new dam.

Many entities were contacted in an attempt to gather more information on the lakes and dams under consideration including Spokane County, the Washington Department of Ecology's Dam Safety Office, the City of Deer Park, Spokane County Conservation District and the Newman Lake Flood Control Zone District. Often an address was recorded for a dam but no contact information could be located in local phone books. USGS 7.5' topographic quads were used to evaluate spatial information at each location. Topographic quads referenced in this section are dated from the 1970s to the 1990s and had contour intervals of either 20 or 40 feet.

The following initial screening criteria were used to eliminate alternatives from further consideration:

- The location is used for some type of wastewater treatment;

- Dam or lake is unable to be located on a topographic map or through sources described above;
- Dam or lake is located such that additional storage would likely be restricted (e.g. Wandermere Lake Dam is located in a golf course);
- A significant number of buildings and docks exist along the lake shore. Almost all natural lakes of a significant size had varying densities of houses along the shore;
- Development is owned and operated by Avista Utilities. Avista owns, from upstream to downstream on the Spokane River, Post Falls, Upper Falls, Monroe Street and Nine Mile hydroelectric dam (HED), of which Upper Falls and Monroe Street are in WRIA 57. The Spokane River HEDs are operated in a coordinated fashion as run-of–river facilities and do not currently have significant storage available. Lake Coeur d'Alene, the source of the Spokane River in Idaho, is the primary storage reservoir with over 225,000 AF of useable storage (Avista IIP, 2003). Avista is in the process of seeking a new operating license for the Spokane River HEDs, the current license expires on July 31, 2007. Results of this relicensing may have some impact on Spokane River flow. Because of the coincident FERC relicensing process, discussion of storage in Avista operated dams is not considered as part of this storage assessment; and,
- Studies to increase storage in the reservoir have already been unsuccessful. The City of Spokane's Upriver Dam is operated as a run-of-river dam in a coordinated manner with other Avista operated dams on the river. Topography in the Spokane River reach upstream of the dam indicates there may be room for additional storage. The City of Spokane had applied to FERC for a 0.5 ft increase in reservoir water surface elevation and was denied due to habitat concerns (pers. comm. Lloyd Brewer, 2004). Therefore it is assumed that modification of this dam for storage purposes is not an option.

Following initial screening, the remaining dams and lakes were assessed using the following parameters, topography, potential size, location of roads and railroads, geology, and potential continuity with local aquifer.

In order to provide a uniform method of comparison three storage parameters were calculated for new or increased dam heights of 20 and 40 foot, these include.

- Additional storage capacity for dam heights of 20 and 40 feet (where this elevation was feasible);
- Dam crest length for each depth; and,
- The ratio of dam crest length to storage volume. This ratio provides a sense of the relative costs of storage. A longer dam would generally require more material and associated higher cost, assuming the upstream and downstream slopes are the same.

At this stage in the storage assessment a specific amount of storage has not been identified for which stored water will be used. Identified storage needs, as discussed in Section 2, range from 1,600 to 4,700 AF in WRIA 55 and 19,000 to 51,000 AF in WRIA 57. Therefore, in WRIA 55 new or expanded dams that supplied less than 1,000 AF were not considered. In WRIA 57 it is unlikely that a surface facility could be located to store the minimum amount of water calculated, additionally groundwater is the largest form of storage in the basin so the minimum of 1,000 AF for surface storage was also used.

For reference, 1,000 AF, if used in a day, is equivalent to approximately 500 cfs of flow over that day. For example, if 1000 AF of storage was used over 60 days it could provide 8.4 cfs of continuous flow.

3.3.1 Existing Dams

A summary of existing dams in WRIA 55 and 57 is provided in Table 3-1. This table provides basic information including the stream channel on which the dam is located, whether it is off-channel, owner and owner type (if applicable), the type of dam, dam purpose, date built, crest length, height, max storage, normal storage, surface area, drainage area, downstream hazard, and regulating authority are provided. The crest length is defined as the distance along the top of the dam. Dam height is measured from the lowest point of the original stream channel to the lowest point of the crest of the dam. The maximum storage is the space in the reservoir at the crest level. The normal storage is the space in the reservoir at the normal retention level (elevation where the water level in the reservoir is normally kept) including unusable and dead storage, and the surface area is measured at normal storage water surface elevation. The drainage area is the area above the dam that contributes runoff to the volume of water in the dam. The downstream hazard is a term used to describe the potential hazard to structures downstream of the dam in the event of a dam failure. The locations of existing dams are shown on Figure 3-6.

The initial screening of dams resulted in the removal of all but Ponderosa Lake Dam and Newman Lake Dam from additional assessment. Newman Lake Dam would have been removed due to buildings and docks along the lake and anticipated public resistance, but this lake was specifically identified in the scoping of this work as a potential alternative due to its location, size and existing infrastructure. The reason behind removal of each dam is indicated in the reason removed column of Table 3-1.

3.3.1.1 Baker (Ponderosa) Lake Dam

Baker Lake Dam is located in Stevens County on Beaver Creek a tributary of the West Branch Little Spokane River. Estimated storage for this lake ranged from 2,090 to 6,630 AF for a 20 and 40 foot dam respectively and the dam crest length to storage capacity ratio is the lowest of all the options, which is favorable. The dam and surrounding land is privately owned and is used for recreation. Only one structure exists at an elevation of more than 20 feet above the reservoir elevation. The geology in this location indicates the lake may be underlain by alluvium near the inlet of the lake but underlain by basement near the outlet and it appears to be surrounded by crystalline basement and therefore may be a good location for additional water storage. Flow data for Beaver Creek is not available so it is not clear whether additional storage in the reservoir could be naturally filled or whether it would require conveyance from nearby rivers. The West Branch Little Spokane River and Horseshoe Lake are approximately 1.5 miles away and could provide additional water for storage if pumped.

3.3.1.2 Newman Lake Dam

Newman Lake is fed by Thompson Creek originating at the base of Mount Spokane. The lake is primarily used for recreation and is managed by the Newman Lake Flood Control Zone District. The district provided Golder with information on the dam. Normal operation is to hold the water surface at 2,123 feet until mid March or early April (when the ice has come off the lake and after watershed snowmelt has peaked). Then the water level is gradually increased to the maximum storage goal elevation of 2,125.6 feet by May 31. After that time, the water level is allowed to drop (primarily due to evaporation and groundwater losses) until October 1 when the lake level is drawn down to

2,123 feet. If needed, spring releases are made to reduce flooding. The dam is designed to provide 2 feet of freeboard over the 100-year lake elevation of 2,127’. The 1.6 mile long dam is made of native peat soils, except near the outlet structure and is prone to settling. The dam spillway directs water into a man-made channel ultimately discharging to a 40 acre sump (of which 7 acres is maintained gravel bed) almost 4 miles south of the lake near Trent Road where the water infiltrates. Maximum infiltration in the sump area is recorded at 425 cfs. Several homes and docks are located along the shores of Newman Lake, and when the water elevation is over 2125.6’ residents report flooding problems.

Newman Lake Flood Control Dam has the largest normal storage of all dams in WRIA 57 with an additional 35,040 AF of storage with a 20 foot dam and 81,120 AF of storage with a 40 ft. dam. It should be noted that this additional storage assumes the existing dam can be raised, this may not be an option due to the materials (native peat) used in the existing dam and would likely require excavation and construction of a new dam. The lake would have been removed from further consideration in this study due to the density of housing along the shore, but its location and existing infrastructure made it a candidate for additional analysis.

Operational changes to the existing dam could be used for groundwater recharge/Spokane River flow augmentation. For example, normal storage and surface area are defined as 8700 AF (includes dead and unusable storage) and 1,200 acres respectively, normal operation is 2.6 ft which could be equated to at least 2,000 AF of useable storage (without exact bathymetry this cannot be calculated). A usable storage of 2,000 AF could sustain a streamflow augmentation of approximately 17 cfs for 60 days.

Alternatively, the Newman Lake Flood Control District sump could be evaluated as a potential groundwater recharge area for flows from the Spokane River. This option would be similar to the Spokane Watershed Model Injection Scenario.

3.3.2 Natural Lakes

Existing unregulated lakes are summarized in Table 3-2 and shown in Figure 3-6. This table provides basic information including the inlet and outlet stream channel on which the lake is located and whether it is off-channel, surface area and volume (if available). If a lake is at the end of a stream or river it is labeled as a “Terminal Lake”. All of the lakes listed had at least some roads or structures within 40 feet of elevation of the lake. Fifteen of the natural lakes had large densities of buildings and or docks along the shore and therefore were considered unsuitable for additional storage. Four lakes, Chain, Horseshoe, Trout and Lake of the Woods showed low structure densities around the lakes, few roads and the surrounding geology was crystalline basement.

3.3.2.1 Chain Lake

Chain Lake is on the Little Spokane River in Pend Oreille County just north of the Spokane County Line. Existing data on the extent of the Little Spokane River aquifer and regional geology indicates that this lake does not overly the aquifer but overlies alluvium and is surrounded by crystalline basement. There are some buildings near the mid-point of the lake with a road leading towards them; additionally the Burlington Northern Railroad line goes along the northwest side of the lake. These two issues would restrict elevation increases to an estimated amount of 15 feet (contour intervals in this area are 40 feet). At a 15 foot elevation increase storage could be increased by approximately 2,940 AF. Development of a reservoir on this lake would depend on the extent of alluvium underlying the lake, habitat impacts within and upstream of the dam and the current extent of development around the lake.

3.3.2.2 Horseshoe Lake

Horseshoe Lake is located at the confluence of the West Branch of the Little Spokane River, Buck Creek and Spring Heel Creek. Buildings and a boat ramp exist along the west shore. The lake is shaped as a downward facing horseshoe with a primary channel extending south from one arm and marshy channel extending south from the western arm. This results in several options for reservoir configuration on either or both channels leading south from the lake. The chosen configuration, two dams which flood both channels, would result in the largest volume and area flooded. At 20 and 40 foot dam heights this configuration would result in approximately 14,660 AF and 45,880 AF of storage respectively. Any configuration would cause flooding of roads which cross the two channels. Anecdotal evidence indicates that a dam has been considered in the marshy western channel just south of the lake (Baker pers. comm., 2004). The geology indicates this lake is underlain by alluvium and surrounded by crystalline basement. A reservoir in this location could likely be filled from natural inflow. The topographic map indicates that several roads may have been built in the area since the map was developed. This could indicate that additional development has occurred in the area and, therefore, expansion of this reservoir may be more difficult.

3.3.2.3 Trout Lake

Trout Lake is located upstream from Horseshoe Lake on the West Branch Little Spokane River. On the south side of the lake there is a road and a few docks and buildings, but no extensive development. It appears that if the lake were raised by more than 30 feet it would flood back up into Spring Heel Creek towards Sacheen Lake. At 20 and 40 foot dam heights this configuration would result in approximately 3,830 AF and 12,490 AF of storage respectively. Geology indicates this lake is underlain by peat and surrounded to the north by basement and to the south by gravel flood deposits which are likely part of the Little Spokane Aquifer. Additionally, the map indicates several roads may have been built since the map was originally developed which may indicate additional development of homes. This and the extent of sands and gravels underlying the lake could present challenges.

3.3.2.4 Lake of the Woods

Lake of the Woods is located off-channel from the Little Spokane River near Chain Lake. A road runs along the north side of the lake. At 20 and 40 foot dam heights storage would increase to approximately 490 AF and 2,220 AF of storage respectively. The lake is underlain by alluvium but bounded by crystalline basement. It has no defined inlet or outlet channels but may be a depressional area where run-off collects. It is approximately a mile from the Little Spokane River on the other side of a ridge. The ridge is approximately 200 to 400 feet above the river.

3.3.3 <u>New Dams in Non-major, Dry or Intermittently Fed Valleys</u>

In general, the location of a new dam would have to balance impacts from the construction of the reservoir (loss of land, fisheries impacts, costs, etc) with a location that would provide the greatest benefit for its intended purpose such as streamflow augmentation or water supply. When considering streamflow augmentation, a greater length of stream benefit can be achieved by locating a dam high in the watershed. Conversely, a dam that is located high in the watershed generally has less natural run-off available (simply based on drainage area) and water may need to be conveyed to the reservoir. If the primary purpose is water supply or irrigation, then the location of the reservoir is best situated in an area close to or within a preferably natural conveyance system to the location of need.

The first step in locating potential areas for new dams was to map all areas underlain by basement and then remove sub-basins where main channel habitat was noted to exist (Figure 2-1 displays habitat reaches of interest). Figure 3-7 outlines the sub-basins which appear to have potential for new storage.

The potential for new surface water dams in WRIA 57 is limited. Much of the WRIA overlies the SVRP aquifer where water infiltrates too rapidly to store water for controlled release. Some of these areas are also rapidly developing which complicates the locating of storage. Portions of the WRIA to the north of Newman Lake and south of Liberty Lake have surficial geology of crystalline basement and therefore may have new dam potential. No information on rates of flow in the Newman and Liberty Lake drainages was obtained. Both drainages are fed by run-off from high mountain areas (Mt. Spokane and Mica Peak respectively) and so may have significant run-off or water could be pumped from the Spokane River to fill storage needs.

There is a larger portion of WRIA 55 that is underlain by crystalline basement and is therefore considered suitable for siting a new dam. Much of this area is in the upland portions of the watershed to the northwest in the West Branch Little Spokane River Drainage and a small portion of the Dragoon Creek Drainage and to the east and northeast on the slopes of Mount Spokane, primarily in the Little Deep and Deer Creek drainages.

Intermittent snapshot gaging data is available from Ecology for the upper reaches of Little Deep Creek and Buck Creek (tributary of the West Branch of the Little Spokane River). Flow in Little Deep Creek was recorded from May through October at approximately 2 week intervals between 1990 and 1991. Maximum recorded flow on the North Fork of Little Deep Creek was 21 cfs in June of 1990 but was generally less than 5 cfs. Flow in Buck Creek was record between 1987 and 1990 approximately monthly between May and November. Recorded flows for Buck Creek ranged from 0.6 to 56.7 cfs but were generally less than 10 cfs. These flow measurements indicate that flow may be sufficient during the wet season in the upper reaches of these rivers to fill a reservoir of 1,000 AF. For example to fill a reservoir with 1,000 AF of water a continuous diversion of approximately 17 cfs for one month is required or, for example, 8.5 cfs for 2 months.

3.3.4 Infiltration using Existing Lakes or Natural Depressions

Several identified small lakes and reservoirs were estimated to overlie sands and gravels associated with the Diamond Lake, Deer Park or the Little Spokane Aquifer in WRIA 55. Many of these lakes appear to be fed or drained by intermittent streams and are located close to a river which may indicate continuity with that river. Lakes such as these may provide an opportunity for small storage expansion through the use of small berms or dams. Water could be diverted to these small lakes during peak flow and then be left to infiltrate and return to the river as baseflow. An evaluation of return flow (how quickly water recharges and moves back to the stream) would be required to quantify the timing of infiltrated water reaching the river. This is option could be combined with wetlands construction or reconstruction discussed in the next section. This option is most beneficially implemented on a watershed-wide scale.

3.3.5 Wetlands

The U.S. Fish and Wildlife Service National Wetland Inventory (NWI) groups wetlands found in WRIA 55 and 57 into the following three systems (Cowardin, 1979):

- Palustrine: Nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens. Generally off-channel, small systems.

- Riverine - Wetlands and deepwater habitats contained in natural or artificial channels periodically or continuously containing flowing water or which forms a connecting link between two bodies of standing water. Directly associated with stream channel.

- Lacustrine: Wetlands and deepwater habitats situated in a topographic depression or a dammed river channel, lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage and total area in excess of 20 acres. Generally encompasses lakes and reservoirs.

It is unclear what kind of wetland performs better at storing water and lessening downstream flooding. Downstream wetlands are perhaps most effective at reducing flood episodes and creating wildlife habitat due to their size, regular hydrology and longevity. However, wetlands in the upper reaches of a watershed will increase the low flow rate of streams within the watershed (Demissie & Khan, 1993). Wetland characteristics which may lend themselves to storage include wetlands that are surface water controlled (infiltration is low) and that are larger and deeper such as lacustrine systems. Replacement of wetlands may be implemented based on a watershed-scale perspective. Without also placing wetlands in the upper reaches to decrease peak and flood flows, streams and riparian wetlands in the lower reaches will be subject to increased streambank and channel erosion (Baker, 1993).

The distribution of wetlands systems in each WRIA is described in Table 3-3. This table indicates that the majority of wetlands are either in or around Lakes and Reservoirs (note that the National Wetlands Inventory System [NWIS] includes the whole lake in its area calculation) or in the form of smaller, off-channel wetlands. Wetlands with seasonally flooded water regimes are the predominant type in both watersheds. This likely indicates close continuity with streams or groundwater. A large portion of the wetlands exist in the upper basin, primarily the West Branch, Scotia and Deer Park Sub-basins. Based on their locations over gravel flood deposits these wetlands may be recharged by groundwater during the wet season and/or discharge to local aquifers during dryer seasons. Additionally the lower Little Spokane River is shown to have wetlands along the length downstream of Dartford Creek; these also may be fed by springs and seeps which occur in this area.

Numerous wetlands throughout WRIA 55 and 57 are recorded having been historically drained or converted to non-wetland area. This removal of a significant number and acreage of wetlands within the watershed has reduced the wetland to watershed area ratio from 3.1% to 2.9% for WRIA 55, and from 3.3% to 2.3% for WRIA 57. Seasonally flooded palustrine wetlands have been most affected in the WRIA 55/57 watersheds. Figure 3-8 provides an overview of the location of drained wetlands within WRIA 55/57. The greatest area of drained wetlands occurs in WRIA 57 and including Saltese Flats and areas around Newman Lake.

Opportunities exist in WRIA 55/57 to increase water storage by restoration of previously drained wetlands and creation of new wetlands. These opportunities may include: excavated or bermed wetlands; natural depressions, storage impoundments, and/or capture and spread of water over hydric soils, capable of absorbing and holding the water for slow release back to the water table and eventually to streams. A series of wetlands adjacent to the main channel mimics natural conditions by impounding floodwaters adjacent to the stream and developing a long linear floodplain.

3.3.5.1 Saltese Flats

Saltese Flats was once a shallow lake encompassing approximately 1,270 acres. The land was ditched and drained for irrigation purposes (Morrison, Dosser Reservoir, Williams and Deruwe Dam are part of the flats area). The area is fed by the intermittent Saltese Creek and Quinnamose Creek.

The creek continues, in what appears to be several channels across the Flats to Shelley Lake within the City of Spokane Valley municipal boundaries. The land has ecological significance due to existing wetlands and the State has attempted to purchase it, but to date this has not occurred and the land is still privately owned. The area is likely hydraulically connected to the Spokane Valley Aquifer similar to Liberty and Newman Lake. The size of Saltese Flats and its former state as a shallow lake indicate it could be used as a wetlands, or infiltration basin storage option.

3.3.5.2 Newman Lake

Approximately 700 acres of drained wetlands previously existed to the north of Newman Lake. These wetlands were drained through dikes developed historically by farmers draining land for irrigation. Agriculture historically and currently was developed in the flat areas surrounding the lake. Currently irrigated agriculture exists along the outlet channel and Newman Lake Flood Control District has agreed to provide, when possible drainage and sub-irrigation for these areas. Often agricultural land, such as this can provide the best location for constructed wetlands because of relatively flat topography and low relative development.

3.3.5.3 WRIA 55

In WRIA 55 there are 6 large drained wetlands to the northeast of Diamond Lake with a total area of approximately 840 acres. These wetlands historically acted as seasonal, palustrine, emergent wetlands. They present a unique opportunity over many watersheds in that they are concentrated in several large wetland units in a single sub-basin rather than many small wetland units spread throughout the watershed.

3.4 First Step Surface Water Storage Recommended Options

In evaluating existing reservoirs and natural lakes, the most common restriction to additional development of the lake or reservoir was (1) it was underlain by porous material, and (2) it had significant development in the form of roads, railroads, structures and/or docks. Therefore options were chosen which had geology which could support water storage and had little development. Potential locations that were discussed included:

- Expansion of storage in Ponderosa Lake Dam on Beaver Creek;
- Storage options (such as infiltration, wetlands reconstruction and operational changes) surrounding Newman Lake Flood Control Dam. However, expansion of the existing dam may be limited due to existing development along the shoreline;
- Expansion of storage in Chain Lake through in-channel dam on the Little Spokane River;
- Expansion of storage in Trout Lake through new in-channel dam on the West Branch Little Spokane River;
- Expansion of storage in Horseshoe Lake for new in-channel dam on West Branch Little Spokane River;
- Expansion of storage in Lake of the Woods for possible off-channel dam; and,

In addition, an evaluation of potential off-channel dam areas indicates that there are areas where conditions such as geology, development and run-off are conducive to new storage dams.

Alternatives to large surface storage facilities that were discussed include the following.

- There are many lakes which may be in direct continuity with groundwater and are located adjacent to rivers which could provide return flow to streams through seasonal flooding and infiltration. An evaluation of return flow and volume impacts would be necessary.
- Wetlands for storage with dual benefits of improved water quality through uptake of nutrients and increased baseflow conditions. Additional research on the type of wetlands and the locations in the WRIA which will support it could be undertaken in Phase 2. Two areas in WRIA 57 that show immediate potential include the area surrounding Newman Lake and Saltese Flats.

A summary of the estimated storage that is available in each potential storage option (where volume could be estimated is shown in Table 3-4. In addition the table presents the equivalent flow that would have to be diverted from each creek to fill each storage option to the recommended level. The values given are the continuous flow that would have to be diverted to achieve the desired water surface elevation either over the entire year or over any one month. These values present the general range of diversion rates that would be necessary. In WRIA 55 and 57 surface water storage would likely be filled between March and June when the highest flows are available.

4.0 GROUND WATER STORAGE ALTERNATIVES

The rise and fall of water levels in aquifers is a response to an increase or decrease in the amount of water stored in the aquifer. Aquifers are commonly described as reservoirs, and in terms of the water that "flows" through them. Water that is stored naturally in an aquifer interacts closely with the water that flows through the aquifer, but the storage and flow components of groundwater flow are fundamentally different. Storage is an intrinsic property of the aquifer, while the rate and direction of water that flows through the aquifer is also dependent on many other factors relating to the aquifer's boundary conditions. The amount of storage in an aquifer can vary from year to year in response to climate. Groundwater storage also has time dependent variables.

The amount of storage in an aquifer can be artificially increased by enhancing recharge. The various forms of artificial recharge, including aquifer storage and recovery (ASR), are increasingly being recognized as a valid water resource tool. Enhanced recharge is already being conducted in the Spokane Valley through the use of dry wells for stormwater runoff on impervious areas. Typical applications of artificial recharge consist of using excess water for injection, usually during peak flow periods, and releasing it or pumping it during critical low flow periods to meet demands. A benefit of this is that peak flow diversions have lower impacts than low flow diversions because they are a smaller fraction of total flow. Additionally, as a result of direct flow augmentation or replacement water used, periods of low streamflow can be augmented. A source of water for recharge is usually required, and this water has to be technically, legally and economically available in order for an artificial recharge project to be feasible.

The current regulatory setting for groundwater rights essentially assumes that, in most cases, a right to pump groundwater ultimately implies a right to withdraw surface water as a result of "hydraulic continuity". Over a long enough time scale, groundwater wells either intercept groundwater flow that would eventually discharge to a surface water body, or they increase the amount of leakage from a surface water body into the groundwater. There are special cases where the aquifer is "perfectly" confined and isolated from surface waters, or where the discharge is to salt water, but generally speaking, the first assumption should be that they are connected. Therefore, where there are basin closures or where there are minimum in-stream flow limits, a new water right that is hydraulically connected with surface water may be interruptible. Storage allows an interruptible water source to be transformed into an uninterruptible source by mitigating impacts.

In this section, applications that involve the groundwater aquifer system are reviewed. An overview of general applications of artificial recharge is provided, including aquifer storage and recovery. A special section is devoted to the recharge of reclaimed water to groundwater.

4.1 Overview of Aquifer Storage and Recovery (ASR)

Artificial recharge consists of increased introduction of water to aquifer systems. When artificially recharged water is recovered for further use, this special application of artificial recharge is called Aquifer Storage and Recovery, or ASR. Water may be introduced into permeable geological formations by infiltration from ground surface, or direct injection using wells. Water may be stored for a period of weeks, months or longer, and then recovered for potable or other uses. ASR is being used throughout the world with facilities operating in many different environments, including Oregon California, Nevada, Utah, Texas, Arizona, New Mexico, Florida and New Jersey. The Salem Heights wellfield for the City of Salem, Oregon is the only fully permitted and operational ASR system in the Pacific Northwest. Seattle Public Utilities has operated the Highline Wellfield for a number of years in an extended testing mode. A number of promising feasibility and pilot projects are also underway in the Pacific Northwest, including the Cities of Yakima, Walla Walla, and others.

4.1.1 General Requirements

A series of technical water supply issues must be adequately satisfied for ASR to be feasible. These include an appropriate source of water, associated infrastructure, a receiving aquifer, acceptable water quality, and a demand profile that can take advantage of the stored water. These are further described below:

- Suitable Source Water: Source water is needed for recharging aquifers. The availability of the source water for ASR is ideally during times of low environmental and human demand to allow diversions with minimal environmental impacts, and to allow the use of underused infrastructure capacity for transmission and recharge.
- Adequate Infrastructure: Adequate transmission capacity is needed to deliver source water to the receiving aquifer. The cost feasibility of ASR generally limits areas to those with access to regional water supply infrastructure. ASR systems may require specialized well construction, wellhead design, pump specifications, and system pressure modifications. Treatment of the source water and recovered water (often by chlorination) is usually needed, and real-time monitoring of ASR injection, aquifer build-up, and recovery volumes is required to ensure system operation meets permitting requirements. Existing water systems with surface and groundwater sources, and a distribution system tying them together, are particularly well-suited for considering ASR.
- Suitable Receiving Aquifer: The receiving aquifer needs to have one of the following attributes: 1.) Physical or hydrochemical boundaries that restrict movement of the injected water and minimize water quality changes during storage; or 2.) Suitable discharge boundaries that provide mitigation to surface waters during ASR operations, if one purpose of ASR is to provide streamflow mitigation
- Acceptable Water Quality: Water may be introduced by infiltration from ground surface or by direct injection through wells. Suspended sediment must be sufficiently low so as not to clog the infiltration pathway, particularly if directly injected. Treated water is generally considered the most feasible quality water for direct injection. Geochemical reactions between the infiltrated water and aquifer materials may sometimes occur. The presence of dis-infection by-products (DPB's) in treated water may require resolution with groundwater antidegradation rules (WAC 173-200). Taste and odor, or corrosion problems with the recovered water also have to be evaluated to minimize impacts to distribution infrastructure and esthetics.
- Suitable Demand Profile: ASR is, by nature, a non-continuous use, and therefore is best suited to meeting seasonal demand. An ASR program typically works in conjunction with other water supply sources to meet year-round water demand. ASR systems are typically evaluated in terms of the total storage capacity, peak pumping capacity, and efficiency of recovery, rather than average annual yield. Seasonal or peaking supply is the typical use of ASR, whereby storage occurs during low demand periods (e.g. winter/spring) and water is recovered during high demand periods (e.g. summer/fall). An ASR wellfield could serve as emergency storage. Most systems, however, are designed for regular injection/recovery cycling, and longer term storage and recovery may result in additional efficiency losses or water quality concerns. The reliability of an ASR system can be quite high, depending on the nature of the receiving aquifer.

4.1.2 ASR Configurations

ASR can be used for different purposes, and can be optimally configured for each purpose. In general there are three primary purposes for which ASR is being considered in this assessment:

1. To seasonally shift sources of water supply from direct surface or groundwater withdrawal to ASR during critical low flow periods. In this scenario ASR provides the direct replacement for potable water supply;
2. To improve or divert poor quality groundwater from higher quality groundwater near pumping wells; and,
3. To enhance river flows either by withdrawal of stored water and discharge to streams, or by leakage from the aquifer in which water is stored.

ASR is commonly used in confined aquifers; aquifers that have limited recharge, or in depleted aquifers where historic pumping has lowered water-levels. In these settings, water injected into the aquifer is stored in "available" pore spaces of the aquifer. For confined systems, the pressure head of the aquifer is increased. For unconfined systems, the water table surface is raised. The efficiency of ASR system intended for recovery for direct use in potable water supply systems is dependent on the hydraulics of the aquifer system and its ability to "hold" the injected storage for a sufficiently long period of time.

ASR is also used in aquifers with poor water quality. In this application, the availability of excess physical storage capacity in the aquifer is not always necessary. Water injected into the aquifer simply displaces poor quality water, creating a zone of higher quality water in the aquifer.

ASR is less commonly used in unconfined aquifers that are in close communication with surface waters. The seepage of water recharged to such aquifers can be used to seasonally augment streamflow using the time lag between recharge and seepage.

4.1.3 Environmental Impacts/Benefits

The environmental impacts or benefits from ASR will depend on the site specific conditions of the ASR system. Significant environmental benefits of ASR may include:

Seasonal shifts in sources of water supply from direct surface or groundwater withdrawal to ASR during critical low flow periods can result in improved streamflow conditions. The City of Salem, for example, can reduce its use of the Santiam River by up to 10 MGD for three months by using its ASR system.

Water quality improvement can be achieved through injection of potable water into non-potable or marginal aquifers. The City of Portland is examining the use of high quality Bull Run water to improve iron and manganese conditions in its Columbia South Shore aquifer.

Direct enhancement of stream flows can be achieved by recovering recharged water and discharging it directly to streams. The timing of augmentation can be closely controlled and implemented only when needed.

Indirect enhancement of stream flows can occur through leakage from ASR systems to adjacent surface waters. Similar to the current concept of hydraulic continuity for groundwater withdrawals, groundwater injection works in reverse and can improve baseflows to streams. ASR could replace deeper winter recharge that has been lost to impervious surfaces or from localized year-round groundwater withdrawals.

Negative impacts from an operating ASR system are generally minor, but could include:

- Water quality changes;
- Slope stability under certain circumstances;
- Increases or declines in aquifer levels during the ASR cycle; and,
- Increases or declines in surface water discharges.

4.1.4 Permitting

The following regulations are addressed in separate sections:

- Water Rights;
- Well Construction (Ch. 173-160 WAC);
- Water Quality (Ch. 173-200 WAC);
- Underground Injection Control Program (Ch. 173-218 WAC); and,
- Washington State Department of Health (Ch. 160-290 WAC).

4.1.4.1 Water Rights

ASR is permitted under WAC 173-157. Three permits are necessary:

- A primary water right for the water that will be used for injection/recharge;
- A permit to store the water; and,
- A secondary permit to withdraw the stored water and put it to beneficial use (this permit is not always necessary, depending on the nature of the primary water right).

Use of existing water rights in an ASR program may require processing of a change application. Obtaining a new water right for off-season use (i.e., outside of low flow periods) will be much easier than obtaining a year-round water right.

4.1.4.2 Well Construction (Ch. 173-160 WAC)

According to WAC 173-160-390 (Standards for Construction and Maintenance of Wells), "Approval must be obtained from the department [Ecology] before starting any project related to the artificial recharge of ground water bodies." Generally existing water supply wells can be retrofitted for ASR applications. Major considerations are an adequate surface seal, a sufficiently large casing diameter to house pumps, water level monitoring equipment and associated hardware.

4.1.4.3 Water Quality (Ch. 173-200 WAC)

Through this code, the Department of Ecology (Ecology) establishes an antidegradation policy for the protection of groundwater for beneficial use. Drinking water is the beneficial use generally requiring the highest quality of groundwater (WAC 173-200-040(1)(a)). It is assumed that directly injected water will be treated to drinking water standards and that compliance with the objective of this regulation is attained.

Groundwater criteria have been established by Ecology for a number of parameters. Of these parameters, chloroform and bromodichloromethane in chlorinated drinking water may exceed groundwater quality criteria. These compounds are created as a disinfection byproduct of the chlorination process through the reaction of chlorine and organic carbon contained in the surface water. Both of these compounds are trihalomethanes (THMs) for which there is a total drinking water quality criteria of 80 μg/l. Generally, organic carbon in surface water is lowest during the winter when there is diminished biological activity in the river. Therefore, surface water used for recharge to groundwater during the winter will have minimal potential THM production.

Concentrations are allowed to exceed specified levels under certain conditions. Conditions that apply to the proposed ASR pilot testing are identified in WAC 173-200-050 (3)(b)(vi), and include:

(A) There is benefit to the environment;

(B) It is in the public interest of human health and the environment; and,

(C) Impacts will be minimized.

Additionally, approval by the Director of Ecology or his designee is required. Operation of an ASR program satisfies the above-listed conditions in following ways:

1) Aquifer Storage and Recovery (ASR) has been identified as a water resource management tool that provides a benefit to the environment as a whole;
2) ASR is in the overriding public interest in that it could provide a benefit to the environment and would also benefit public health by improving the reliability of public water supply systems;
3) ASR can be designed to minimize impacts in all affected areas, including surface water and groundwater. Withdrawals from surface water are occurring during period of higher flow, thereby avoiding impacts that would occur during critically low flow conditions.

4.1.4.4 Underground Injection Control Program (Ch. 173-218 WAC)

The Washington State Department of Ecology regulates the injection of fluids into wells under the federal Underground Injection Control Program (UIC Program; 40 CFR 146). The intent of this program is to regulate the injection of waste fluids. The fluid to be recharged is assumed to be water treated to drinking water standards that comply with the Safe Drinking Water Act. Recharge wells used to replenish the water in an aquifer qualify as a Class V injection well under both state and federal regulations (40 CFR 146.5(e)(6)). Class V wells require only notice to Ecology (WAC 173-218-090; 40 CFR 144.24).

4.1.4.5 Washington State Department of Health (Ch. 160-290 WAC)

Facilities used in an ASR program that are part of the drinking water system are permitted by the Washington State Department of Health (DOH). Routine inspections and monitoring are usually conducted in compliance with DOH regulations governing public drinking water systems. Retrofitting of the wells to allow both recharge and withdrawal from a well should be coordinated with the DOH regional engineer. Upon completion of retrofitting activities, the well and associated facilities should be disinfected with techniques that conform with AWWA standards or other standards acceptable to DOH.

Routine water quality monitoring should be conducted for compounds of concern and an extended list of analyses for the purposes of providing a detailed characterization of processes and an understanding of system operation and dynamics, as well as ensuring the protection and maintenance of drinking water quality standards as defined by DOH, and the federal Safe Drinking Water Act.

4.1.5 Economics

The cost of ASR is variable and site specific. A systematic assessment of costs for ASR systems has not been published, and the estimates presented below are based on limited research of ASR systems nationwide. Feasibility and pilot testing programs generally range between $100,000 and $500,000 for systems with existing infrastructure.

Published annualized unit costs for developed water using ASR range from $30 to $350 per acre-foot ($92 to $920 per million gallons) for systems that do not require new treatment facilities. Costs are significantly higher for systems that require new treatment facilities or other major infrastructure upgrades.

Unit costs for ASR facilities have also been expressed in terms of recovery capacity, and range from about $200,000 to $600,000/mgd of recovery capacity, with an overall average of about $400,000/mgd (Pyne, 1996). Although operating costs are less well defined, available data suggest that annual operating costs are typically about $15,000/mgd of recovery capacity. Municipalities with excess treatment capacity can often justify ASR projects when projecting costly capital improvement upgrades to meet increasing demand. ASR systems can result in the more efficient use of off-peak capacity from existing infrastructure, which can defray or delay the cost of system upgrades to meet increasing peak needs.

4.2 Potential Artificial Recharge Projects

Both WRIA 55 and 57 contain groundwater resource aquifers that have potential for use in an artificial recharge program. In this section potential aquifers for recharge are identified, followed by a description of recharge projects that consider use of the Spokane River and Little Spokane River as source water.

4.2.1 Potential Artificial Recharge Aquifers

4.2.1.1 Flood Sands and Gravels (Qfg, Qfs, Qs)

In WRIA 55 the sands and gravels are primarily located within the central valley of the Little Spokane River and in the north central part of the basin spanning the area between Dragoon Creek and the Little Spokane River (Figure 4-1). The Diamond Lake aquifer is also composed of flood sands and gravels. Thicknesses of the sands and gravels within WRIA 55 generally range from between 50 to 200 feet with the greatest thickness (up to 700 feet) found south of the Little Spokane River in the Hillyard Trough. The aquifer is generally unconfined.

In WRIA 57, the deepest portions of the sands and gravels are between 300 and 700 feet narrowing to a few feet in thickness on the north and south sides of the SVRP. The aquifer is unconfined, highly conductive and is the primary source of water in WRIA 57.

4.2.1.2 Basalt Aquifers: (Tw and Tgr)

In WRIA 55 basalt aquifers are found in several areas both outcropping at ground surface and underlying the sands and gravels in the Deer Park area (Figure 4-2). There is a hydraulic connection between the flood sands and gravels and the basalt systems. Basalts are also found in several flat top prairies including Five Mile, Orchard, Pleasant, Halfmoon and Wildrose Prairies as well as Green Bluff.

4.2.2 Artificial Recharge – WRIA 57

There are two primary gaining reaches in the Spokane River the reach: just down stream of Upriver Dam and the reach downstream of Sullivan Road. Injection or infiltration of water to the aquifer could target discharge to the stream in these reaches. By default any increase in aquifer levels during the summer in these reaches would cause discharge to the river to increase. A recent scenario run of the Spokane Watershed Model indicated that injection resulted in increased discharge to the river in both the Sullivan and Upriver reaches as well as small decreases in recharge from the river in the Harvard Road area. However, water injected near Barker Road, approximately 1 mile from the river, spread quickly back towards the river with a lag time of less than 7 days (Figure 4-3). This resulted in benefits from injected water being exhausted, generally, by August. A longer time lag is generally preferred for use in interseasonal water resource management.

Injection into the sands and gravels of the Spokane Valley aquifer for the purpose of flow augmentation is a possibility but locating an injection point that will slowly release the water towards the river with an interseasonal time lag may prove difficult. The Mike She model can be used to run alternative injection scenarios.

Although the Spokane Aquifer is not well suited for storing water, it can act as a source of water as a result of the degree of hydraulic continuity between the Spokane Aquifer and the Spokane River. Conventional ASR programs divert surface water during peak flow periods for storage in aquifers. Because the Spokane Aquifer is in excellent hydraulic continuity, withdrawing aquifer water is analogous to diverting surface water. Additionally, the aquifer can act as a filter of the surface water and withdrawal of groundwater may avoid problems of suspended sediment and associated metal contamination that might otherwise require pre-treatment; though this is dependant on the distance from the river and timing of withdrawal.

4.2.3 Artificial Recharge – WRIA 55

The Little Spokane River has flows above regulatory levels (Ch. 173-555 WAC) during the wet season that may be available for artificial recharge applications. If surface water is used for recharge by direct injection, in general it is required to be treated to drinking water quality standards. This could be a limiting factor in WRIA 55 because there are no existing surface water treatment facilities, and the cost of new facilities is likely prohibitive. Two options are discussed here including aquifer storage and recovery within the SVRP and Little Spokane aquifers of WRIA 55 as well as surface percolation of surface water.

4.2.3.1 Aquifer Storage and Recovery in the Lower Little Spokane Aquifer

The extensive infrastructure capacity in the form of wells and transmission pipelines in the SVRP within eastern WRIA 57 and southern WRIA 55 provide several opportunities for implementation of an ASR program. A continuous coverage of water system service areas from the City of Spokane and up along the lower reach of the Little Spokane River allows for the transmission of water (possibly through interties) from the Spokane Aquifer using wells of the City of Spokane, for artificial recharge injection in the aquifer system between Dartford and the confluence of Deadman Creek and the Little Spokane River. Injection could be into the shallower unconsolidated sediments or into the deeper basalt aquifer, which is several hundred feet thick in this area (Figure 4-2). Recharge to the shallow aquifer could seep back to the Little Spokane River with an appropriate time lag to augment streamflows during low flow periods and provide associated environmental habitat benefits. Recharge to the deeper basalt aquifer may be used for seasonal withdrawal and direct use for drinking water supply.

4.2.3.2 Recharge to Gravel Pits in WRIA 55

Gravel pits provide prospective recharge sites. They are usually located in relatively permeable sand and gravel formations that would sustain high infiltration rates, and their topographic depressions provide hydraulic containment during infiltration. However, many gravel pits are developed in floodplain gravels immediately adjacent to streams. Recharge to these may not provide any significant time lag between recharge and resultant seepage back to streams, and would not provide any interseasonal effects in managing streamflows. Therefore sites located further away from stream channels may be the best candidates for this purpose.

Gravel pits are summarized in Table 4-1 and shown in Figure 4-4 for the WRIA and in more location detail in Figure 4-5 through 4-10. The Washington Department of Natural Resources classifies sand and gravel pits as archived or current. It is presumed that archived are no longer operational, and that current are operational. The status of archived pit is unknown, and they may have been reclaimed and/or filled. Owners of operational pits may be interested in making the pits available for storage projects if they can forego reclamation work upon completion of mining operations.

A drawback of using gravel pits that are located away from stream channels is that conveyance would be needed to deliver water diverted from a stream during high flow conditions to the pit. Planning level cost estimates for pipelines may range from $100,000 per mile to $1M per mile, depending on the size of the pipe, degree of development, infrastructure, topography, ground conditions, ownership of the land that must be crossed by the transmission line, and other factors. Pumping stations may also be needed at additional cost.

4.3 Reclaimed Water

Preliminary site development studies and environmental analysis have been completed for the new Spokane County Regional Treatment Plant (SCRTP). The planned amount of water availble from this source is projected to be from 10 mgd (~ 15 cfs) to 20 mgd (~ 30 cfs) to meet future capacity needs to the year 2050 (HDR, 2004). The wastewater treatment plant has selected membrane bioreactor (MBR) with nitrification/denitrification (NDN) and primary clarifiers. This treatment alternative could facilitate potential implementation of groundwater recharge.

There is currently concern over the planned SCRTP discharge to the Spokane River due to the high hydraulic connection between the river and the aquifer and the potential for water supply well contamination. This same concern would also apply to recharge of reclaimed water to the aquifer. Proposed wellhead protection areas cover almost the whole of the Spokane Aquifer (Figure 4-11). The proposed wellhead protection areas were simulated using a groundwater model, and so there is a degree of uncertainty to their locations. Future groundwater development may also occur in the Hillyard Trough in areas where there are currently no proposed wellhead protection zones.

Groundwater flow in the Spokane Aquifer is expected to be highly stratified, and exchange between the river and groundwater occurs at the water table. Therefore, whether the reclaimed water is distributed to the river or infiltrated from ground surface the reclaimed water is expected to remain close to the water table as opposed to moving vertically down into the aquifer. However vertical gradients in close proximity to pumping production wells may drawdown water from the water table. The influence of reclaimed water recharge on water quality in drinking water wells will be less if those wells are screened deeper in the aquifer.

A potential recharge site has been identified for reclaimed water from the SCRTP (Figure 4-12). This recharge site is located immediately upgradient of a gaining reach of the Spokane River. Reclaimed water recharged at this site would be expected to travel through the unsaturated vadose zone to the water table and then travel horizontally to the river. At this point, some groundwater discharges to the river including a portion of the introduced reclaimed water. The reclaimed water will undergo significant dispersion in the river. First, discharge of groundwater in the gaining reach represents approximately 7.5% of the total stream flow, or a 13-fold dilution (assuming a groundwater discharge of 90 cfs to a low streamflow of 1,200 cfs). Secondly, the losing reach of the stream immediately downstream is approximately 2.5 miles long. As the river recharges groundwater further dilution of the portion of reclaimed water would occur.

Further evaluation of this scenario could focus on estimating the partitioning and resulting concentrations of reclaimed water between: the portion that enters and remains in groundwater; the portion that discharges back to and remains in the Spokane River, and the portion that discharges to the river and re-enters groundwater.

Impacts of groundwater withdrawal from the Spokane Aquifer result in a reduction of streamflow at the recommended compliance point for the Spokane River at Spokane, and a reduction of groundwater flows through the Hillyard Trough. Reduced groundwater flow through the Hillyard Trough results in a reduction of groundwater discharge to the Little Spokane River. Some of the impacts to Spokane River flows are mitigated by non-consumptive water use that is discharged back to the Spokane River at the existing downstream waste water treatment plant. Proposed recharge of reclaimed water near the SCRTP site will mitigate most of the impacts of groundwater withdrawal from the Spokane Aquifer, including reduced groundwater flow through the Hillyard Trough.

4.3.1 Reclaimed Water Regulations

Under the Washington State Reclaimed Water Act, a permit is issued to the generator of the reclaimed water, who may then distribute the water subject to water quality regulations. The implementation of reclaimed water systems is regulated by the Washington Department of Ecology (Ecology), and Washington Department of Health (DOH), and by the United States Environmental Protection Agency (EPA) through the federal Clean Water Act.

The storage of reclaimed water in freshwater systems is subject to the following regulations and standards:

- RCW 90.46– Reclaimed Water Act, as operationalized by DOH and Ecology guidelines (see Water Reclamation and Reuse Standards below);
- RCW 90.48– Water Pollution Control Act, requiring an NPDES permit to discharge pollutants to waters of the state (RCW 90.48.080 and 90.48.162);

- WAC 173-200 -Water quality standards for ground waters of the state of Washington, including water quality criteria and treatment requirements for primary and secondary contaminants, radionuclides, and carcinogens;
- WAC 173-201A - Water quality standards for surface waters of the state of Washington, including water quality criteria and treatment requirements for both freshwater and marine systems according to the receiving water body classification system. This regulation also includes the Antidegradation Policy for all Waters of the State;
- WAC 173-221 – Technical criteria for discharges from municipal wastewater treatment facilities;
- Water Reclamation and Reuse Standards, prepared by DOH and Ecology in accordance with RCW 90.46, based on the reclaimed water quality classification system; and,
- Federal Clean Water Act (1987), regulating water body water quality and requiring streams to not exceed their natural assimilative capacity as defined by the Total Maximum Daily Load (TMDL).

4.3.2 Reclaimed Water Quality

Many chemicals may be present in wastewater, depending on the industries and land uses in the municipality. Essentially, chemicals are one of three types:

- Inorganic and organic substances naturally present in potable water (e.g., metals);
- Trace organic and inorganic chemicals from industrial, commercial and residential sources; and,
- Chemicals generated as a result of water treatment (e.g., disinfection by-products).

There are potential health risks associated with exposure to any of the above chemical types. The ability to evaluate and manage those risks is greatest for naturally present chemicals and least for the unidentified mix that comprises the majority of the organics in wastewater.

It is not expected that substances would be present in wastewater at concentrations that would be acutely toxic. Municipalities will be required to achieve available water quality guidelines for treated wastewater. However, there are many chemicals for which guidelines and regulations are not available. Proprietary chemicals and chemical mixtures from industrial applications (including products used by the general public), breakdown products of those chemicals and possible generation of new compounds by interaction with disinfection by-products are not included in routine water quality analysis. Furthermore, analytical laboratories are unable to analyze for many trace organic compounds.

Wastewater treatment facilities are recognized sources of endocrine disrupting compounds (EDCs). EDCs are substances that are able to bind to hormone receptors in fish, wildlife and humans, which can affect hormone activity. The EDCs found in WWTP effluent originate from a number of potential sources, including industrial and residential surfactants (detergents and dispersants), and breakdown products of pharmaceutical products used by human populations. For example, one important EDC in WWTP effluent is ethynylestradiol – which is the synthetic estrogen found in birth control pills. Ethynylestradiol in particular causes concern because effects are apparent at low concentrations.

Although reclaimed water is expected to have a poorly characterized range of compounds, the Spokane River probably already has a background level of these compounds as a result of upstream discharges from waste water treatment plants. Understanding potential environmental and health impacts, and public perception, will be important components in evaluating applications of reclaimed water. Improved awareness of these variables should consider current baseline conditions and potential benefits of options, along with identified concerns.

5.0 OPTIONS FOR DETAILED STORAGE ASSESSMENT

The purpose of the first step of the storage assessment was to identify a wide range of storage options for consideration by the Planning Unit for more detailed development in the second step. An initial list of options was developed by the Planning Unit in conjunction with Golder Associates. During the execution of this work, additional options were identified and included (e.g., recharge through gravel pits, and wetlands storage). By better defining the parameters of the options, the Planning Unit can better select which options will be more feasible and will meet their watershed planning objectives. Summaries of identified options are presented below. This list is derived from work conducted so far, and does not preclude the addition of more options. In depth discussion will be held at the workshop to be held Wednesday, July 21, 2004.

5.1 Ponderosa Lake Dam Raise

Concept: Ponderosa Lake is located in the northwestern corner of WRIA 55. It is a privately owned dam for the purpose of recreation. Raising the dam 20 feet or 40 feet would provide an additional 2,000 AF or 6,600 AF respectively.

Benefits: Additional storage in Ponderosa Lake can be used for many purposes because it is located relatively high in the watershed. Water quality concerns downstream of Ponderosa Lake include phosphorus in the West Branch of the Little Spokane River and Eloika Lake, and PCBs in the Little Spokane River immediately upstream of the confluence with the Spokane River.

Augmentation could be applied to habitat improvement, including that of rainbow trout from Eloika Lake to Chattaroy (Figure 2-1).

Stream flow augmentation could be achieved for all instream flow compliance points in WRIA 55 except for the Elks station. Such augmentation could allow continuous use of water rights that are currently interruptible in low flow years because they are junior to instream flow regulations. Storage of 2,000 AF (i.e., a 20-foot dam raise) could fully mitigate all existing junior water rights below the control station Elk for approximately four months.

Filling of the additional created storage could be used as part of a flood control program.

Logistical Considerations: The existing dam is based on alluvial sediments and geotechnical studies are required to further evaluate the feasibility of raising the dam and to provide a better cost estimate. A road along the east side of the lake may have to be relocated.

Costs for enlargement of existing reservoirs have ranged from $200/AF to over $5,000/AF. Raising the Ponderosa Lake dam to contain an additional 2,000 AF would correspond to a cost range of $400,000 to $10M. Free market values for water rights provide some perspective of the total cost. Water rights have been exchanged for at rates of between $600 and $3,000 per AF/yr. Therefore, 2,000 AF/yr would have an approximate value of between $1.2M and $6M.

5.2 Newman Lake Dam Raise

Concept: Raising the dam on Newman Lake by 20 feet or 40 feet may allow an additional 35,000 AF or 81,000 AF of additional storage respectively.

Benefits: This option provides the largest additional storage of all of the surface water storage options evaluated. It is located in the northeast corner of the Spokane Valley. Controlled release of water stored by a 20-foot dam raise could provide a flow of 200 cfs for three months. Previously drained wetlands may be partially restored.

Logistical Considerations: Land surrounding Newman Lake is relatively developed and resistance from lakeshore property owners to raising the dam may be anticipated. Leakage from Newman Lake may be significant, thereby lowering the interseasonal storage carry-over. The existing dam is made of native peat soils and may have to be replaced to provide a solid foundation if the dam is raised.

5.3 Enhancement of Natural Lake Storage through Dams

Concept: Four prospective sites were identified for new in channel dams: Trout Lake, Chain Lake, Horseshoe Lake and Lake of the Woods. Three are located in the northwest corner of WRIA 55, and three are located in the headwaters of Little Deep, Deer and Dry Creeks.

Benefits: New dams could provide flood control, and storage for use in augmenting streamflow during the summer and early fall low flow periods for environmental improvement of mitigation of impacts from exercising water rights.

Logistical Considerations: The cost of construction and the environmental permitting process for new dams usually causes these to be among the least viable of storage options. Most of the lakes had roads, railways or other infrastructure and/or development along the shores. Lake of the Woods had the least development (i.e., one road). Chain Lake is one of the few natural habitats populated by native kokanee (land-locked salmon) and construction of a dam on this lake may face difficult permitting obstacles.

5.4 New Dams

Concept: New dams may be constructed in suitable sub-basins which provide good retention of stored water and solid foundations.

Benefits: New dams could provide flood control, and storage for use in augmenting streamflow during the summer and early fall low flow periods for environmental improvement and mitigation of impacts from exercising water rights.

Logistical Considerations: The cost of construction and permitting process for new dams usually causes these to be among the least viable of storage options. Source water would need to be identified. Site specific data would have to be collected for further evaluation of selected options, including habitat sensitivity, geotechnical suitability of sites, and flow catchment and topographic calculations for conceptual design.

5.5 Gravel Pit Infiltration in the Little Spokane Watershed

Concept: Sand and gravel pits may act as locations for artificial recharge. Seepage into the groundwater and back to nearby streams may augment low streamflows if there is an appropriate time lag between the timing of recharge and seepage back to the stream.

Benefits: Depending on the location in the watershed, many of the same potential benefits and applications identified for the Ponderosa Lake Dam (e.g., water quality improvement through higher flows with cooler water; habitat improvement; mitigation of current and or future impacts; lower interruptibility of junior water rights on the Little Spokane River).

Logistical Considerations: Sand and gravel pits that are no longer operational and have not been reclaimed or filled in provide the best options. Operating gravel pits that may soon stop operations are also good candidates, particularly if the current owner/operator has reclamation and closure responsibilities that may be avoided if the land is deeded for artificial recharge use. Hydrogeologic evaluations will have to be conducted to estimate the seepage rate from gravel pits to the receiving streams. Gravel pits in the WRIA 57 were not considered in greater depth because of the anticipated lack of a significant lag time between recharge and streamflow augmentation.

5.6 Artificial Recharge in the Lower Little Spokane Basin

Concept: Withdraw groundwater from the Spokane Aquifer during the winter and higher streamflow periods and recharge it to aquifers in the Little Spokane watershed above Dartford. Water could be recharged to either the shallow sand and gravel aquifer or the deep basalt aquifer.

Benefits: Recharge to the shallow sand and gravel aquifer may seep back to the Little Spokane River and augment streamflow during the low flow period. This may reduce the duration and frequency that regulatory flows are not met at the Dartford control station.

Water may be recharged to the deeper basalt aquifer during the winter and higher flow periods for recovery during low flow periods. This is a typical Aquifer Storage and Recovery (ASR) program.

Logistical Considerations: The participation of several purveyor distribution systems would have to be coordinated. Water may be withdrawn from the Spokane Aquifer by City of Spokane wells during the winter, when they are not fully used. Distribution of water to the Whitworth and/or Spokane County Water District #3 would be accomplished through interties. Depending on the pressure zones of the systems and location of wells, booster pumps and/or pressure reducing valves in the distribution systems may be needed to deliver water to recharge sites.

5.7 Reclaimed Water Recharge to the Spokane Aquifer

Concept: A new regional waste water treatment plant is planned in the west end of the Spokane Valley that will be treating water to reclaimed standards. Discharge of the reclaimed water may be directly to the stream, or infiltrated to groundwater.

Benefits: Recharge to groundwater will most directly offset existing and future impacts to the aquifer from groundwater withdrawals. Some of the recharged water may discharge to the Spokane River in gaining reaches, and recharge back from the river to the aquifer in losing reaches. Some of the water is expected to flow through the Hillyard Trough and discharge to the Little Spokane River. There is an instream flow recommendation for the Spokane River at Spokane. Some of the streamflow augmentation that currently occurs at the existing waste water treatment plant below the Spokane River at Spokane will occur above this point in the future, thereby resulting in a nominal reduction of time that the recommended flows are not met.

Logistical Considerations: Water quality standards to protect groundwater from degradation will be strict. There is also concern from purveyors of the introduction of reclaimed water to wellhead protection zones.

5.8 Saltese Flats Wetlands Restoration

Concept: To restore the natural habitat and wetlands storage function. The Saltese Flats have historically provided significant habitat and are considered sufficiently valuable in this context to have been identified by state agencies as a potential restoration project.

Benefits: Valuable habitat restoration could be accomplished concurrently with creating additional storage. The site could also be configured for enhanced infiltration assuming a water source could be identified. Current engineered storage of less than 200 AF in this 1,600 acre area could be significantly increased with a small dike (e.g., 1,600 AF with a 1-foot dike). Delayed seepage from the wetland to the Spokane Aquifer may increase flows in the Spokane River.

Logistical Considerations: A significant amount of land ownership remains private. Habitat restoration funds may be available for funding this project. Current irrigation water use may have to be accommodated.

5.9 WRIA 55 Wetlands Restoration

Concept: To restore the natural habitat and wetlands storage function in wetlands of WRIA 55.

Benefits: Valuable habitat restoration could be accomplished concurrently with creating additional storage. The site could also be configured for enhanced infiltration assuming a water source could be identified. Storage in formerly seasonal, drained wetlands could be restored in order to provide a late summer source of infiltrated or released water to local streams.

Logistical Considerations: A significant amount of land ownership remains private. Quantifying the storage benefit of a wetlands or a number of wetlands can be difficult and is site dependant. Some wetlands can decrease water available because of increased wetlands evapotranspiration. Habitat restoration funds may be available for funding this project. Current irrigation water use may have to be accommodated.

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TABLES

TABLE 2-1

WRIA 55 Water Rights Junior to Instream Flows (Chapter 173-555 WAC)

Control Point	**Number of Rights**	**Total AF** (Qa)	**Total cfs** (Qi)	**Qi for 2 mo*** (AF)	**Qi for 3 mo*** (AF)
Confluence (w S.R.)	8	493.81	0.73	87.94	131.19
Dartford	47	1,453.18	3.62	437.93	653.31
Chattaroy	74	243.68	2.64	319.46	476.58
Elk	15	3,125.86	1.67	201.52	300.63
Total	**144**	**5,316.53**	**8.65**	**1,046.86**	**1,561.71**

Source: John Covert, Ecology, Personal Communications 2004.
Note: *Calculated by assuming Qi rate is used continuously for 2 or 3 months.

TABLE 2-2

Predicted Volume Necessary to Off Set Future Water Use
[20-year Growth and Full Inchoate Water Right Use]

	20 year Growth	**Full Inchoate Rights**	**20 year Growth**	**Full Inchoate Rights**
Location of Discharge Prediction	**Aug-Sep** (AF)		**Jul-Oct** (AF)	
WRIA 57: Spokane at Spokane	6,620	25,645	13,080	51,290
WRIA 55: Little Spokane River at Chattaroy	31	603	63	1,374
WRIA 55: Little Spokane River at Dartford	1,734	1,690	3,949	3,882
WRIA 55: Little Spokane River near Dartford (confluence)	1,721	2,097	3,471	4,751

Note: Calculated as an average monthly discharge decrease from existing conditions. Calculated using Spokane Watershed Model (Golder, 2003)

TABLE 2-3

Existing Applications for New Water Rights

	Number of Documents		**Qi**		**Annual Volume** (AF)*	**Jul – Oct Volume** (AF)
WRIA	**Groundwater**	**Surface Water**	**Groundwater** (gpm)	**Surface Water** (cfs)		
55	12	6	16,920	1.4	28,305	9,539
57	26	9	32,468	< 1	52,501	17,693

Source: Washington State Department of Ecology Water Rights Website, September 30, 2004, http://www.ecy.wa.gov/programs/wr/rights/tracking-apps.html
Note: *assumes year round application of Qi

1998 and Draft 2002/2004 303(d) and Water Quality Assessment Listings in WRIAs 55 and 57

WRIA	Waterbody	Parameter	Medium	TRS	Listed in 1998	Draft 2002/2004 Listing	Category 5	Category 4a	Category 4c	Category 2
55	Bear (Kuester) Lake	Total Phosphorus	Water	T28N R43E S15		Yes				Yes
55	Chain Lake	Total Phosphorus	Water	T28N R06E S24		Yes				Yes
55	Deadman Creek	Aluminum	Water	T26N R43E S03		Yes				Yes
55	Deadman Creek	Ammonia-N	Water	T27N R43E S33		Yes				
55	Deadman Creek	Dissolved oxygen	Water	T27N R43E S33		Yes				
55	Deadman Creek	Fecal Coliform	Water	T27N R43E S33		Yes				
55	Deadman Creek	pH	Water	T27N R43E S33	Yes	Yes				Yes
55	Deadman Creek	Temperature	Water	T27N R43E S33	Yes	Yes	Yes			Yes
55	Deadman Creek	Fish Passage Barrier	Habitat	T28N R45E S28		Yes			Yes	
55	Deadman Creek	Fish Passage Barrier	Habitat	T28N R45E S33		Yes			Yes	
55	Deer Creek	Dissolved oxygen	Water	T28N R43E S34		Yes				
55	Deer Creek	Fecal Coliform	Water	T28N R43E S34		Yes				
55	Deer Creek	pH	Water	T28N R43E S34		Yes				
55	Deer Creek	Temperature	Water	T28N R43E S34		Yes				
55	Diamond Lake	Invasive Exotic Species	Habitat	T30N R44E S03		Yes			Yes	
55	Diamond Lake	Total Phosphorus	Water	T30N R44E S03		Yes				
55	Dragoon Creek	Ammonia-N	Water	T28N R42E S03		Yes		Yes		
55	Dragoon Creek	Chlorine	Water	T28N R42E S03		Yes		Yes		
55	Dragoon Creek	Dissolved oxygen	Water	T28N R42E S03	Yes	Yes				Yes
55	Dragoon Creek	Total Phosphorus	Water	T28N R42E S03		Yes		Yes		
55	Dragoon Creek	Ammonia-N	Water	T28N R43E S33		Yes				
55	Dragoon Creek	Dissolved oxygen	Water	T28N R43E S33		Yes				
55	Dragoon Creek	pH	Water	T28N R43E S33		Yes				Yes
55	Dragoon Creek	Temperature	Water	T28N R43E S33		Yes	Yes			Yes
55	Dragoon Creek	Dissolved oxygen	Water	T29N R42E S08	Yes	Yes				Yes
55	Dragoon Creek	Fecal Coliform	Water	T29N R42E S08	Yes	Yes				Yes
55	Dragoon Creek	Dissolved oxygen	Water	T30N R42E S18	Yes	Yes				Yes
55	Dragoon Creek	Fecal Coliform	Water	T30N R42E S18		Yes				Yes
55	Eloika Lake	Invasive Exotic Species	Habitat	T29N R43E S15		Yes			Yes	
55	Eloika Lake	Total Phosphorus	Water	T29N R43E S15		Yes				Yes
55	Eloika Lake	Total Phosphorus	Water			Yes				Yes
55	Fan Lake	Invasive Exotic Species	Habitat	T30N R43E S32		Yes			Yes	
55	Fan Lake	Total Phosphorus	Water			Yes				Yes
55	Horseshoe Lake	Invasive Exotic Species	Habitat	T30N R43E S08		Yes			Yes	
55	Horseshoe Lake	Fecal Coliform	Water	*T36N R01W S33*		Yes				
55	Little Spokane River	Ammonia-N	Water	T26N R42E S05		Yes				
55	Little Spokane River	Dissolved oxygen	Water	T26N R42E S05		Yes				Yes
55	Little Spokane River	Fecal Coliform	Water	T26N R42E S05		Yes				
55	Little Spokane River	pH	Water	T26N R42E S05		Yes				Yes
55	Little Spokane River	Temperature	Water	T26N R42E S05		Yes				Yes
55	Little Spokane River	Fecal Coliform	Water	T26N R42E S11	Yes					
55	Little Spokane River	Ammonia-N	Water	T26N R43E S03		Yes				
55	Little Spokane River	Fecal Coliform	Water	T26N R43E S03		Yes				
55	Little Spokane River	Ammonia-N	Water	T26N R43E S06		Yes				

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WRIA	Waterbody	Parameter	Medium	TRS	Listed in 1998	Draft 2002/2004 Listing	Category 5	Category 4a	Category 4c	Category 2
55	Little Spokane River	Fecal Coliform	Water	T26N R43E S06		Yes				
55	Little Spokane River	Turbidity	Water	T26N R43E S06		Yes				
55	Little Spokane River	Fecal Coliform	Water	T27N R43E S32	Yes					
55	Little Spokane River	Ammonia-N	Water	T27N R43E S33		Yes				
55	Little Spokane River	Dissolved oxygen	Water	T27N R43E S33		Yes				
55	Little Spokane River	Fecal Coliform	Water	T27N R43E S33		Yes				
55	Little Spokane River	Fecal Coliform	Water	T27N R43E S33	Yes	Yes				
55	Little Spokane River	pH	Water	T27N R43E S33	Yes	Yes				
55	Little Spokane River	Temperature	Water	T27N R43E S33	Yes	Yes				Yes
55	Little Spokane River	Ammonia-N	Water	T28N R43E S27		Yes				
55	Little Spokane River	Dissolved oxygen	Water	T28N R43E S27		Yes				
55	Little Spokane River	Fecal Coliform	Water	T28N R43E S27	Yes	Yes				Yes
55	Little Spokane River	pH	Water	T28N R43E S27		Yes				
55	Little Spokane River	Temperature	Water	T28N R43E S27		Yes				Yes
55	Little Spokane River	Invasive Exotic Species	Habitat	T31N R45E S34		Yes			Yes	
55	Reflection Lake	Total Phosphorus	Water			Yes	Yes			Yes
55	Sacheen Lake	Total Phosphorus	Water	T31N R43E S35		Yes				
55	Sacheen Lake	Total Phosphorus	Water	T31N R43E S35		Yes				
55	Sacheen Lake	Invasive Exotic Species	Habitat	T31N R45E S35		Yes	Yes		Yes	
55	Sacheen Lake	Fecal Coliform	Water	T31N R45E S35		Yes	Yes			
55	Trout Lake	Total Phosphorus	Water	T25N R12E S31		Yes				Yes
57	Liberty Lake	Invasive Exotic Species	Habitat	T25N R45E S22		Yes			Yes	
57	Liberty Lake	alpha-BHC	Water	T25N R45E S22		Yes				
57	Liberty Lake	alpha-Endosulfan	Water	T25N R45E S22		Yes				
57	Liberty Lake	beta-BHC	Water	T25N R45E S22		Yes				
57	Liberty Lake	beta-Endosulfan	Water	T25N R45E S22		Yes				
57	Liberty Lake	Endosulfan Sulfate	Water	T25N R45E S22		Yes				
57	Liberty Lake	Endrin	Water	T25N R45E S22		Yes				
57	Liberty Lake	Fecal Coliform	Water	T25N R45E S22		Yes				
57	Liberty Lake	gamma-BHC (Lindane)	Water	T25N R45E S22		Yes				
57	Liberty Lake	Total Phosphorus	Water	T25N R45E S22		Yes		Yes		
57	Liberty Lake	Total Phosphorus	Water	T25N R45E S22		Yes				
57	Newman Lake	Invasive Exotic Species	Habitat	T26N R42E S10		Yes			Yes	
57	Newman Lake	Total Phosphorus	Water	T26N R45E S11	Yes	Yes				
57	Shelley Lake	Total Phosphorus	Water	T25N R44E S24		Yes	Yes			Yes
57	Spokane River	Ammonia-N	Water	T25N R42E S13		Yes				
57	Spokane River	Lead	Water	T25N R42E S13		Yes		Yes		
57	Spokane River	pH	Water	T25N R42E S13	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R42E S13	Yes	Yes				
57	Spokane River	Zinc	Water	T25N R42E S13		Yes		Yes		
57	Spokane River	Dissolved oxygen	Water	T25N R42E S24		Yes				
57	Spokane River	pH	Water	T25N R42E S24	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R42E S24	Yes	Yes				
57	Spokane River	Dissolved oxygen	Water	T25N R43E S02		Yes				

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WRIA	Waterbody	Parameter	Medium	TRS	Listed in 1998	Draft 2002/2004 Listing	Category 5	Category 4a	Category 4c	Category 2
57	Spokane River	pH	Water	T25N R43E S02	Yes	Yes	Yes			
57	Spokane River	Temperature	Water	T25N R43E S02	Yes	Yes	Yes			
57	Spokane River	Ammonia-N	Water	T25N R43E S09		Yes	Yes			
57	Spokane River	Lead	Water	T25N R43E S09		Yes	Yes	Yes		
57	Spokane River	pH	Water	T25N R43E S09	Yes	Yes				
57	Spokane River	Zinc	Water	T25N R43E S09		Yes		Yes		
57	Spokane River	Dissolved oxygen	Water	T25N R43E S10		Yes				
57	Spokane River	pH	Water	T25N R43E S10	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R43E S10	Yes	Yes				
57	Spokane River	Dissolved oxygen	Water	T25N R43E S11		Yes				Yes
57	Spokane River	pH	Water	T25N R43E S11	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R43E S11	Yes	Yes				Yes
57	Spokane River	Dissolved oxygen	Water	T25N R43E S18		Yes				
57	Spokane River	pH	Water	T25N R43E S18	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R43E S18	Yes	Yes				
57	Spokane River	Lead	Water	T25N R44E S03		Yes		Yes		
57	Spokane River	Temperature	Water	T25N R44E S03		Yes				
57	Spokane River	Zinc	Water	T25N R44E S03	Yes	Yes		Yes		
57	Spokane River	Dissolved oxygen	Water	T25N R44E S04		Yes				
57	Spokane River	pH	Water	T25N R44E S04	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R44E S04	Yes	Yes				Yes
57	Spokane River	Dissolved oxygen	Water	T25N R44E S06	Yes	Yes				Yes
57	Spokane River	Temperature	Water	T25N R44E S06	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R44E S10	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R44E S11	Yes	Yes				
57	Spokane River	Ammonia-N	Water	T25N R44E S12		Yes				
57	Spokane River	Dissolved oxygen	Water	T25N R44E S12		Yes				
57	Spokane River	pH	Water	T25N R44E S12	Yes	Yes				Yes
57	Spokane River	Temperature	Water	T25N R44E S12	Yes	Yes				Yes
57	Spokane River	Zinc	Water	T25N R44E S12		Yes		Yes		
57	Spokane River	Ammonia-N	Water	T25N R45E S07		Yes				
57	Spokane River	pH	Water	T25N R45E S07	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R45E S07	Yes	Yes				Yes
57	Spokane River	Total PCBs	Water	T25N R45E S07		Yes				Yes
57	Spokane River	Zinc	Water	T25N R45E S07		Yes		Yes		
57	Spokane River	Dissolved oxygen	Water	T25N R45E S08		Yes				
57	Spokane River	pH	Water	T25N R45E S08	Yes	Yes				Yes
57	Spokane River	Temperature	Water	T25N R45E S08	Yes	Yes	Yes			Yes
57	Spokane River	Dissolved oxygen	Water	T25N R45E S10		Yes				Yes
57	Spokane River	pH	Water	T25N R45E S10	Yes	Yes				
57	Spokane River	Temperature	Water	T25N R45E S10	Yes	Yes				Yes
57	Spokane River	Ammonia-N	Water	T25N R46E S06		Yes				
57	Spokane River	Arsenic	Water	T25N R46E S06	Yes	Yes				
57	Spokane River	Cadmium	Water	T25N R46E S06	Yes	Yes		Yes		

1998 and Draft 2002/2004 303(d) and Water Quality Assessment Listings in WRIAs 55 and 57

WRIA	Waterbody	Parameter	Medium	TRS	Listed in 1998	Draft 2002/2004 Listing	Category 5	Category 4a	Category 4c	Category 2
57	Spokane River	Copper	Water	T25N R46E S06		Yes				
57	Spokane River	Dissolved oxygen	Water	T25N R46E S06	Yes	Yes				
57	Spokane River	Fecal Coliform	Water	T25N R46E S06		Yes				Yes
57	Spokane River	Lead	Water	T25N R46E S06	Yes	Yes		Yes		
57	Spokane River	Mercury	Water	T25N R46E S06		Yes				Yes
57	Spokane River	Nickel	Water	T25N R46E S06		Yes				
57	Spokane River	pH	Water	T25N R46E S06		Yes				Yes
57	Spokane River	Temperature	Water	T25N R46E S06		Yes				
57	Spokane River	Zinc	Water	T25N R46E S06	Yes	Yes		Yes		
57	Spokane River	Temperature	Water	T25N S43E R09	Yes	Yes				
57	Spokane River	Dissolved oxygen	Water	T26N R42E S07		Yes				
57	Spokane River	pH	Water	T26N R42E S07	Yes	Yes				
57	Spokane River	Temperature	Water	T26N R42E S07	Yes	Yes				
57	Spokane River	Dissolved oxygen	Water	T26N R42E S17		Yes				
57	Spokane River	pH	Water	T26N R42E S17	Yes	Yes				
57	Spokane River	Temperature	Water	T26N R42E S17	Yes	Yes				
57	Spokane River	Dissolved oxygen	Water	T27N R42E S32		Yes				
57	Spokane River	pH	Water	T27N R42E S32	Yes	Yes				
57	Spokane River	Temperature	Water	T27N R42E S32	Yes	Yes				
57	Trask Lake	Total Phosphorus	Water	T30N R46E S30		Yes				Yes
	Dragoon Creek	Fecal Coliform	Water	T28N R43E S33		Yes				

TABLE 3-1

Dams WRIAs 55 and 57

Name	WRIA	Federal NID ID	County	Stream	Owner Name	Owner Type	Type of Dam	Dam Purpose	Date Built	Crest Length (ft)	Height (ft)	Max Storage (acre-ft)	Normal Storage (acre-ft)	Surface Area (acres)	Drainage Area (mi2)	Downstream Hazard	Regulating Authority	Reason Removed
Beryl Baker Dam	55	WA01324	Stevens	Tr-Dragoon Creek	Baker, Beryl	Private	Earth	Recreation	1977	390	25	48	22	22	3	Significant	WaDOE	Unable to locate on USGS 7.5' Topographic Map
Decie Lake Dam	55	WA01029	Pend Oreille	Tr-Little Spokane River	Wells, Leroy A	Private	Earth	Irrigation	1960	190	22	33	25	4	0	Significant	WaDOE	Less than 1000 AF of new storage
Deer Park Sewage Treatment Lagoon	55	WA01467	Spokane	Tr-Dragoon Creek-Offstream	City of Deer Park	Local Government	Earth	Water Quality	1984	1340	12	25	21	21	0	Significant	WaDOE	Wastewater Treatment
Deer Park Waste Water Storage Lagoon	55	WA01468	Spokane	Tr-Dragoon Creek-Offstream	City of Deer Park	Local Government	Earth	Water Quality	1984	3300	12	205	176	176	0	High	WaDOE	Wastewater Treatment
Diamond Lake Aeration Lagoon No. 2	55	WA00568	Pend Oreille	Tr-Little Spokane River-Offstream	Diamond Lake Sewer District	Private	Earth	Water Quality	1987	800	16	61	51	51	0	Significant	WaDOE	Wastewater Treatment
Diamond Lake Aeration Lagoon No. 3	55	WA00567	Pend Oreille	Tr-Little Spokane River-Offstream	Diamond Lake Sewer District	Private	Earth	Water Quality	1987	1570	17	61	51	51	0	Significant	WaDOE	Wastewater Treatment
Diamond Lake Sewage Lagoon No. 1	55	WA01632	Pend Oreille	Tr-Little Spokane River-Offstream	Diamond Lake Sewer District	Private	Earth	Water Quality	1988	500	12	12	10	1	0	Significant	WaDOE	Wastewater Treatment
Dragoon Lake Dam	55	WA00342	Spokane	Dragoon Creek	North Park Development Company	Private	Concrete Gravity	Recreation	1913	200	18	157	157	22	17	Low	WaDOE	Roads and railroad adjacent to site. Less than 1000 AF of new storage
Gatlin Dam No. 1	55	WA01657	Spokane	Dartford Creek-Offstream	Gatlin, Howard H	Private	Earth	Irrigation	1988	110	8	50	25	9	0	Significant	WaDOE	Unable to Locate on USGS 7.5' Topographic Map
Gatlin Dam No. 2	55	WA01658	Spokane	Dartford Creek-Offstream	Gatlin, Howard H	Private	Earth	Irrigation	1988	100	6	50	25	9	0	Low	WaDOE	Unable to Locate on USGS 7.5' Topographic Map
Gatlin Dam No. 3	55	WA01659	Spokane	Dartford Creek-Offstream	Gatlin, Howard H	Private	Earth	Irrigation	1988	100	6	50	25	9	0	Low	WaDOE	Unable to Locate on USGS 7.5' Topographic Map
Homestead Lake Dam	55	WA00035	Pend Oreille	Tr-Moon Creek		Private	Earth	Recreation	1971	420	18	52	30	7	0	Low	WaDOE	Location does not provide room and topography for expansion, adjacent to Moon Creek. Less than 1000 AF of new storage
Isabelle Lake Dam	55	WA01028	Pend Oreille	Tr-Little Spokane River	Wells, Leroy A	Private	Earth	Irrigation	1960	180	22	16	10	2	0	Significant	WaDOE	Location cannot provide significant storage, combined with Decie Dam alternative
Kettwig Wildlife Dam	55	WA00385	Pend Oreille	Spring Heel Creek	Kettwig, D R	Private	Earth	Recreation	1979	550	13	180	100	100	2	Low	WaDOE	Unable to Locate on USGS 7.5' Topographic Map
Koenig Dam	55	WA01014	Pend Oreille	Tr-Otter Creek		Private	Earth	Recreation	1968	80	12	35	15	15	0	Low	WaDOE	Less than 100 AF of new storage
Little Spokane River Dam	55	WA01293	Pend Oreille	West Branch Little Spokane River	Washington Dept. of Wildlife	State	Earth	Recreation	1960	290	8	35	20	20	0	Low	WaDOE	Unable to Locate on USGS 7.5' Topographic Map
Loon Lake Aeration Lagoon	55	WA01495	Stevens	Tr-Loon Lake-Offstream	Loon Lake Sewer District No. 4	Private	Earth	Water Quality	1986	840	12	18	15	1	0	Significant	WaDOE	Wastewater Treatment
Lynda Lake Dam	55	WA01027	Pend Oreille	Tr-Little Spokane River	Wells, Leroy A	Private	Earth	Irrigation	1960	170	22	17	9	2	0	Significant	WaDOE	Location cannot provide significant storage, combined with Decie Dam alternative
Martin Dam	55	WA00531	Spokane	Tr-Deadman Creek	Pizelo, Paul	Private	Earth	Irrigation	1972	500	15	55	30	10	1	Significant	WaDOE	Unable to Locate on USGS 7.5' Topographic Map
Ponderay Newsprint Mill Settling Lagoon	55	WA00598	Pend Oreille	Pend Oreille River-Offstream	Ponderay Newsprint	Private	Earth	Water Quality	1989	2250	24	105	82	8	0	Low	WaDOE	Wastewater Treatment

TABLE 3-1

Dams in WRIAs 55 and 57 (Continued)

Name	WRIA	Federal NID ID	County	Stream	Owner Name	Owner Type	Type of Dam	Dam Purpose	Date Built	Crest Length (ft)	Height (ft)	Max Storage (acre-ft)	Normal Storage (acre-ft)	Surface Area (acres)	Drainage Area (mi2)	Downstream Hazard	Regulating Authority	Reason Removed
Ponderosa Lake Dam	55	WA00041	Stevens	Beaver Creek	Baker, Kedric	Private	Earth	Recreation	1969	412	55	710	357	75	8	Significant	WaDOE	
Reflection Lake North Dam	55	WA00362	Spokane	Sheets Creek	Reflection Lake Homeowners Assoc.	Private	Earth	Recreation	1955	200	8	440	370	58	1	Significant	WaDOE	Extensive development surrounds lake
Reflection Lake South Dam	55	WA00050	Spokane	Sheets Creek	Reflection Lake Homeowners Assoc.	Private	Earth	Recreation	1955	710	23	570	490	58	1	High	WaDOE	Extensive development surrounds lake
Wandermere Lake Dam	55	WA00304	Spokane	Tr-Little Spokane River		Private	Earth	Recreation	1930	1500	4	70	45	11	0	Low	WaDOE	Location within golf course
Deruwe Dam	57	WA01023	Spokane	Saltese Creek		Private	Earth	Irrigation	1966	1200	12	39	24	24	0	Low	WaDOE	Combined with discussion of Saltese Flats
Dosser Reservoir Dam	57	WA00049	Spokane	Quinnamose Creek	Dosser, G A	Private	Earth	Irrigation	1959	950	10	55	42	10	6	Low	WaDOE	Combined with discussion of Saltese Flats
Monroe Street Dam	57	WA00039	Spokane	Spokane River	Washington Water Power Company	Public Utility	Concrete Gravity	Hydroelectric	1973	217	26	68	30	30	4290	Significant	FERC	Owned by Avista Utilities
Morisson Dam	57	WA01605	Spokane	Saltese Creek	Morrison Cattle Company	Private	Earth	Irrigation	1945	1000	5	50	5	5	0	Low	WaDOE	Combined with discussion of Saltese Flats
Newman Lake Flood Control Dam	57	WA00396	Spokane	Thompson Creek	Newman Lake Flood Control Zone Dist	Private	Earth	Recreation	1976	8400	10	11300	8700	1200	29	Low	WaDOE	
Upper Falls Dam	57	WA00038	Spokane	Spokane River	Washington Water Power Company	Public Utility	Concrete Gravity	Hydroelectric	1922	366	25	800	800	135	4290	Significant	FERC	Owned by Avista Utilities
Upriver Station Control Works	57	WA00074	Spokane	Spokane River	City of Spokane	Local Government	Earth	Hydroelectric	1935	725	38	3000	200	160	4215	Significant	FERC	Additional storage is not permitable
Warner Dam	57	WA01325	Spokane	Thompson Creek-Offstream		Private	Earth	Recreation	1975	240	15	25	20	20	0	Low	WaDOE	
Williams Dam	57	WA01520	Spokane	Saltese Creek	Williams, Charles M	Private	Earth	Recreation	1982	1400	10	50	30	30	0	Low	WaDOE	Combined with discussion of Saltese Flats
Woods Lake Dam	57	WA01294	Pend Oreille	Tr-Little Spokane River		Private	Earth	Recreation	1930	225	3	35	35	29	0	Low	WaDOE	Unable to Locate on USGS 7.5' Topographic Map

Notes:

Data obtained from the National Inventory of Dams Database, "Lakes of Washington, Volume II: Eastern Washington" and "Water Resources Study, Metropolitan Spokane Region".

"NA" = not available.

TABLE 3-2

Existing Natural Lakes

Name	WRIA	County	Stream	Volume (AF)	Surface Area (acres)	Drainage Area (mi^2)	Reason Removed	Overlies Aquifer	Roads/Railroads	Inflow	Outflow
Bailey Lake	55	Spokane	Off Stream, Bear Creek	NA	NA	NA	Surrounded by roads would expand into Bear Creek	Little Spokane Aquifer	Roads	Fed by intermittent Creeks	No visible outflow
Bear Lake	55	Spokane	Little Spokane River - Off Stream	NA	33.8	NA	Next to route	Little Spokane Aquifer	Adjacent to Highway 2	None	None
Blue Lake							Connected to Horse Shoe Lake	No	No	Horseshoe Lake	None
Chain Lake	55	Pend Oreille	Little Spokane River	NA	100	13		No	Railroad	Little Spokane River	Little Spokane River
Diamond Lake	55	Pend Oreille	Moon Creek at the Headwaters	21,600	800	6	Extensive development surrounds lake	Diamond Lake Aquifer	Yes	None	West Branch LSR
Eloika Lake	55	Spokane	West Branch Little Spokane River	6,018	661	101	Extensive development surrounds lake	Little Spokane Aquifer	Yes	WB Little Spokane River	WB Little Spokane River
Fan Lake	55	Pend Oreille	West Branch Little Spokane River	NA	72.9	NA	Room for expansion unavailable due to Eloika Lake location	No, some alluvium	Yes	Intermittent Creek	WB Little Spokane River
Horseshoe Lake	55	Pend Oreille	West Branch Little Spokane River	NA	128	80		No, some alluvium	yes	Spring Heel Creek, Buck Creek, West Branch LSR	West Branch LSR
Lake of the Woods		Pend Oreille	Off-stream Little Spokane River	NA	10			No	1 road	None	None
Lost Lake	55	Pend Oreille	Spring Heel Creek	NA	22.1	NA	Little Additional Storage Available	No	No	Spring Heel Creek	Spring Heel Creek
Mallard Marsh Lake	55	Pend Oreille	Unnamed Creek - Terminal Lake	NA	NA	NA	Over aquifer	Diamond Lake Aquifer	Roads and buildings	None	None
Panhandle Lake	55	Pend Oreille	Unnamed Creek - Off Stream	NA	NA	NA	Near roads over aquifer location	Diamond Lake Aquifer	Some roads and buildings	small creek	None
Sacheen Lake	55	Pend Oreille	Moon Creek to West Branch Little Spokane River	7,615	317	34	Extensive development surrounds lake	No	extensive	Moon Creek, Cedar Creek	WB Little Spokane River
Trask Pond	55	Pend Oreille	Elmer Creek	NA	50.3	NA	Location near Stateline on opposite side of ridge	No	No	Elmer Creek	None
Trout Lake	55	Pend Oreille	West Branch Little Spokane River	NA	94.8	NA		Upper Little Spokane Aquifer	Yes	WB Little Spokane River	WB Little Spokane River
Unnamed Lake	55	Pend Oreille	Spring Heel Creek - Off Stream	NA	37.9	NA	Possible leakage problems	No	Yes	None	None
Liberty Lake	57	Spokane	Liberty Creek	16,750	781	13	Extensive development surrounds lake	Spokane Valley Rathdrum Prairie	Yes	Liberty Creek	Liberty Creek
Shelley Lake	57	Spokane	Saltese Creek - Terminal Lake	NA	35.6	NA	Location within City restricts expansion	Spokane Valley Rathdrum Prairie	Yes	Saltese Creek	None

TABLE 3-3

Wetland Systems of WRIA 55 and 57

Wetland Type	Acres	
	WRIA 55	WRIA 57
Lacustrine Permanently Flooded	2,367	2,202
Palustrine Temporarily Flooded	658	124
Palustrine Saturated	22	13
Palustrine Seasonally Flooded	9,614	3,016
Palustrine Semipermanently Flooded	392	100
Palustrine Permanently Flooded	546	144
Riverine Permanently Flooded	188	587
TOTAL	**13,787**	**6,186**

TABLE 3-4

Potential Surface Water Storage Alternatives

		Current				Additional 20 ft of Dam Height					Additional 40 ft of Dam Height				
									Flow (cfs) Necessary to fill reservoir over a					Flow (cfs) Necessary to fill reservoir over a	
Dams	WRIA	Crest Length (ft)	Height (ft)	Max Storage (AF)	Normal Storage (AF)	Crest Length (ft)	Additional Storage (AF)	Crest Length/Additional Capacity Ratio	Year	Month	Crest Length (ft)	Additional Storage (AF)	Crest Length/Additional Capacity Ratio	Year	Month
Ponderosa Lake Dam	55	412	55	710	357	560	2,090	0.3	3	35	750	6,630	0.1	9	110
Newman Lake Flood Control Dam[1]	57	8,400	10	11,300	8,700	8,500	35,040	0.2	48	579	8,600	81,120	0.1	112	1341
Chain Lake[2]	55	-	-		-	600	2,939	0.2	4	49	-	-	-	-	-
Horseshoe Lake[3]	55	-	-	-	-	2,600	14,660	0.2	20	242	2,800	45,880	0.1	63	758
Lake of the Woods						112	494	0.2	1	8	777	2,221	0.0	3	37
Trout Lake[4]	55	-	-	-	-	1,100	3,831	0.3	5	63	2,340	12,489	0.2	17	206
									Flow (cfs) Necessary to fill wetlands over a						
Wetlands	WRIA					Area (ac)	Volume[5] (AF)		Year	Month					
Saltese Flats	57					1,270	2540		4	42					
Newman Lake	57					700	1400		2	23					
WRIA 55	55					920	1840		3	30					

1 1st contour was 33 feet above lake, 20 and 40 ft surface area uses this contour.

2 1st contour was 33 feet above lake surface elevation and would flood Burlington Northern Railroad, therefore storage shown assumes 15 feet elevation increase.

3 1st contour was 30 feet above lake, 20 and 40 ft surface area uses this contour.

4 Adding 40 feet would require the construction of two dams to prevent flooding of Lost Lake, Horseshoe Lake, etc. One dam at the southern end would be 1,600 foot long, and the dam near the north end of the lake would be about 740 foot long.

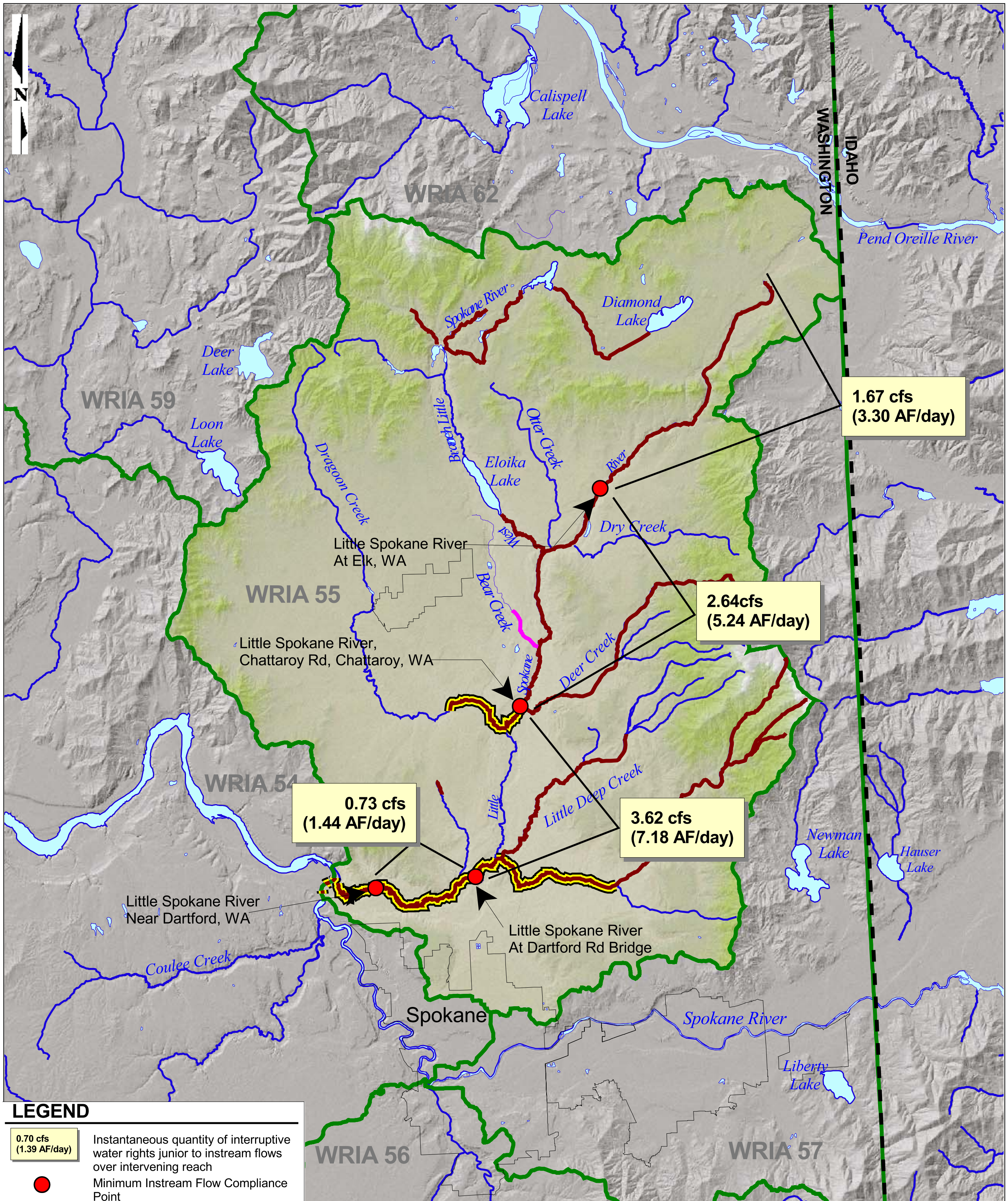
5 Assumes an average depth of 2 feet.

Sand and Gravel Pit Locations
WRIA 55

Id	Permit	Acres	Name	Common Name	Twn	Rge	Section	County	X_coord	Y_coord
Archived										
70012472	12472	6	DEPT OF TRANSPORTATION	SHADY SLOPE CB-C-131	26	43 E	3	Spokane	2772668	907875
70011777	11777	28	SPOKANE ROCK PRODUCTS INC	WANDERMERE	26	43 E	5	Spokane	2762126	907458
70012051	12051	6.49	ACME MATERIALS & CONSTR CO	WEAVER	26	43 E	10	Spokane	2772877	902627
70011535	11535	11.5	DEPT OF TRANSPORTATION	PS-C-45	27	43 E	10	Spokane	2771620	934160
70012188	12188	13	DEPT OF TRANSPORTATION	PS-C-52	29	43 E	14	Spokane	2774587	992484
70010834	10834	3	SPOKANE COUNTY PUBLIC WORKS	DEER PARK/MILAN93-34	29	43 E	34	Spokane	2769909	976449
70012213	12213	30	DEER PARK GRAVEL, INC.	BOGGS PIT	30	42 E	36	Stevens	2747501	1007300
70010119	10119	4.21	PEND OREILLE PUBLIC WORKS	FERTILE VALLEY 3003	30	43 E	3	Pend Oreille	2767594	1034529
70010122	10122	8.2	PEND OREILLE PUBLIC WORKS	SCOTIA	30	45 E	4	Pend Oreille	2825713	1036934
70011078	11078	3	AMERICAN CAMPGROUNDS INC	SCOTIA PIT	30	45 E	4	Pend Oreille	2825713	1036934
70012686	12686	10	PEND OREILLE COUNTY	EMEL #5115	31	45 E	15	Pend Oreille	2830073	1058269
70012653	12653	13	DEPT OF TRANSPORTATION	PS-PO-18 EXT	31	45 E	26	Pend Oreille	2832709	1049465
70010965	10965	5.52	PEND OREILLE PUBLIC WORKS	PIT NO. 5127	31	45 E	27	Pend Oreille	2830530	1047697
70011191	11191	4	DEPT OF TRANSPORTATION	PS-PO-18	31	45 E	26	Pend Oreille	2832480	1048567
Current										
70012873	12873	60	ACME MATERIALS & CONSTR CO	MEAD & LOGAN	26	43 E	2	Spokane	2779161	908071
70010125	10125	40	SPOKANE COUNTY	OLD CORRAL 63-05	26	43 E	5	Spokane	2760436	905374
70010888	10888	10	ACME MATERIALS & CONSTR CO	OLD CORRAL	26	43 E	5	Spokane	2761344	905792
70010276	10276	235	CENTRAL PRE MIX CONCRETE CO	MEAD PIT	26	43 E	9	Spokane	2768743	903281
70012081	12081	15	ACME MATERIALS & CONSTR CO	MEAD-WILSON	26	43 E	10	Spokane	2771122	903954
70010414	10414	50	ACME MATERIALS & CONSTR CO	MEAD BPA PIT	26	43 E	10	Spokane	2770927	903314
70010415	10415	45	ACME MATERIALS & CONSTR CO	CRESTLINE	26	43 E	21	Spokane	2768995	891430
70011939	11939	59.4	ACME MATERIALS & CONSTR CO	HARDESTY	28	43 E	14	Spokane	2777143	959837
70011500	11500	33	DEPT OF TRANSPORTATION	PS-C-105	28	43 E	21	Spokane	2767428	953273
70011589	11589	80	SPOKANE COUNTY PUBLIC WORKS	DENNISON CHATTAROY	28	43 E	28	Spokane	2767077	952042
70012312	12312	36	INTERSTATE CONCRETE & ASPHALT	LEESON #1	29	43 E	14	Spokane	2772428	992250
70012467	12467	36	DEPT OF TRANSPORTATION	PS-C-313	29	43 E	14	Spokane	2773816	990064
70011701	11701	20	TONER SAND & GRAVEL	TONER	29	43 E	14	Spokane	2774384	990064
70010127	10127	44	SPOKANE COUNTY PUBLIC WORKS	NELSON 93-14	29	43 E	14	Spokane	2772551	992915
70012626	12626	80	SPOKANE ROCK PRODUCTS	SRP ELK GRAVEL	29	43 E	14	Spokane	2776055	992120
70012658	12658	5	PEND OREILLE COUNTY	CORNWELL PIT	30	45 E	4	Pend Oreille	2824304	1035851
70012840	12840	20	PEND OREILLE CO PUBLIC WORKS	SMITH PIT	31	45 E	14	Pend Oreille	2836847	1059827
70011773	11773	5	PEND OREILLE PUBLIC WORKS	S COUNTY LANDFILL	31	45 E	28	Pend Oreille	2824033	1046235

Information from WDNR SURFMINES database (http://www.dnr.wa.gov/geology/smgis.htm)

FIGURES



LEGEND

0.70 cfs (1.39 AF/day)	Instantaneous quantity of interruptive water rights junior to instream flows over intervening reach
	Minimum Instream Flow Compliance Point
	Fish Habitat Reaches of Interest (Miller, 2002)
	WRIA Boundaries
	Municipal Boundary
	Lakes
	Rivers and Streams
	City Limits
	State Border
	Mountain Whitefish Distribution
	Rainbow Trout Distribution

0 6

Scale 1" = 6 Miles

Map Projection: Washington State Plane North Zone, NAD83, Feet

Original Data Source: Washington Department of Ecology, USGS, WSDOT

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

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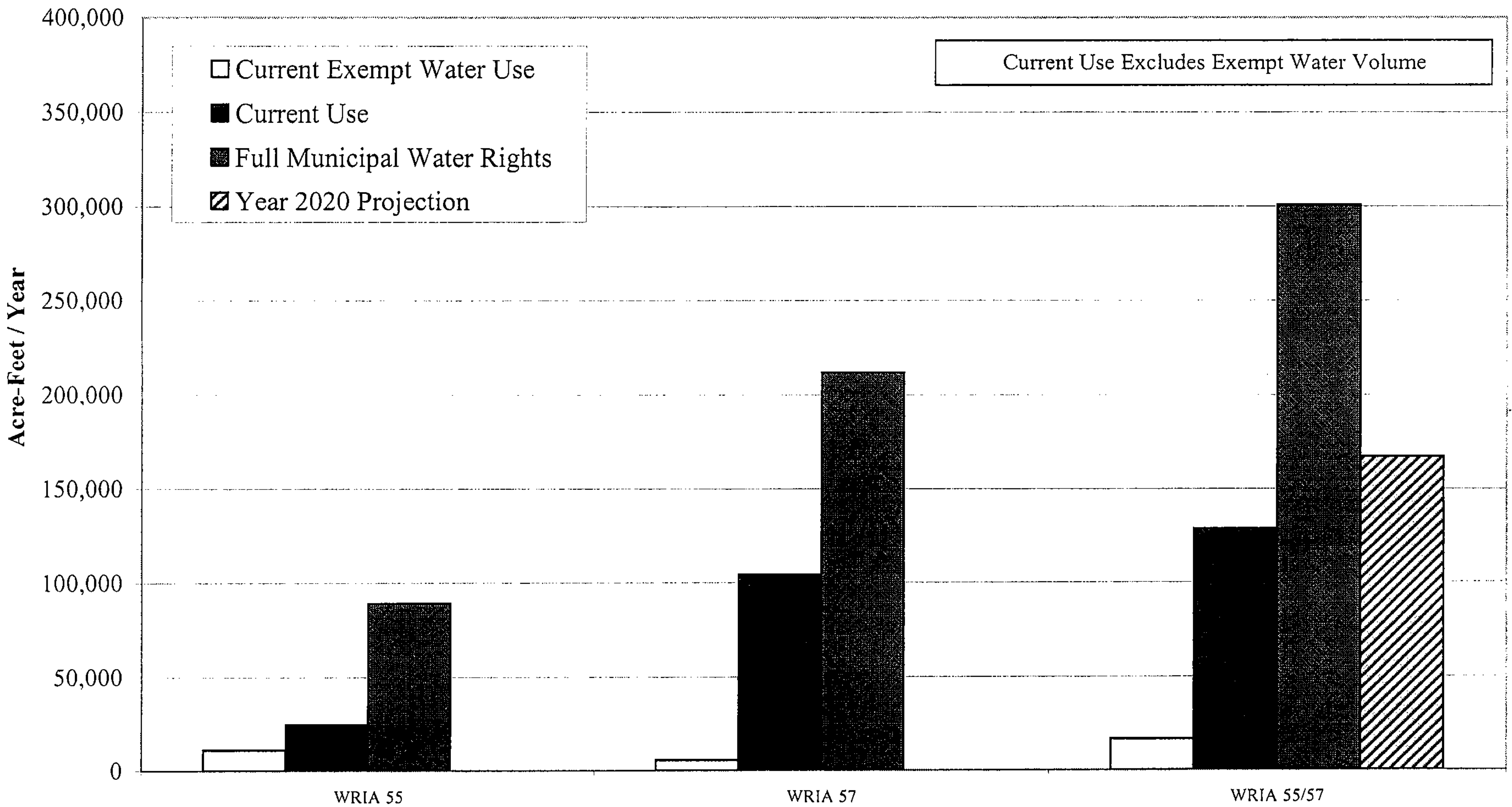
WRIA 55
Junior Water Rights and Fish Habitat Reaches of Interest

Drawn: RMT	Revision: 2	Date: July 06, 2004	Figure: **2-1**

01313725100_062104.apr



Note: Data developed for Spokane Watershed Model Scenarios (Golder, in

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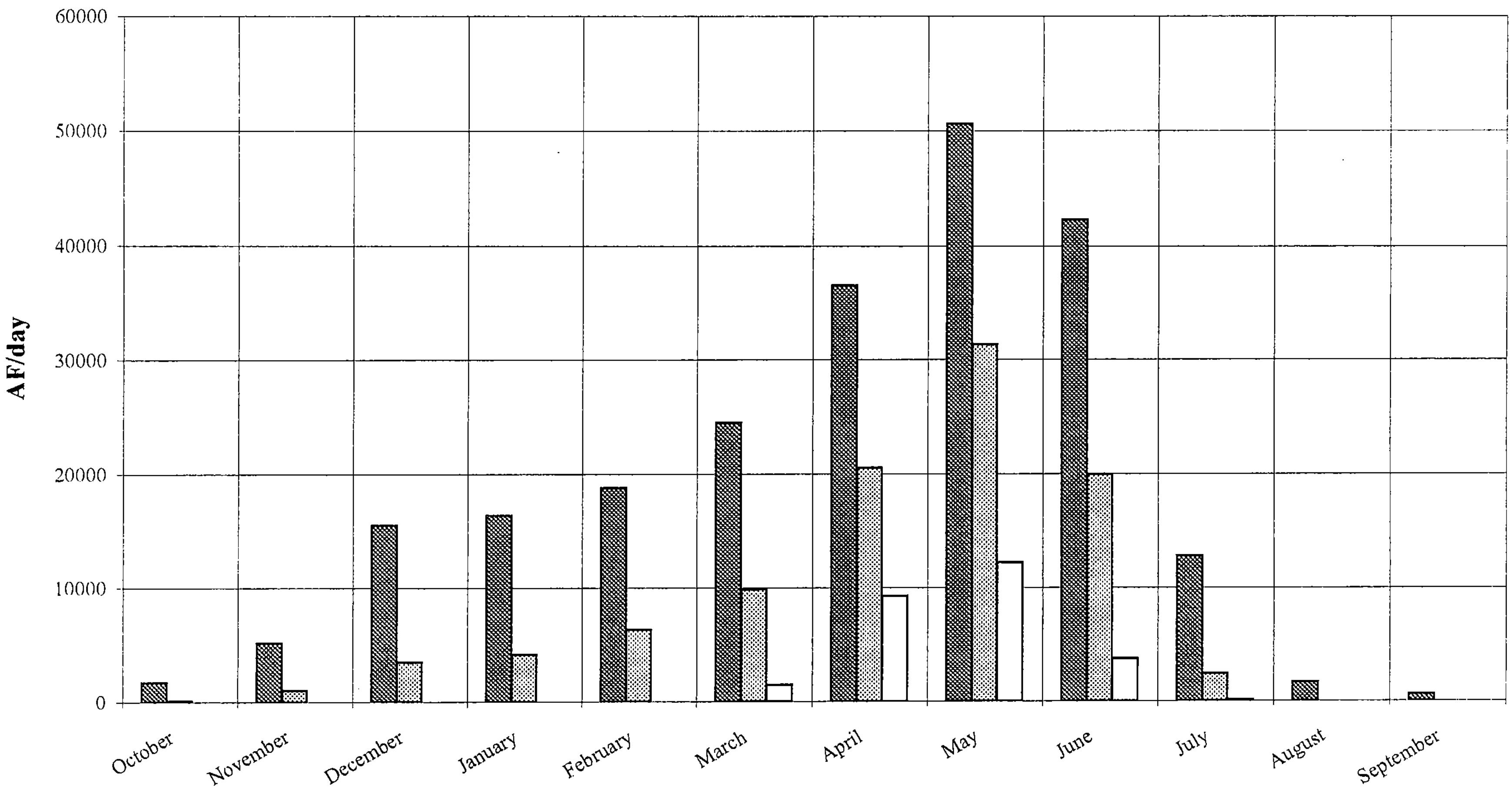
WRIA 55 & 57/ WATERSHED PLANNING/ WA

TITLE

Current, Projected, and Allocated Water Use Comparison

DRAWN	JM	DATE	June 2004	JOB NO.	013-1372
CHECKED		SCALE		DWG. NO.	
REVIEWED		FILE NO.		FIGURE NO.	2.2



Data Source: USGS
Period of Record : 1891-2002
Station Name: Spokane River at Spokane, WA
Station ID: 12422500

Calculated Using
10% Exceedance
50% Exceedance
90% Exceedance

FIGURE 3.1:
Average Daily Volume above WDFW Suggested Minimum Flow (1999) - Spokane River at Spokane, WA

volume available.xls

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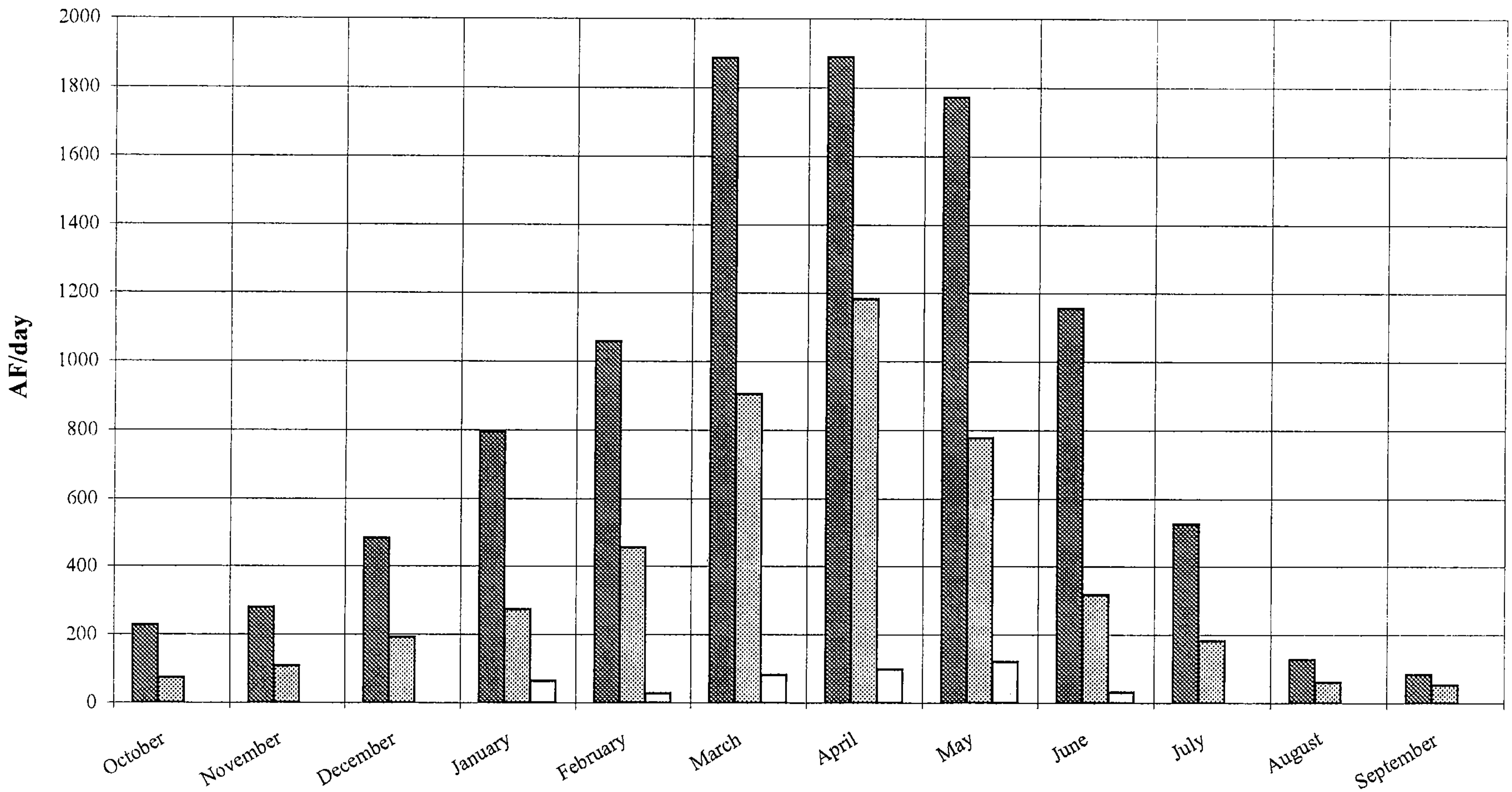
013-1372.001.4100 June 7, 2004



Data Source: USGS
Period of Record : 1948-1952, 1997-2002
Station Name: Little Spokane River near Dartford, WA
Station ID: 12431500

Calculated Using

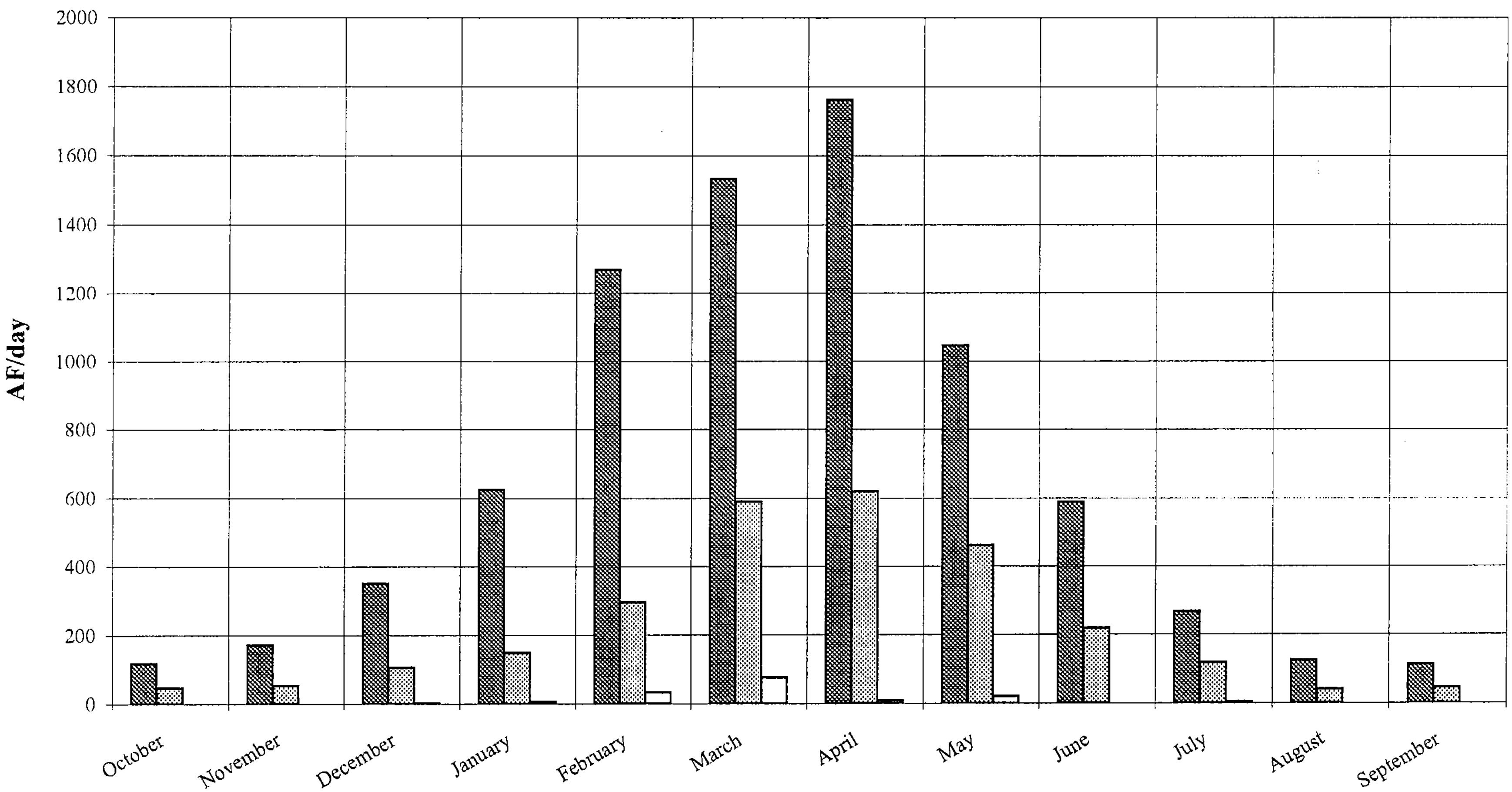
- 10% Exceedance
- 50% Exceedance
- 90% Exceedance

FIGURE 3.2:
Average Daily Streamflow Volume above MISF - Little Spokane River near Dartford, WA

volume available.xls

Golder Associates

013-1372.001.4100 June 7, 2004



Data Source: USGS
Period of Record : 1930-1932, 1948-1999
Station Name: Little Spokane River at Dartford
Station ID: 12431000

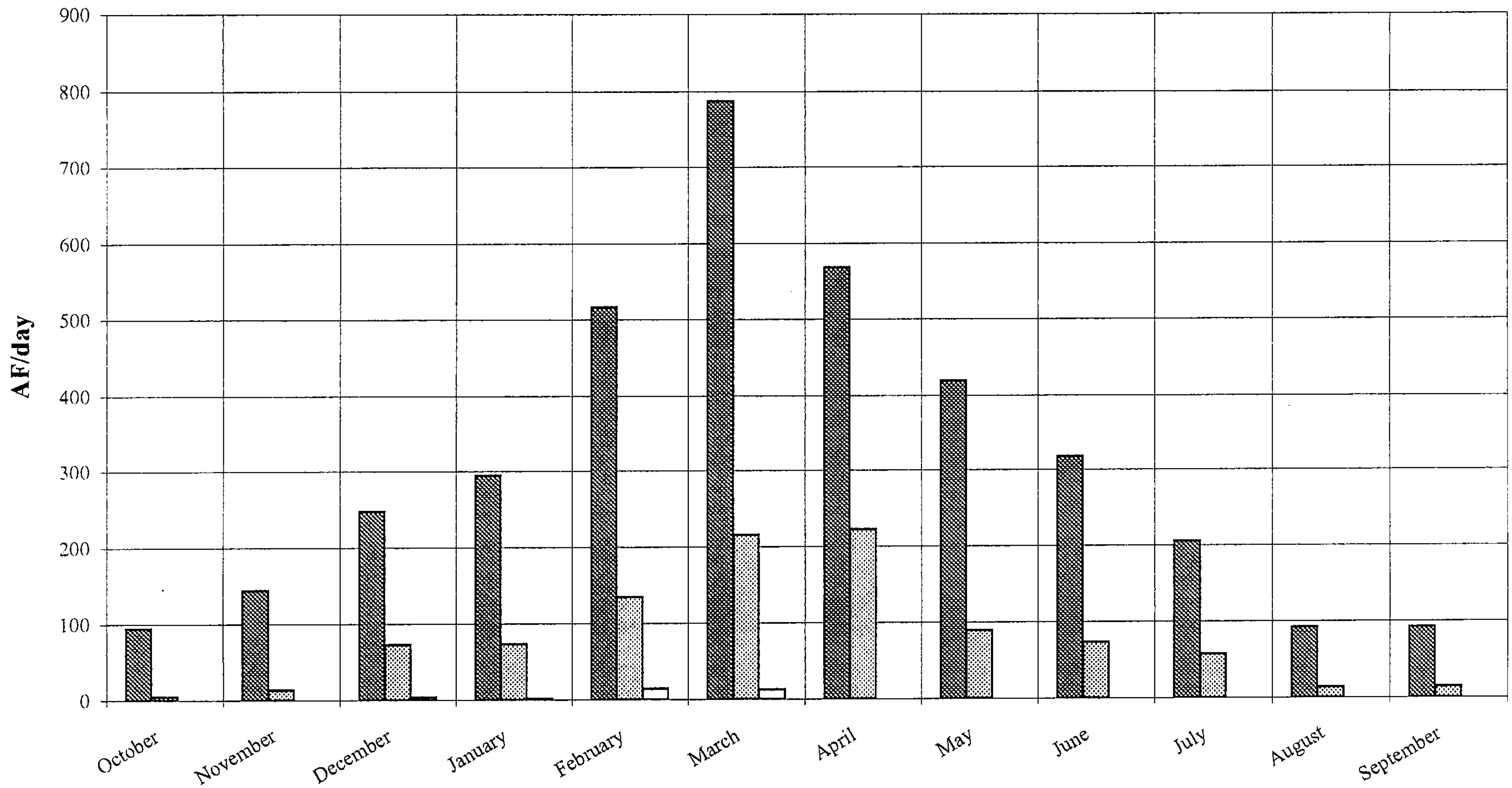
Calculated Using
- 10% Exceedance
- 50% Exceedance
- 90% Exceedance

FIGURE 3.3:
Average Daily Streamflow Volume above MISF - Little Spokane River at Dartford, WA

volume available.xls

Golder Associates

013-1372.001.4100 June 7, 2004



Data Source: USGS
Period of Record : 1976-1996, 1998-1999
Station Name: Little Spokane River, Chattaroy Rd., Chattaroy, WA
Station ID:

Calculated Using
- 10% Exceedance
- 50% Exceedance
- 90% Exceedance

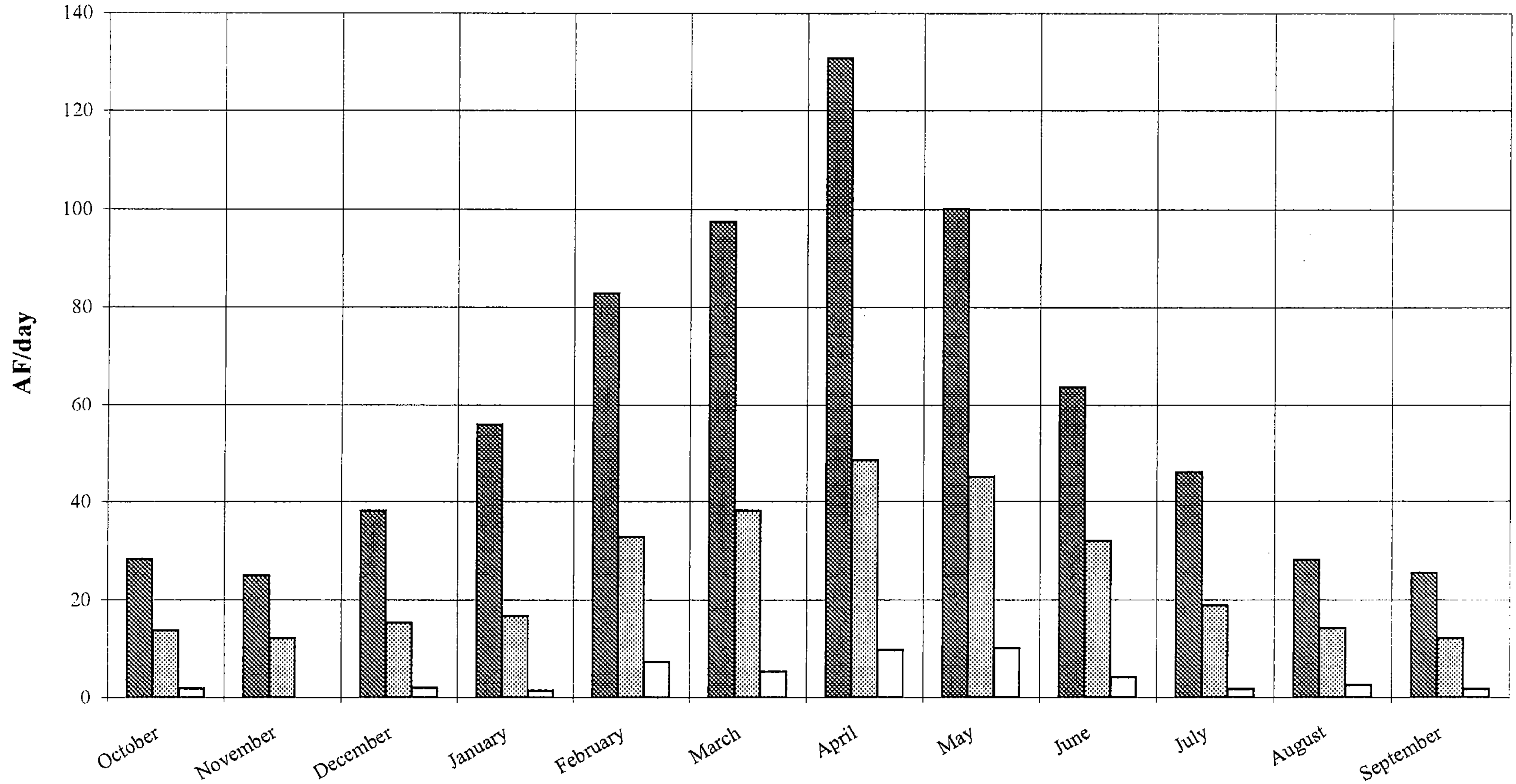
FIGURE 3-4:
Average Daily Streamflow Volume above MISF - Little Spokane River at Chattaroy, WA

volume available.xls

Golder Associates

013-1372.001.4100 June 7, 2004

volume available/LSR at Chattaroy Graph



Data Source: USGS
Period of Record : 1949-1971
Station Name: Little Spokane River at Elk
Station ID: 12427000

Calculated Using

- 10% Exceedance
- 50% Exceedance
- 90% Exceedance

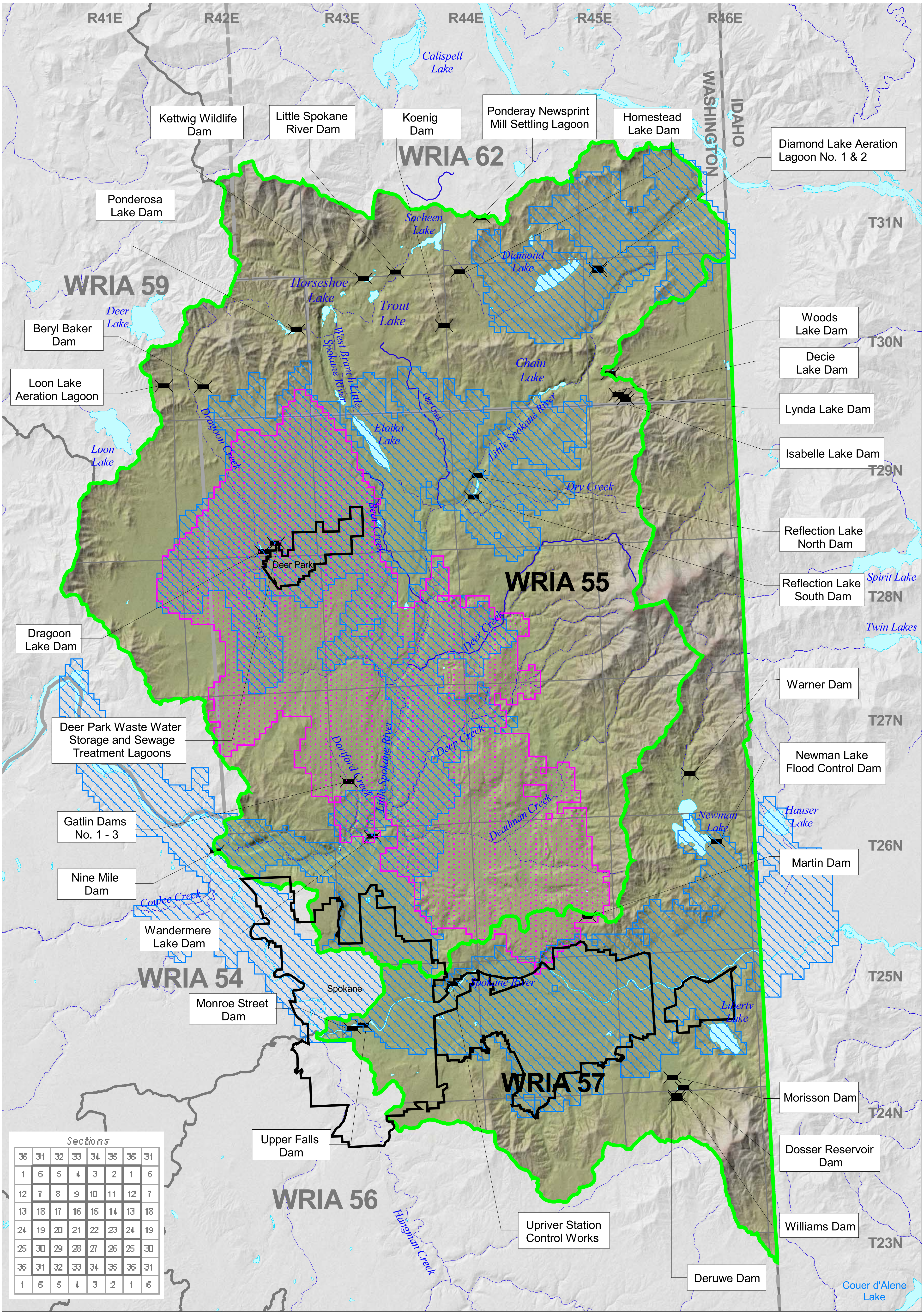
FIGURE 3.5:
Average Daily Streamflow Volume above MISF - Little Spokane River at Elk, WA

volume available.xls

Golder Associates

013-1372.001.4100 June 7, 2004

volume available/LSR at Elk Graph



Legend

- WRIA Boundaries
- Municipal Boundaries
- Basalt and Latah
- Sands and Gravels
- Sections
- Dam
- Rivers and Streams
- Lakes
- County Boundaries

N

0 4

Scale 1" = 4 Miles

Original Data Source: Washington Department of Ecology, USGS, U.S. Army Corps of Engineers

Map Projection: Washinton State Plane North Zone, NAD83, Feet

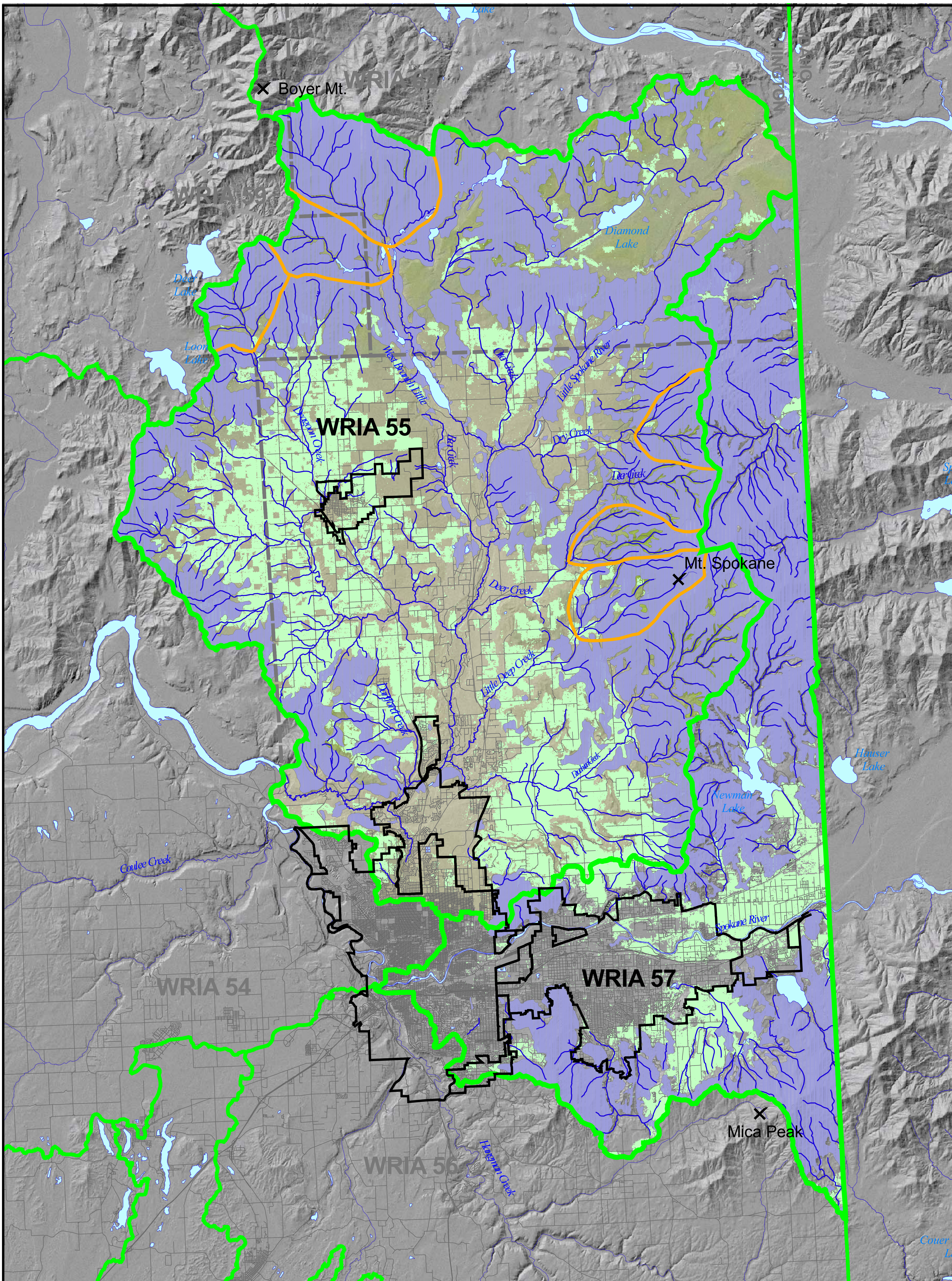
The figure was originally produced in color. Reproduction in black and white may result in loss of information

Golder Associates

Locations of Existing Dams and Surface Water Storage

Drawn: RMT	App'd:	Date: June 21, 2004	Figure: 3-6

01313725100_062104.apr



LEGEND

- WRIA Boundaries
- Lakes
- Urban Growth Area
- City Limits
- Roads
- County Lines
- Rivers
- Agricultural Land - May Include: Crops, Grains, Orchords, Pasture, and Fallow Land.
- Crystalline Basement
- Potential New Storage Sub-basins

Note: Roads coverage for Stevens and Pend Orielle County were not obtained.

0 20,000

Scale 1" = 20,000 Feet

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Map Projection: Washington State Plane, NAD83, North Zone, Feet

Source: National Land Cover Database (1980) USGS, WSDOE, Golder Associates Inc.

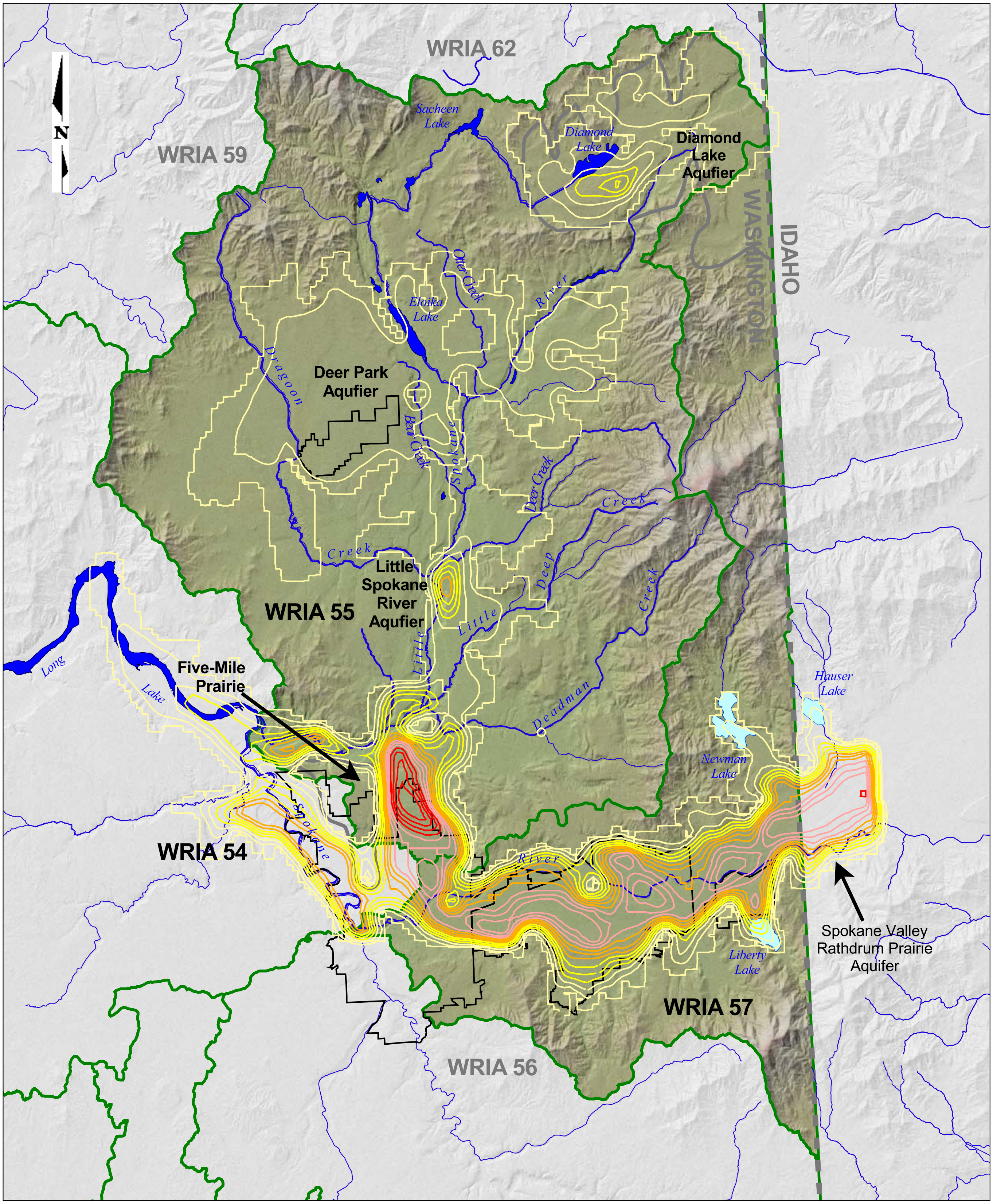
Sub-basins with Storage Potential for New Dams

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: RMT	Date: July 2, 2004	Figure: 3-7

01313725100_062104.apr

Golder Associates



LEGEND

WRIA Boundaries
Aquifer Boundary
Municipal Boundary
Lakes
Rivers
State Line

50 Foot Contours
0 - 100
150 - 250
300 - 400
450 - 550
600 - 750

0 6 Miles
Scale 1" = 6 Miles

Map Projection:
Washington State Plane, NAD83,
North Zone, Feet

Source: USGS, WSDOE,
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

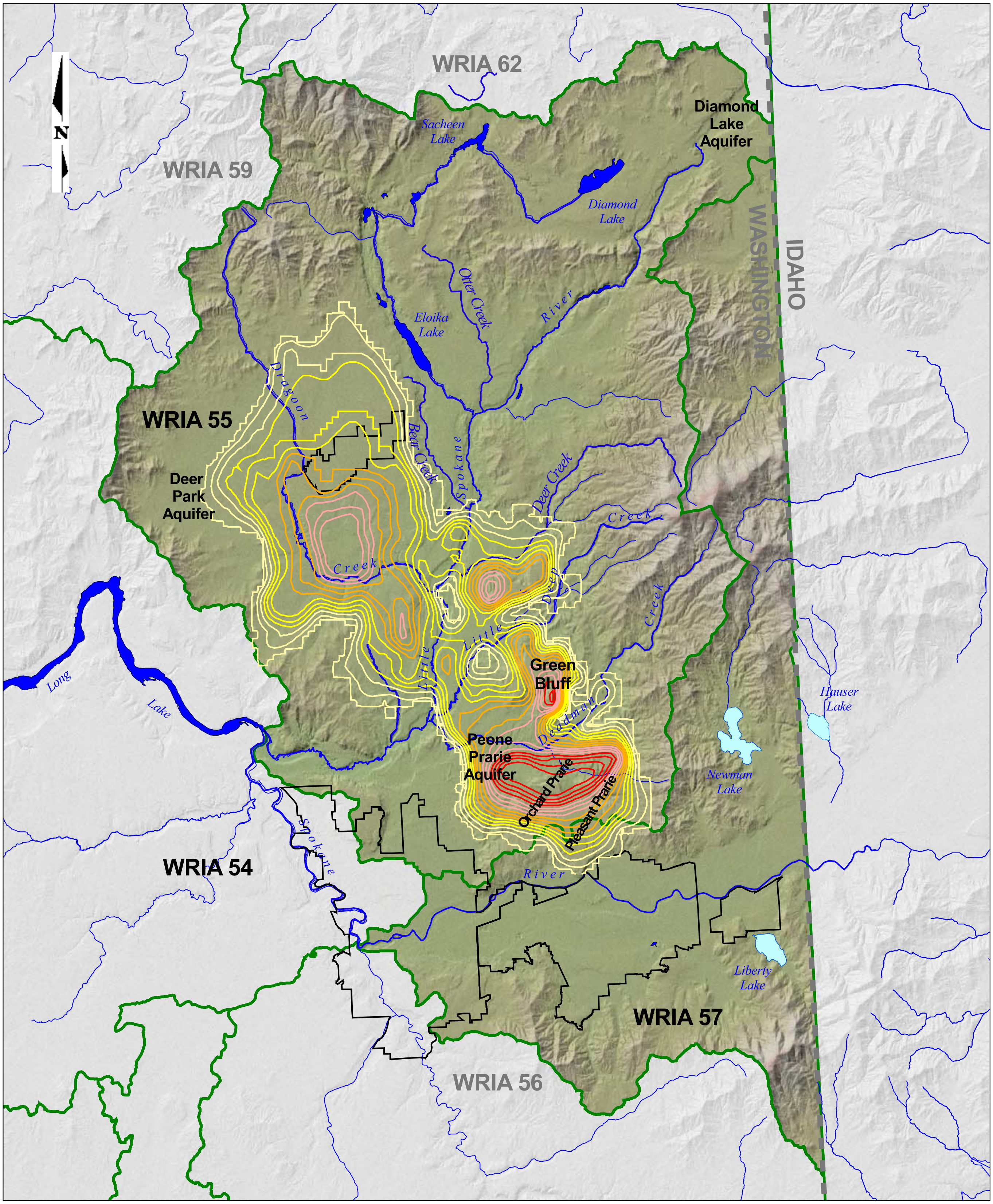
Thickness of Glaciofluvial Sediments (Sands and Gravels)

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: 3	Date: June 21, 2004	Figure: **4-1**

01313725100_062104.apr

Golder Associates



LEGEND

- WRIA Boundaries
- Aquifer Boundary
- Municipal Boundary
- Lakes
- Rivers
- State Line

50 Foot Contours

- 0 - 100
- 150 - 250
- 300 - 400
- 450 - 550
- 600 - 750

0 6 Miles

Scale 1" = 6 Miles

Map Projection:
Washington State Plane, NAD83,
North Zone, Feet

Source: USGS, WSDOE,
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

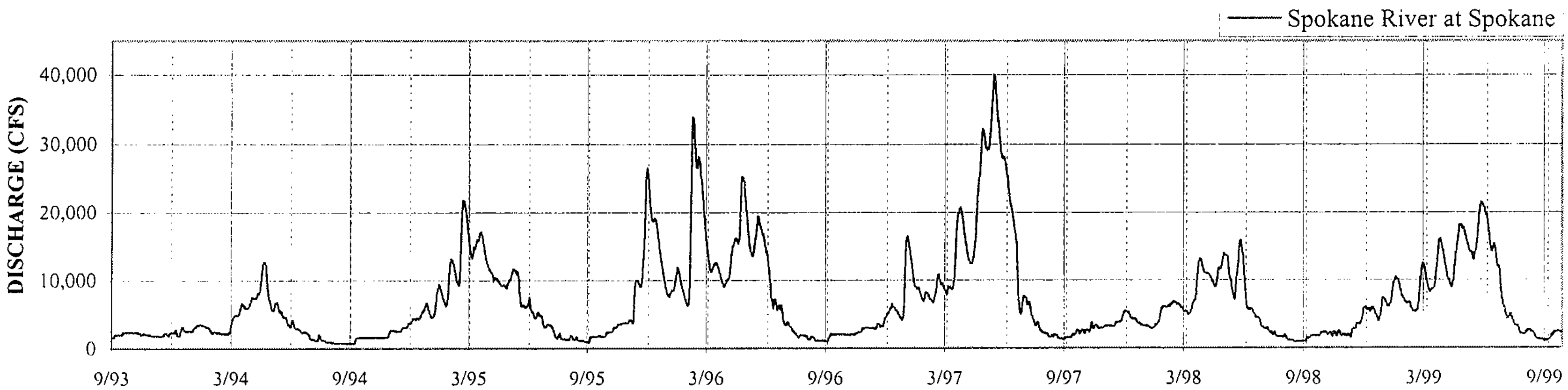
Thickness of Basalt and Latah Formations

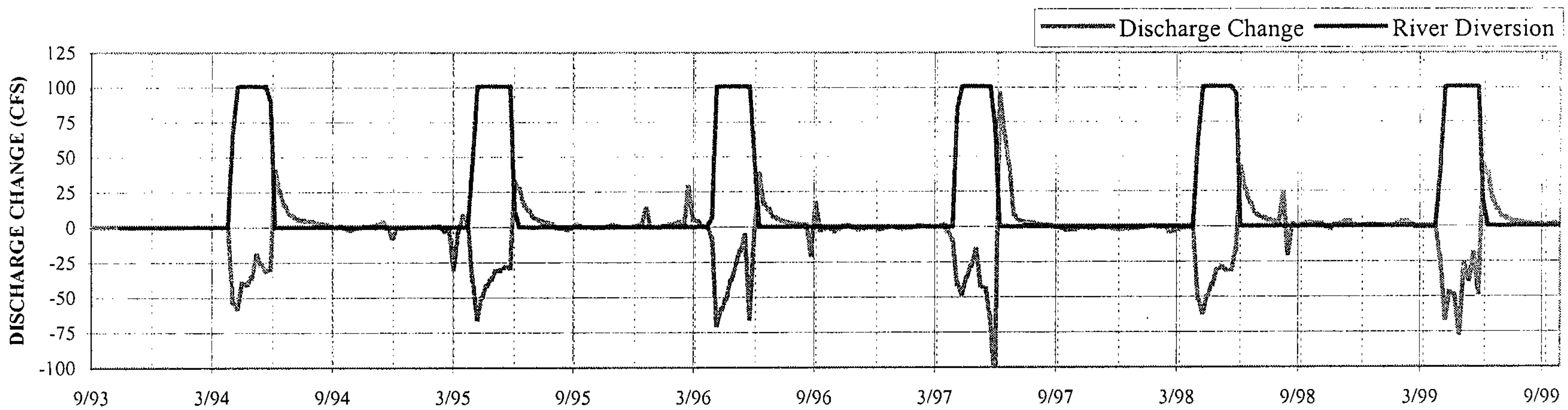
WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: RMT	Date: June 21, 2004	Figure: 4-2

01313725100_062104.apr

Golder Associates





Note: Model Outliers Removed

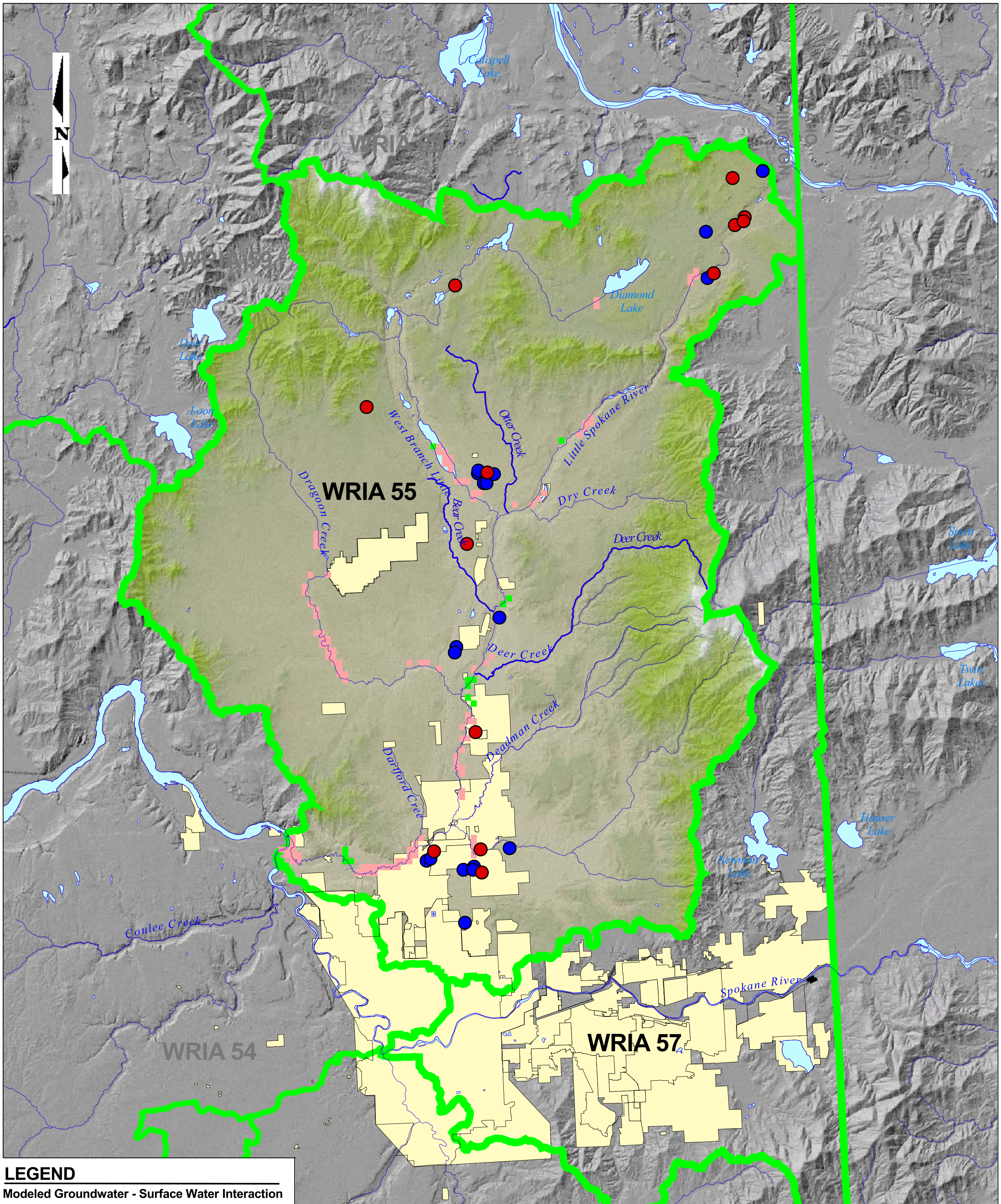
Golder Associates

WRIA 55 & 57/ WATERSHED PLANNING/ WA

TITLE

SCENARIO 2 : CHANGE IN DISCHARGE SPOKANE RIVER AT SPOKANE

DRAWN	JM	DATE	April 2004	JOB NO.	013-1372
CHECKED		SCALE	na	DWG. NO.	
REVIEWED		FILE NO	Scen2InjWell_033004a-c.frf	FIGURE NO.	4.3



LEGEND

Modeled Groundwater - Surface Water Interaction

- Gaining
- Losing

Gravel Pits

- Archived
- Active
- Water District Boundary
- WRIA Boundary
- Lakes
- Municipal Boundary
- Rivers

0 6

Scale 1" = 6 Miles

Map Projection:
Washington State Plane, NAD83,
North Zone, Feet

Source: National Land Cover
Database (1980) USGS, WSDOE,
Golder Associates Inc.

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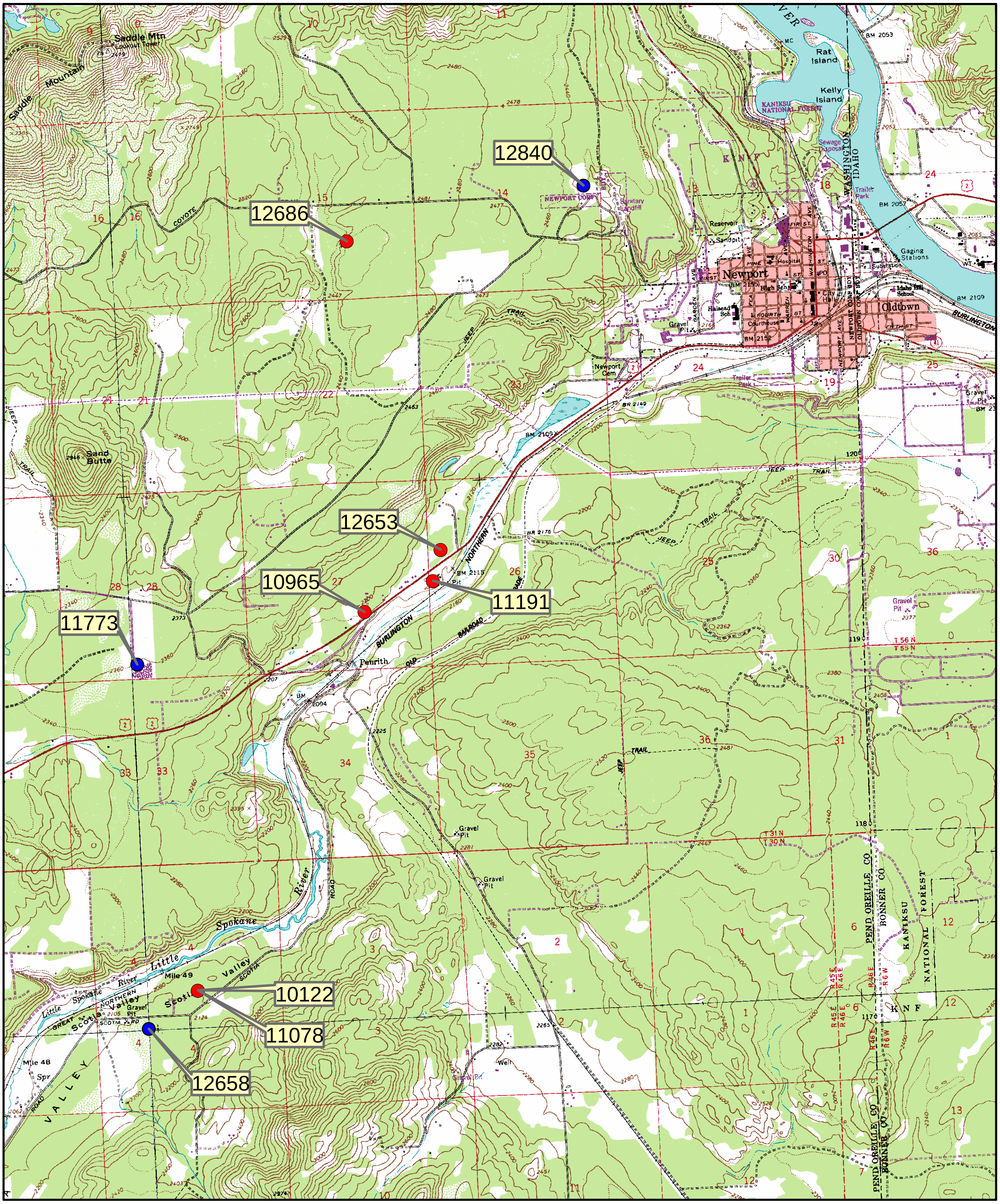
WRIA 55 Gravel Pits

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: 4	Date: July 1, 2004	Figure: 4-4

01313725100_062104.apr

Golder Associates



LEGEND

- Gavel Pits Archived
- Gavel Pits

0 4000 Ft.

Scale 1" = 4000 Feet

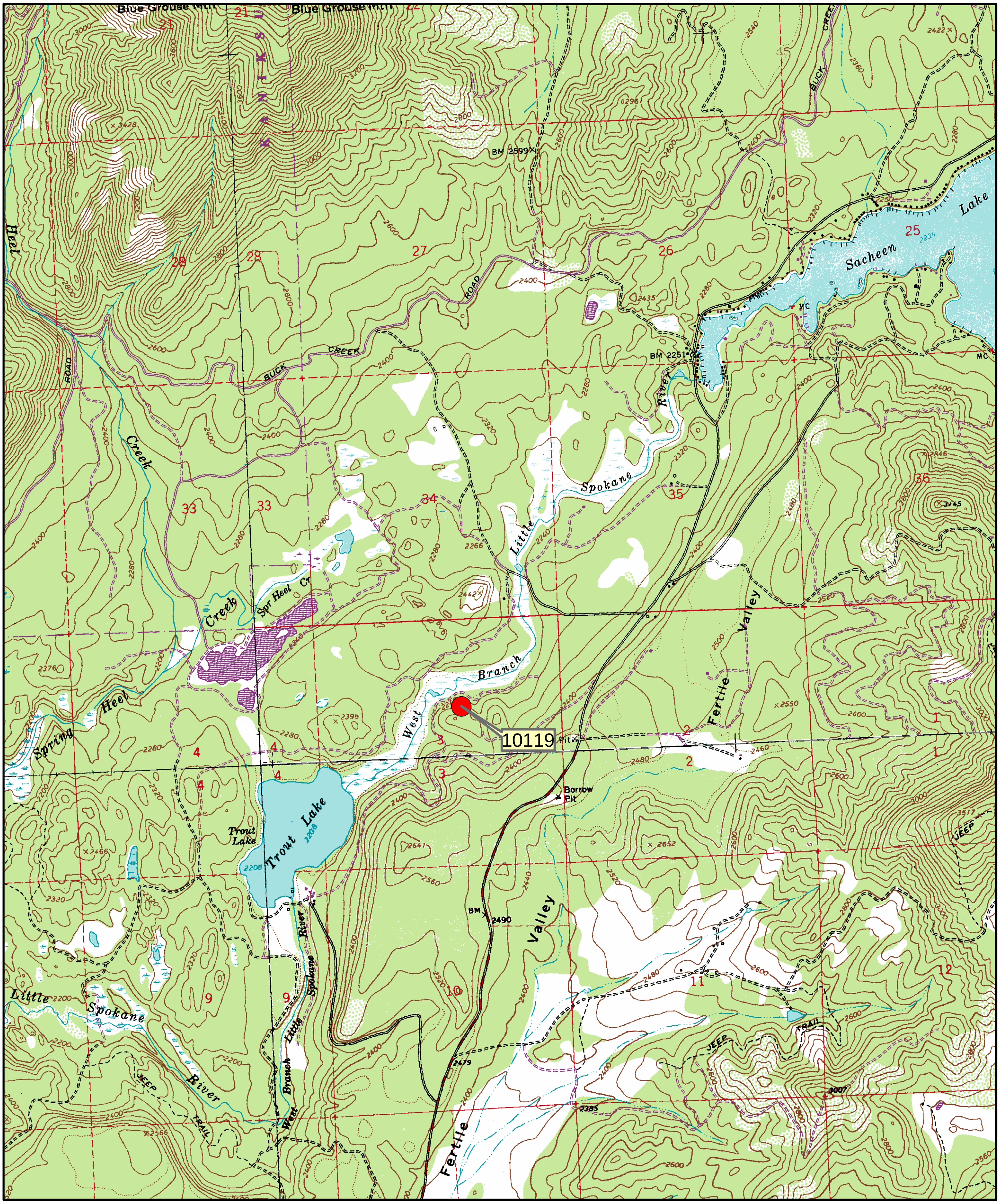
This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Gravel Pits - Area 1

Drawn: RMT	Revision: 1	Date: July 8, 2004	Figure: 4-5

01313725100_Gravel_pits_working1.mxd

Golder Associates



LEGEND

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

- Gavel Pits Archived
- Gavel Pits

0 3000 Ft.

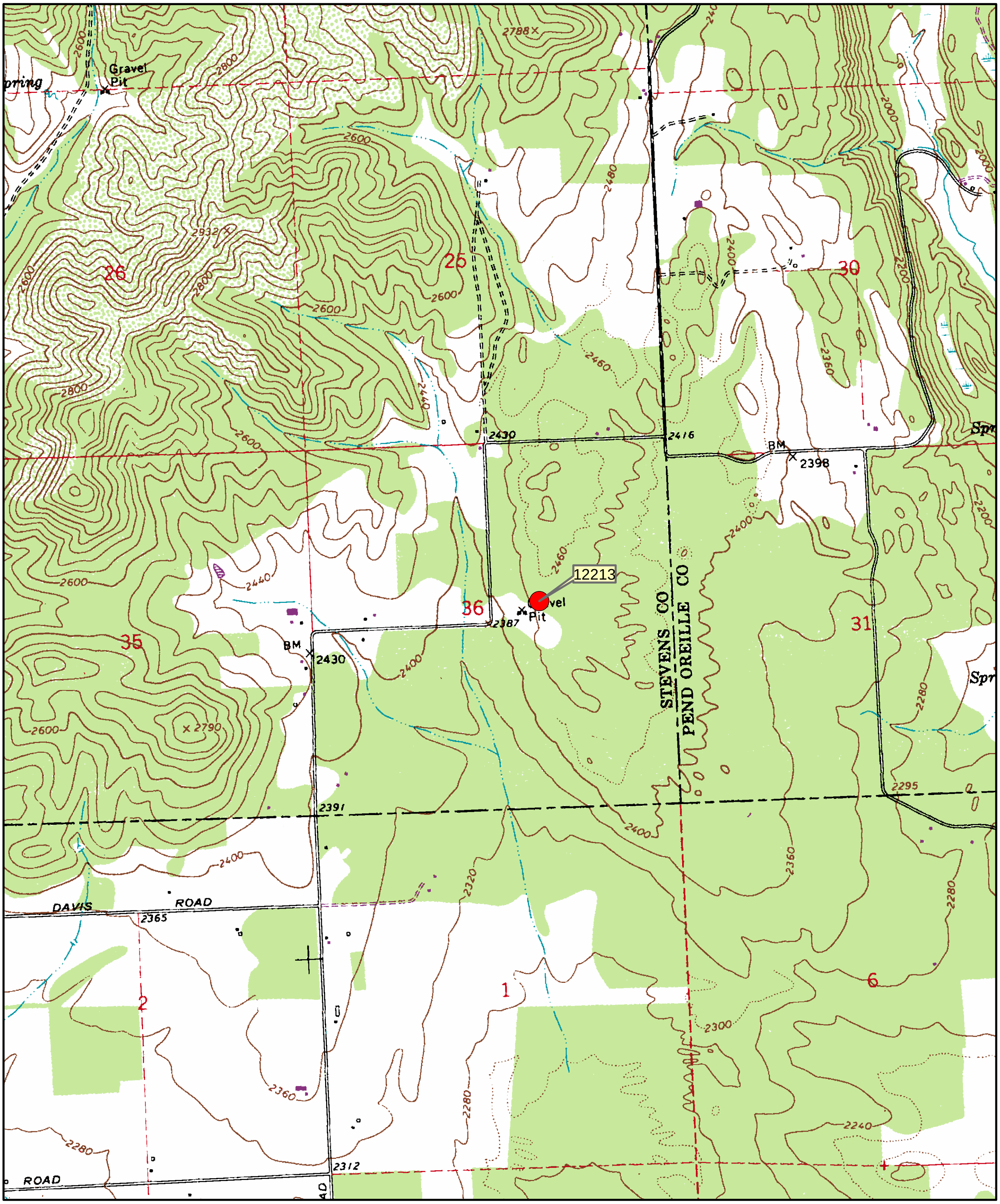
Scale 1" = 3000 Feet

Gravel Pits - Area 2

Drawn: RMT	Revision: 1	Date: July 8, 2004	Figure: 4-6

01313725100_Gravel_pits_working2.mxd

Golder Associates



LEGEND

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

- Gavel Pits Archived
- Gavel Pits

0 2000 Ft.

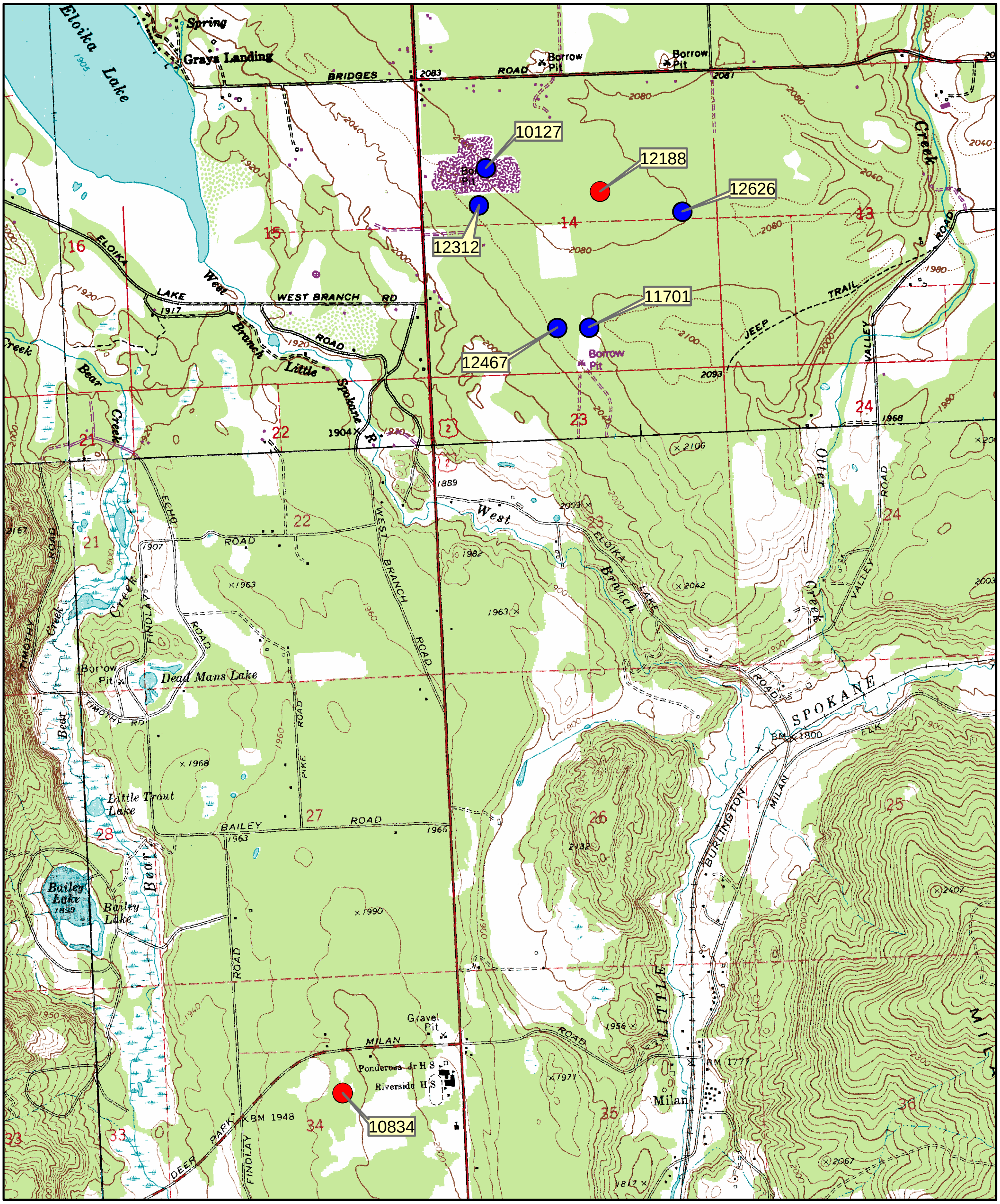
Scale 1" = 2000 Feet

Gravel Pits - Area 3

Drawn: RMT	Revision: 1	Date: July 8, 2004	Figure: 4-7

01313725100_Gravel_pits_working3.mxd

Golder Associates



LEGEND

- Gavel Pits Archived
- Gavel Pits

0 2500

Scale 1" = 2500 Feet

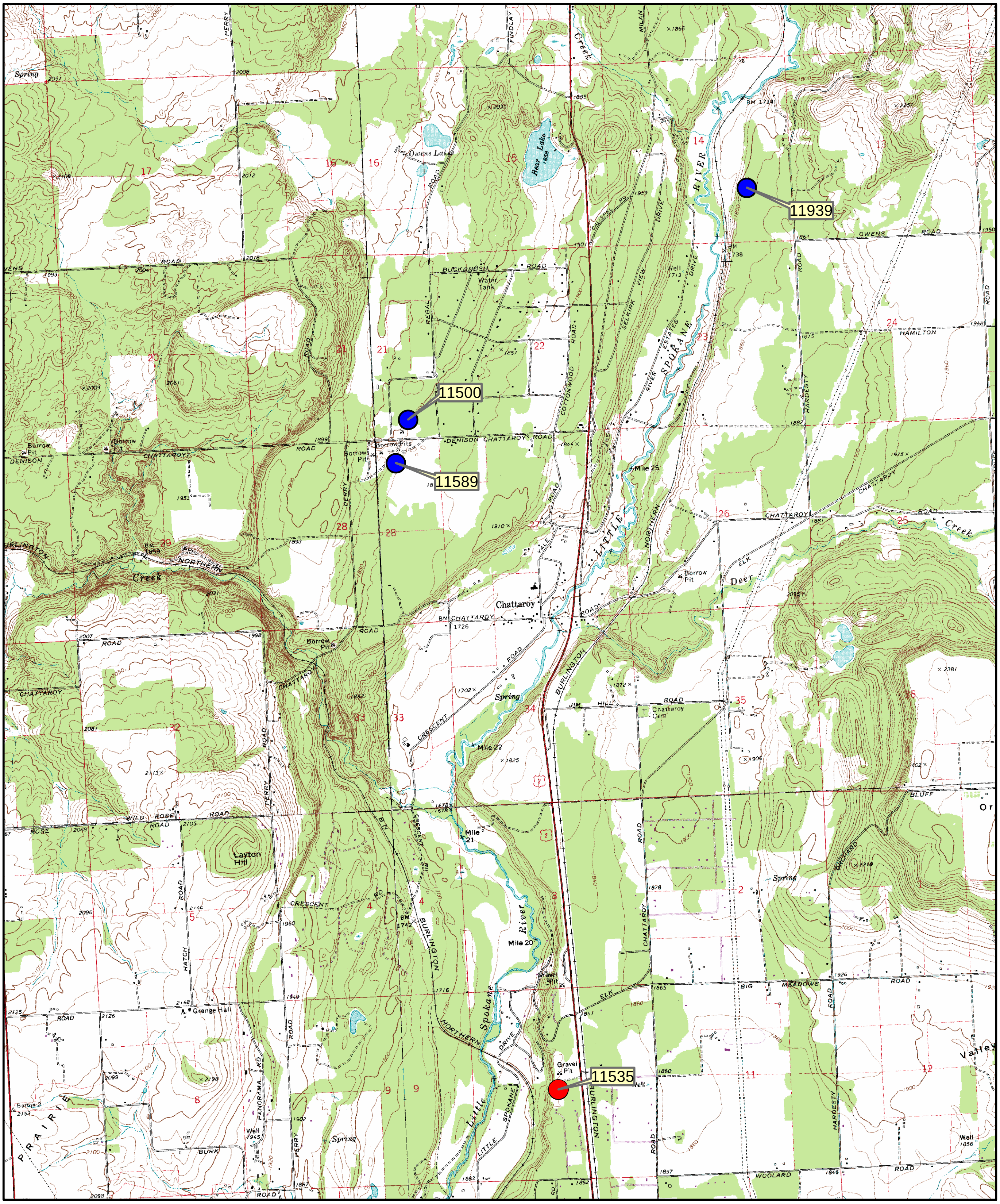
This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Gravel Pits - Area 4

Drawn: RMT	Revision: 1	Date: July 8, 2004	Figure: 4-8

01313725100_Gravel_pits_working4.mxd

Golder Associates



LEGEND

- Gavel Pits Archived
- Gavel Pits

0 4000

Scale 1" = 4000 Feet

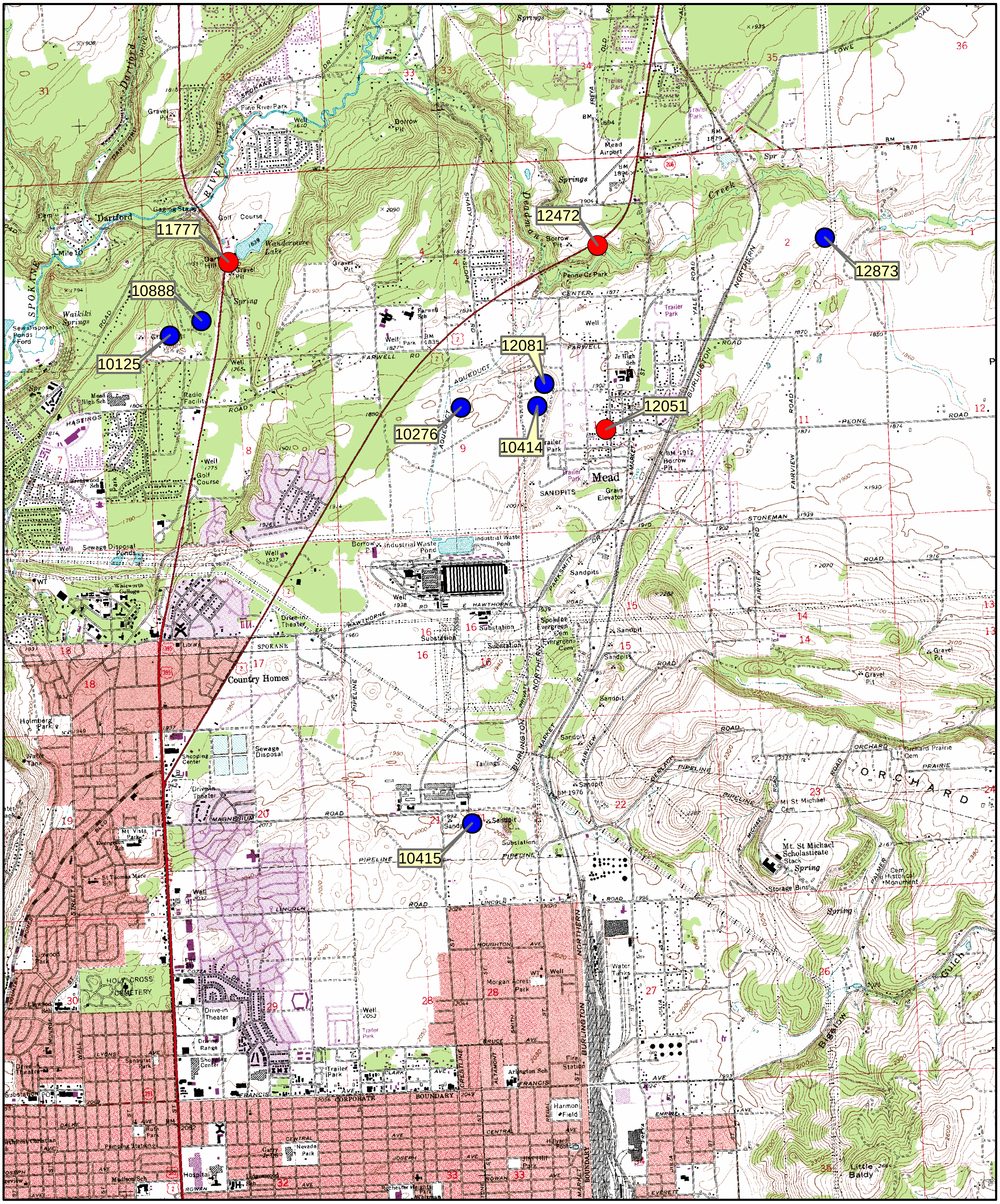
This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Gravel Pits - Area 5

Drawn: RMT	Revision: 1	Date: July 8, 2004	Figure: 4-9

01313725100_Gravel_pits_working5.mxd

Golder Associates



LEGEND

- Gavel Pits Archived
- Gavel Pits

0 4000

Scale 1" = 4000 Feet

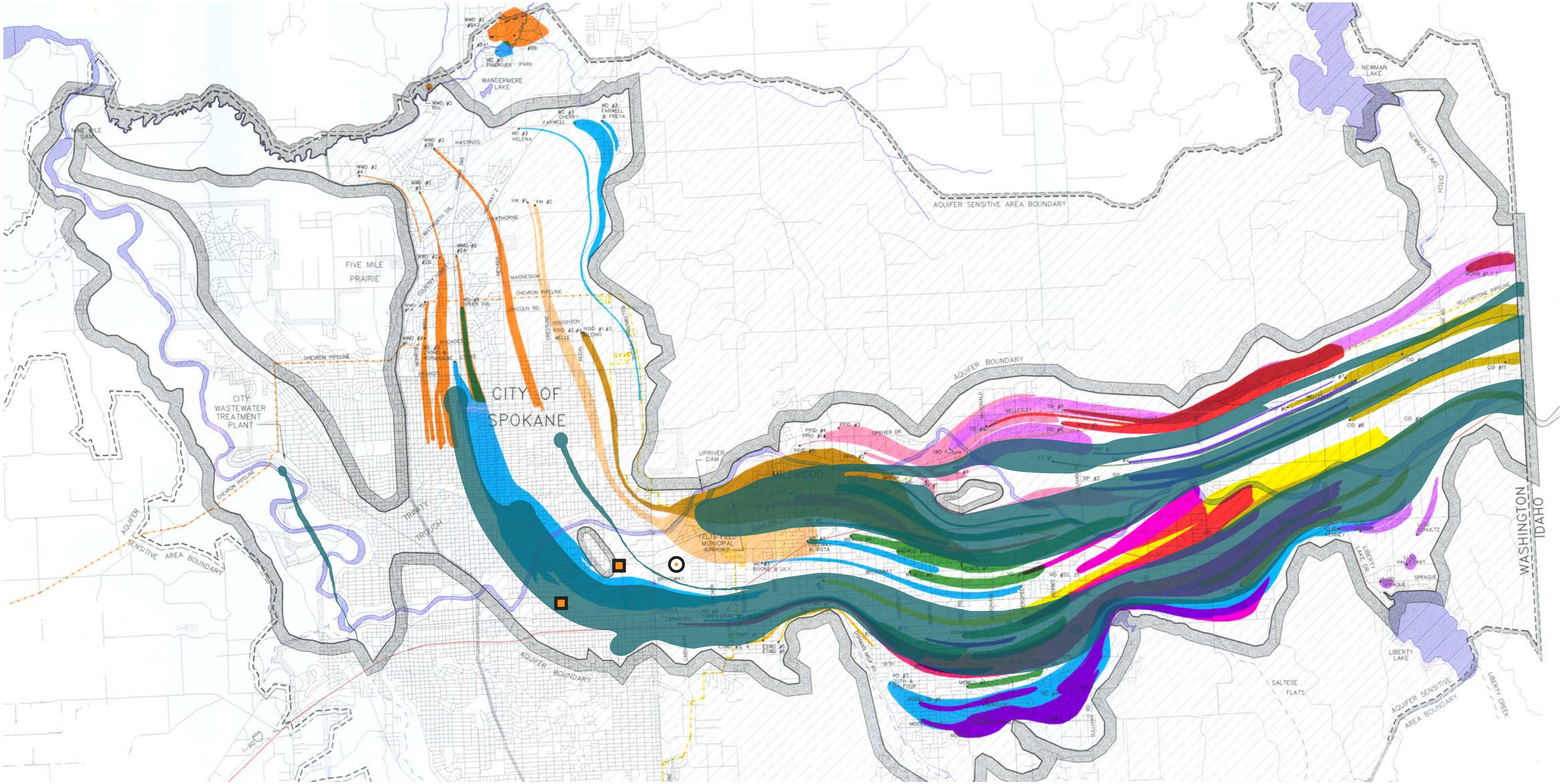
This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Gravel Pits - Area 6

Drawn: RMT	Revision: 1	Date: July 8, 2004	Figure: 4-10

01313725100_Gravel_pits_working6.mxd

Golder Associates



LEGEND

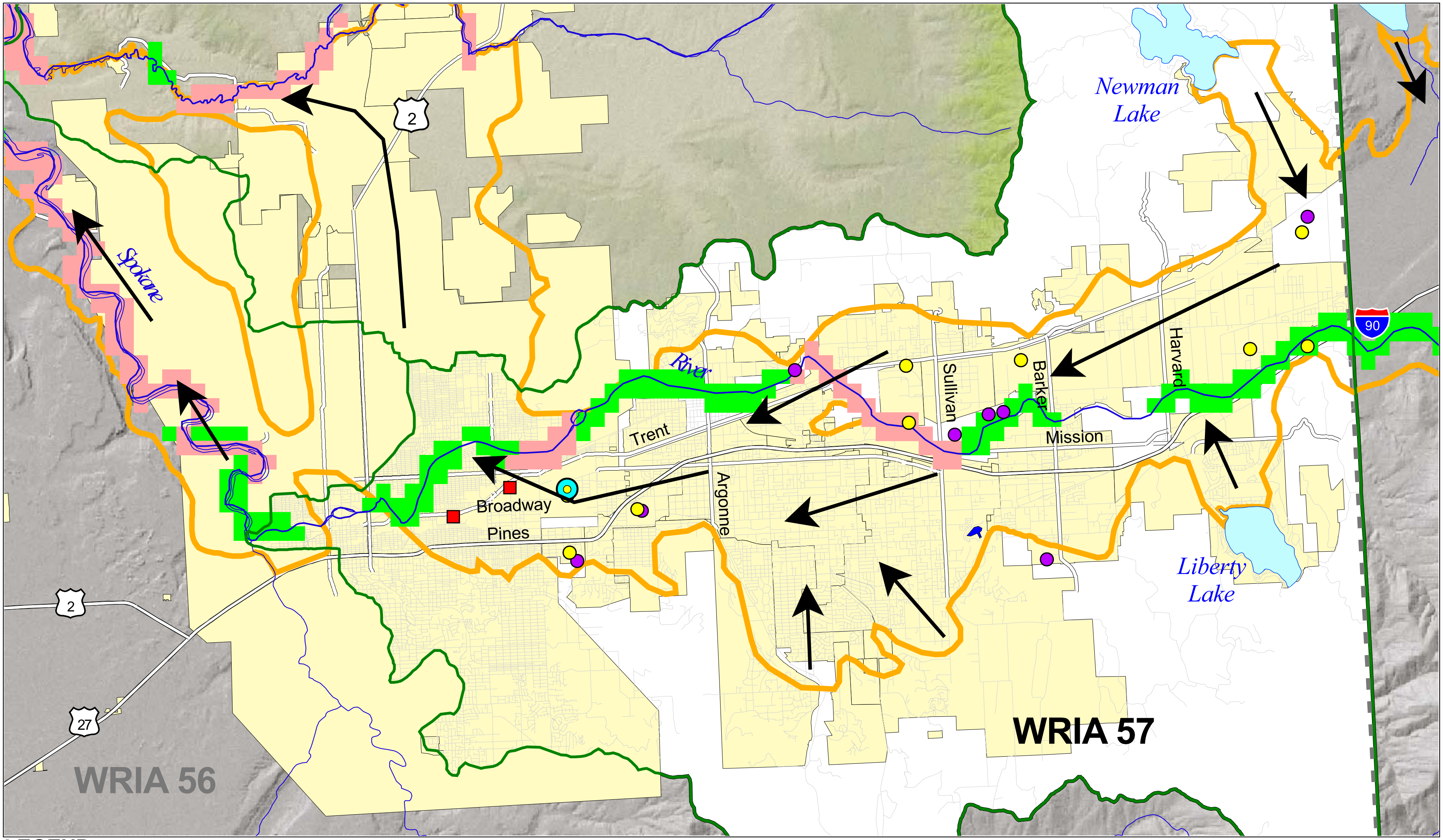
- ■ Proposed Sites For SCRTP
- ⊙ Proposed Recharge Site

Reference: After CH2M Hill (1997,2000)

FIGURE **4-11**
PROPOSED SCRTP SITES AND SPOKANE AQUIFER WELLHEAD PROTECTION AREAS
SPOKANE/WRIA 55 STORAGE ASSESS/WA

DRAWING NO. 01313720014200fg01.fh11 DATE 10/04/04 DRAWN BY AMP

Golder Associates



LEGEND

- WRIA Boundaries
- Lakes
- SVRP Aquifer Boundary
- Water District Boundary
- Potential Sites for SCRTP
- Streets
- General Direction of Groundwater Flow

Modeled Groundwater - Surface Water Interaction

- Losing
- Gaining

Gravel Pits

- Archived
- Active
- Potential Recharge Location from SCRTP

- Rivers
- State Line

0 2.5 Miles

Scale 1" = 2.5 Miles

Map Projection:
Washington State Plane, NAD83,
North Zone, Feet

Source: USGS, WSDOE,
Golder Associates Inc.

N

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Proposed Reclaimed Water Recharge Site

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: 2	Date: Jul. 1, 2004	Figure: **4 - 12**

01313725100_062104.apr

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APPENDIX A

Potential Surface Storage in Existing Lakes and Reservoirs

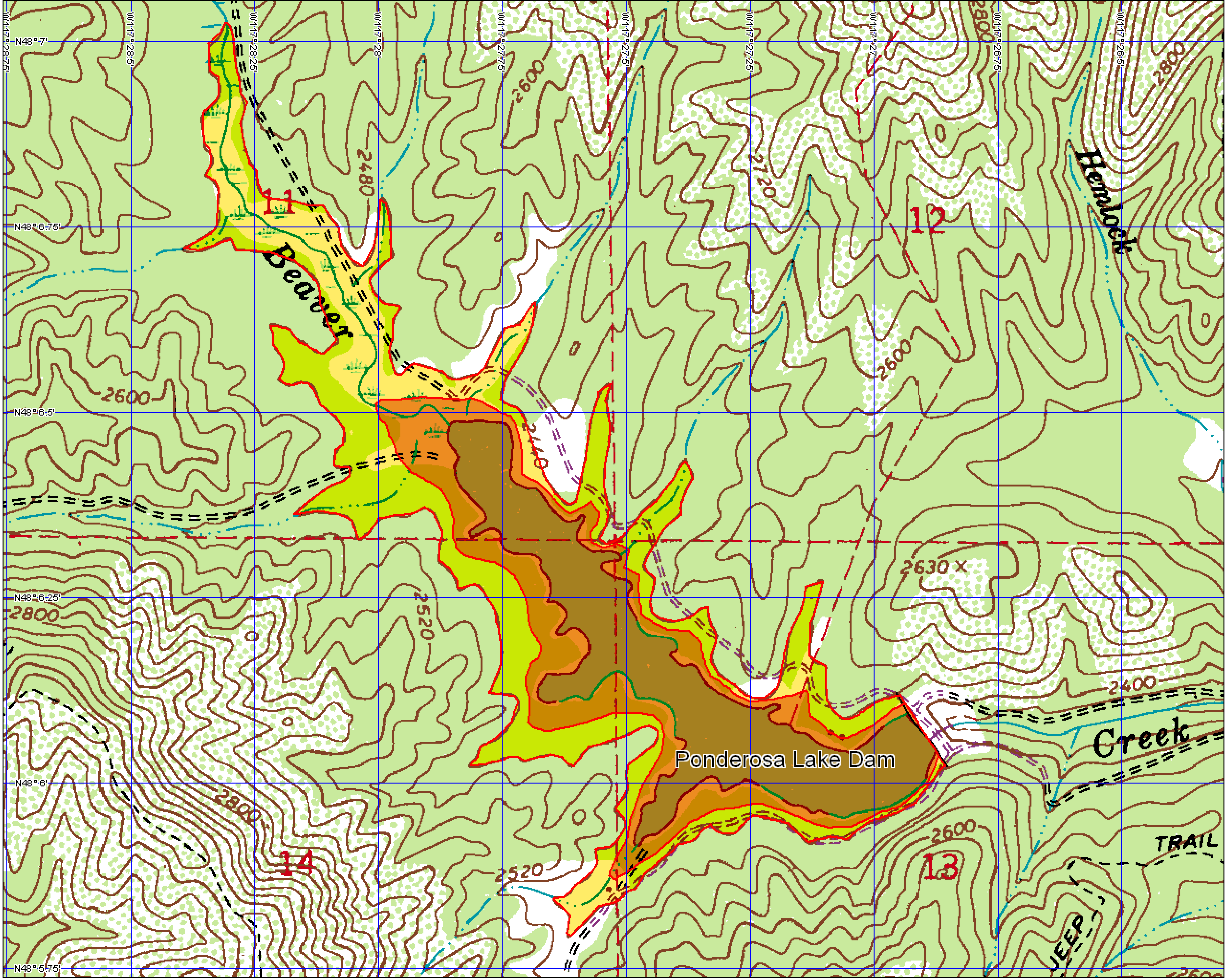
Table of Contents

Legend

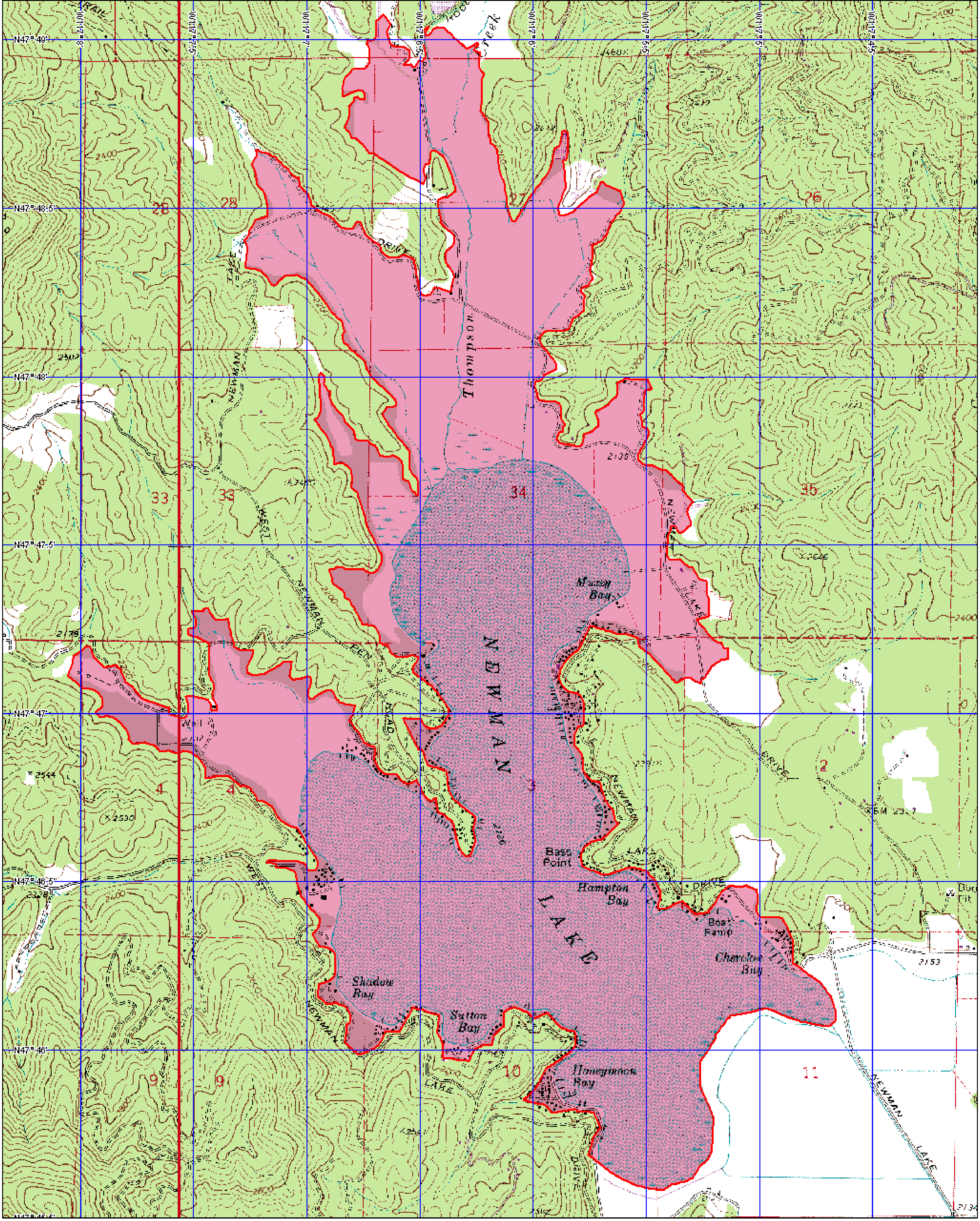
Area flooded by 20-foot dam raise.

Area flooded by 40-foot dam raise (forested/open land).

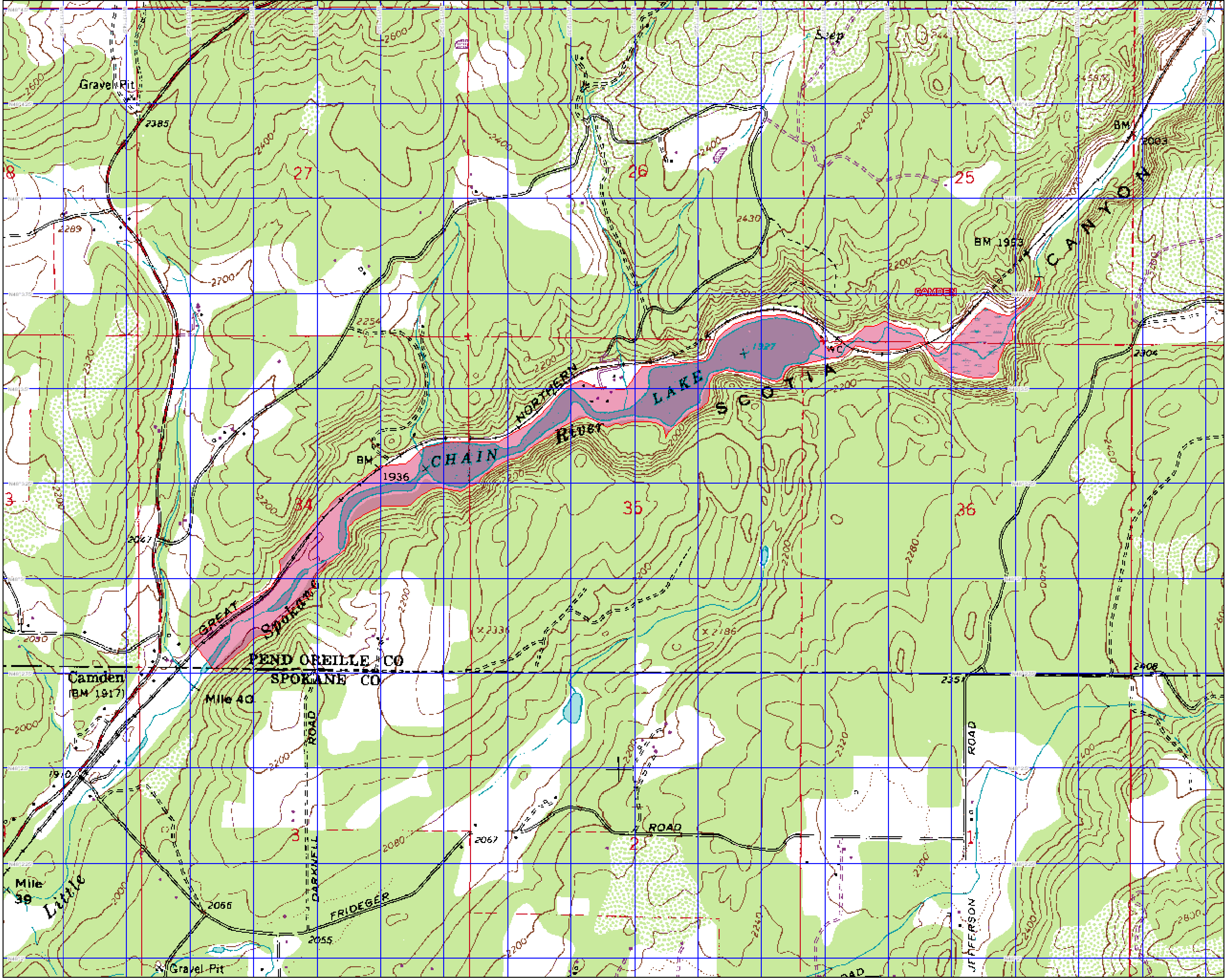
Flooded area: Distinction between 20-foot and 40-foot dam raise not made due to available topographic resolution.



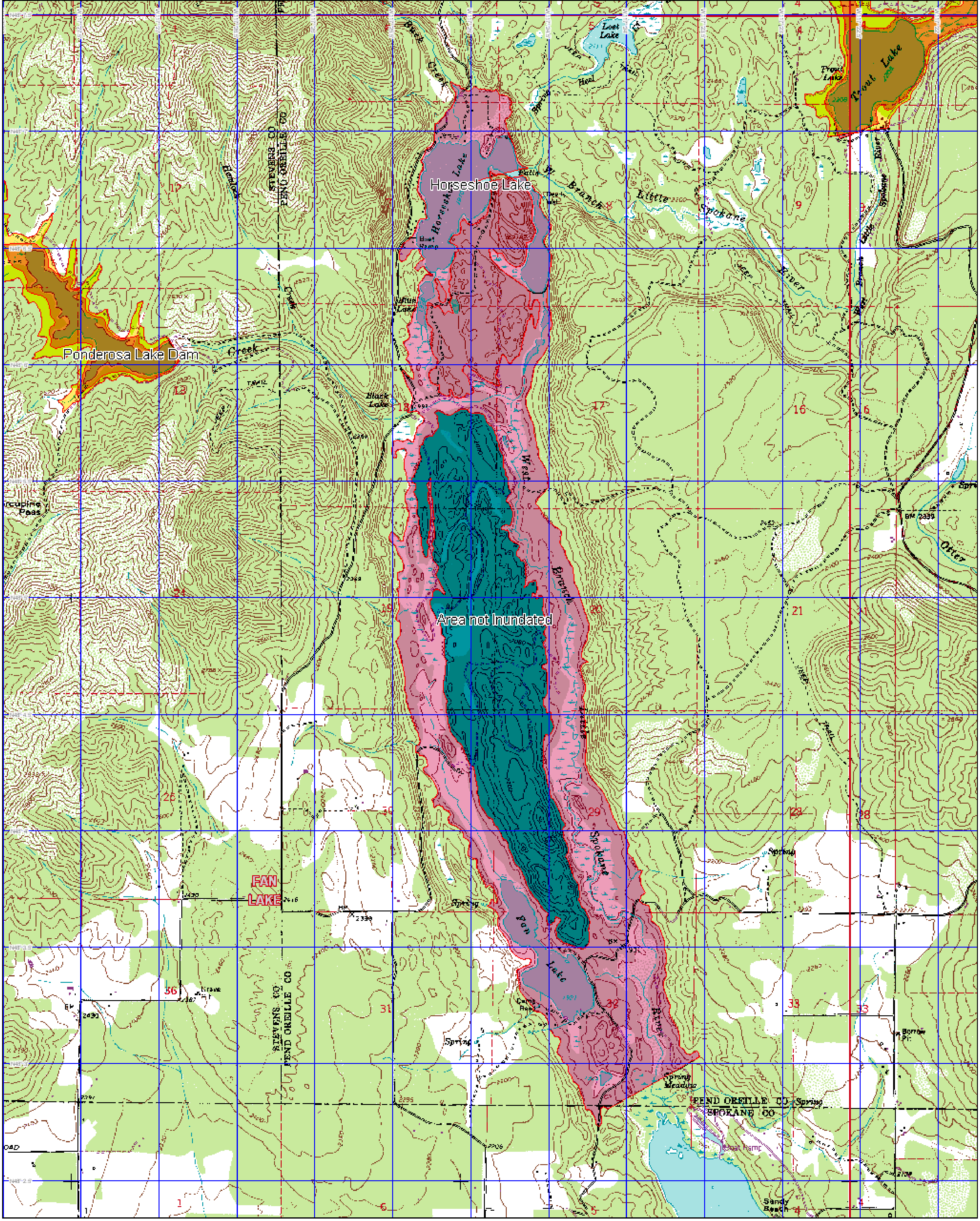
350 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84



800 ft Scale: 1 : 28,125 Detail: 13-0 Datum: WGS84

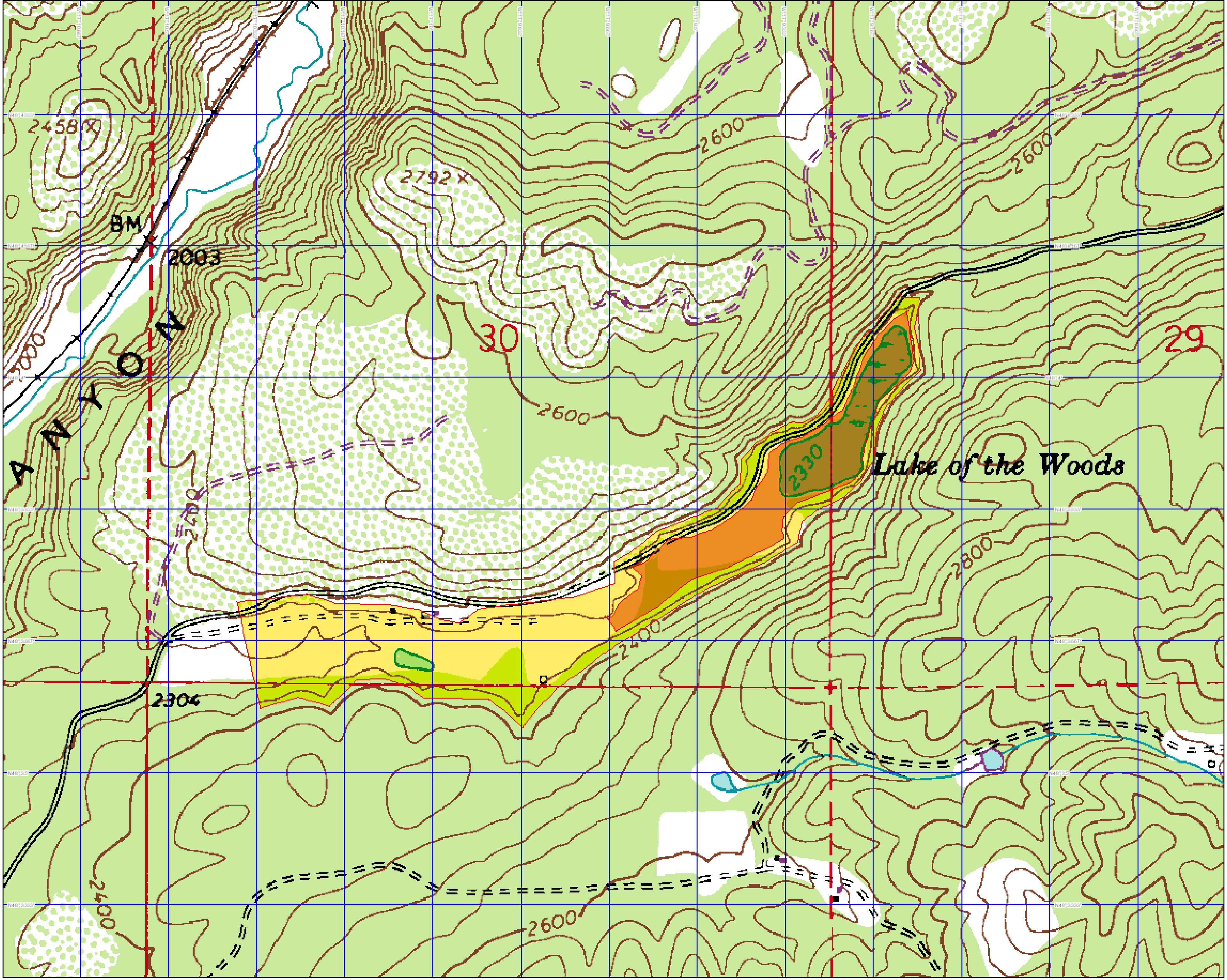


700 ft Scale: 1 : 25,000 Detail: 14-0 Datum: WGS84

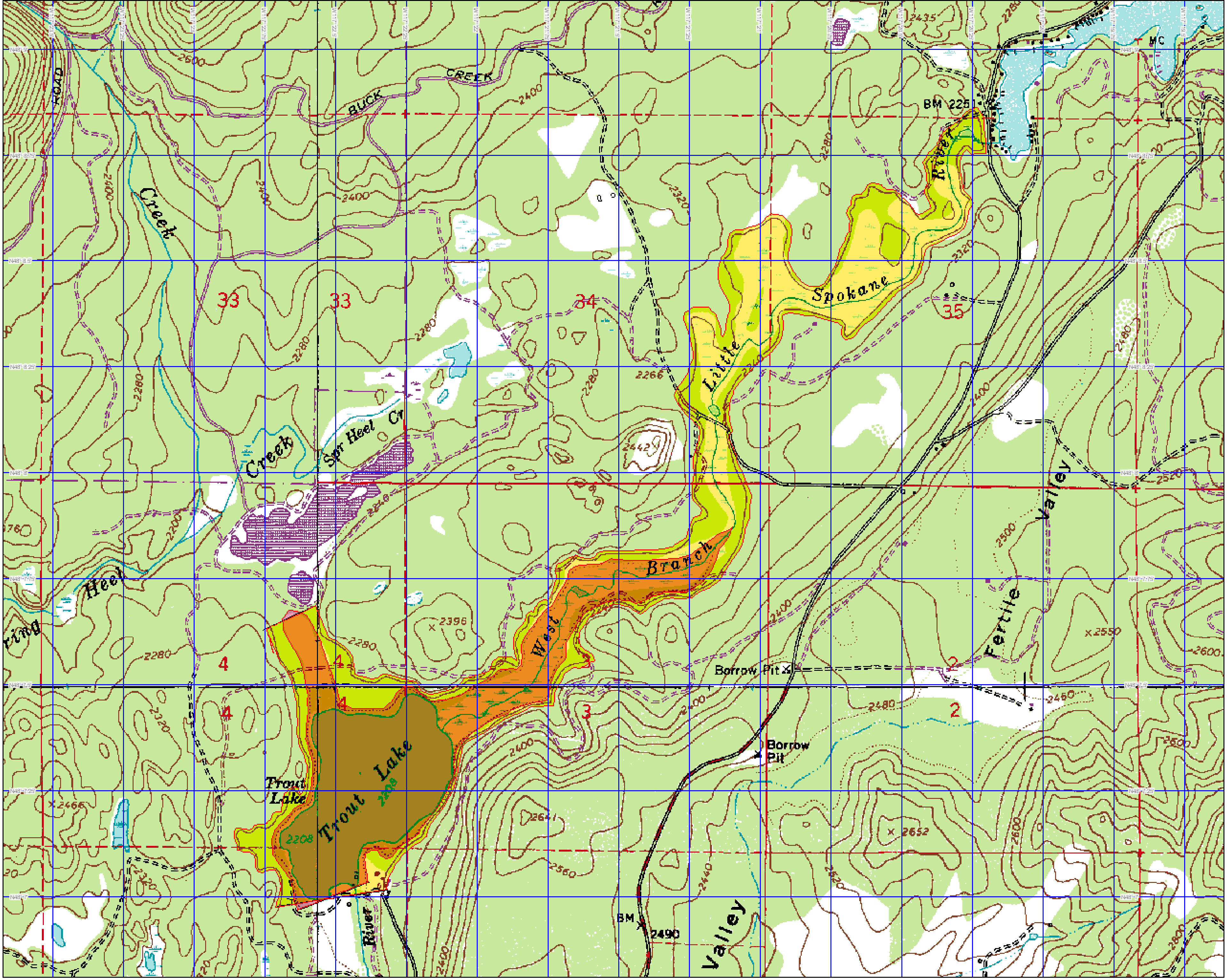


3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

1000 ft Scale: 1 : 40,625 Detail: 13-0 Datum: WGS84



350 ft Scale: 1 : 12,000 Detail: 15-0 Datum: WGS84



650 ft Scale: 1 : 22,400 Detail: 14-0 Datum: WGS84

APPENDIX B

MEMORANDUM REGARDING SUPPLEMENTAL INFORMATION FOR SECOND STEP DIRECTION

MEMORANDUM

TO:	Robert Lindsay, WRIA 55/57 Planning Unit	**DATE:**	August 16, 2004
FR:	Sara Marxen, Chris Pitre, Golder Associates Inc.	**OUR REF:**	013-1372-001
RE:	Storage Assessment Direction for the Second Step		

The purpose of this memo is to provide additional information on selected options to assist the Planning Unit in deciding the focus for the second step of the storage assessment for WRIAs 55 and 57. Seven options were identified at the Planning Unit meeting of July 21, 2004, and three additional options were subsequently identified:

<u>WRIA 55:</u>

1. Ponderosa dam raise;
2. Wetlands restoration in the upper part;
3. Artificial recharge of Deer Park Aquifer;
4. Stormwater to gravel pit infiltration;
5. Dragoon Lake dam raise;

<u>WRIA 55/57:</u>

6. Artificial groundwater storage with the SVRP as source and the Little Spokane Aquifer as receiving aquifer;
7. Direct augmentation ("Pump & Dump") of the Little Spokane River with groundwater pumped from the Spokane Valley Rathdrum Prairie Aquifer;

<u>WRIA 57:</u>

8. Reclaimed water use;
9. Newman Lake wetlands restoration; and,
10. Saltese Flats wetlands restoration;

The Planning Unit may select any or all of the options for further study. The selected options may not exclude either WRIA. Further study could consist of recognizing fatal flaws, preliminary technical design, defining a permitting and development pathway, and identifying funding sources. Selecting a larger number of options will result in a more conceptual assessment of each option. Any options not further evaluated within the storage assessment may still be considered at a later time and/or otherwise included in the watershed plan. Focusing on one or two options (for example one for each WRIA) will allow the work to progress to greater depth, and may be more useful in the implementation phase of watershed planning. However, if fatal flaws are uncovered while considering a narrow range of options, an expansion of the number of options may be required.

For WRIA 55, the **Ponderosa Dam raise** is considered a good option on a technical basis. The site is located in the headwaters of the West Branch of the Little Spokane River, and may be able to provide a significant amount of water (e.g., 2,000-6,000 acre feet per year). This water may be used to mitigate potential impacts from existing junior water right holders and avoid the need to interrupt their pumping, and to improve habitat conditions along a significant reach of the Little Spokane River. Permitting and land ownership are recognized as the limiting variables.

Alternative options for consideration in WRIA 55 include wetland restoration in the upper watershed (e.g., around Diamond Lake) and Aquifer Storage and Recovery (ASR) using water from the SVRP Aquifer to recharge the unconsolidated sediments aquifer in the vicinity of the confluence of Deadman Creek with the Little Spokane River. Wetlands restoration is expected to provide primarily an ecological benefit, while the ASR option is considered best suited to locally meet future water demand and minimize additional impacts to streamflow.

For WRIA 57, the use of **reclaimed water combined with the restoration of the Saltese Flats** is considered an excellent option. This option offers multiple benefits, including:

- Providing a reclaimed water effluent receptor when direct discharge to the Spokane River may be difficult under the developing TMDL process;
- Restoration of habitat recognized as ecologically valuable by many agencies;
- The existence of multiple partnering agencies (e.g., Spokane County, Washington Department of Fish & Wildlife, Ducks Unlimited, waste water treatment plant owners, etc.); and,
- The project is a good candidate for many grant programs;

An initial discussion of most of these options can be found in the Draft First Step Storage Assessment Little and Middle Spokane Watersheds (July, 2004), and additional details on each option is presented below.

OPTION 1 - PONDEROSA LAKE DAM RAISE (WRIA 55)

This option involves raising an existing dam to increase storage. Ponderosa Lake Dam (also referred to as Barker Lake) is located in northwest WRIA 55 on Beaver Creek, a tributary of the West Branch Little Spokane River. Its current normal storage is 357 AF. The estimated additional storage is 2,090 to 6,630 AF as estimated at 20 and 40 ft increments respectively. The 20 and 40 ft dam heights are used for analysis and should not be considered the recommended additional height.

Existing Dam

Currently the dam is owned by a private owner who states he uses it primarily as “his own personal water hole, primarily for cattle”. He maintains a static water level with no real seasonal variation or operating cycle. He owns the only building on the lake and it is approximately 20 feet above the level of the existing water, he also owns the most of the land surrounding the lake.

Ecology’s Dam Safety inspector indicated that raising the existing dam would be feasible but a seepage study would likely be required to address ongoing concerns about seepage. The existing dam is “keyed” into the native soil with a clay key to prevent seepage beneath the dam. Additionally, the inspector indicated an upgrade to the outlet structure would likely be required.

Ecology's Dam Safety office was unable to copy and send the current folder on Ponderosa Dam at the time of this memo's writing. It's expected that if this option were pursued the folder would provide additional necessary information.

Beaver Creek Flow

In order to determine if Beaver Creek could potentially provide enough flow to fill a larger dam a combination of modeled and measured flows were used. Measured flows from Beaver Creek and the West Branch Little Spokane River near the mouth of Beaver Creek were available from Ecology on an, approximately, bi-monthly basis between the late spring and summer months of 1986 through 1990. A total of 32 coincident measurements were taken. Beaver Creek flow ranged from 0.2 cfs to 25.8 cfs. Beaver Creek flow was in general was between 2 and 12 % of the West Branch Little Spokane River flow, with an average of 5%. Using the average ratio and simulated results for the West Branch Little Spokane River near the mouth of Beaver Creek from the Mike SHE model a more continuous flow record was developed for the period between 1994 and 1999.

Assuming that all flow from Beaver Creek could not be used to fill the dam two assumptions were made: flow can only be retained in the dam between December and April of any year, and up to 50% of that flow can be retained. Under these assumptions between up to 1,200 AF of water was annually available between 1994 and 1999. Water might only be released in drier years (e.g., when junior rights may be fully exercised without interruption). Therefore, the full reservoir capacity may be attained with interannual carry over of stored water.

Beaver Creek Habitat

The Washington Department of Fish and Wildlife completed monitoring of the reach of Beaver Creek below the existing dam in August, 2001 (McClellan, 2002). The mean width is 1.8 m and mean depth is 6 cm. There were two natural fish passage barriers below the dam. Eastern brook trout and rainbow trout were observed in the reach below the dam. WDFW personal were not allowed by the current dam owner to monitor the reach above the dam.

OPTION 2 - WETLANDS RESTORATION (WRIA 55)

This option involves pursuing restoration of wetlands in WRIA 55 or potentially evaluating the WRIA for areas where constructed wetlands might provide the most benefit in terms of storage. Wetlands can provide many benefits in terms of water quality, habitat, flood reduction and storage, but in order to meet a goal of storage they would ideally have several characteristics. They would be seasonally drained, surface water controlled (do not drain to groundwater) and be relatively large to store significant amounts of water.

In WRIA 55 there are 6 large drained wetlands to the northeast of Diamond Lake with a total area of approximately 840 acres. These wetlands historically acted as seasonal, palustrine, emergent wetlands. They present a unique opportunity over many watersheds in that they are concentrated in several large wetland units in a single sub-basin rather than many small wetland units spread throughout the watershed.

Existing Land Ownership

According to aerial photos taken between 1995 and 1998, the majority of the land is still used for agriculture. Parcel data for Pend Oreille County is only available by visiting the County

Assessors office (not electronically), therefore specific land ownership was not obtained. There did not appear to be any significant housing or new building going on in any of the drained areas

Land Value

The Pend Oreille County Assessors office stated that the cost of agricultural land in the Newport area can range from $1,500 to $4,000 per acre depending on roads, sub-dividability, water frontage, etc. The proximity of this land to Newport may cause its value to be close to the high end.

Restoration Potential

Aerial photos taken between 1995 and 1998 show the land as ditch drained, this is supported by the USGS topographic quads. This generally indicates a low cost of restoration (as compared to deconstructing tile drains) since restoring hydraulics may simply involve designing a plug for the existing ditch so that water ponds and spreads across the historic wetland.

Also visible in the topographic maps and aerial photos is the surface water connectivity of four of the larger drained wetlands near Diamond Lake. It appears that they may have been historically, and still are, connected by surface channels that drain the wetlands towards Diamond Lake. This may indicate that discharge from the wetlands occurs as surface water as well as, or rather than, groundwater. This may indicate that control could be exerted over the water stored in these wetlands through a control structure allowing water to be released when it's needed. The only concern with these wetlands draining towards Diamond Lake is that raising the level of water in these areas could potentially cause flooding around the lake depending on the connectivity and hydraulics of the system.

OPTION 3 – ARTIFICIAL RECHARGE OF DEER PARK AQUIFER (WRIA 55)

This option involves diverting water from Dragoon Creek during high flow (e.g., December-April) periods to infiltration trenches for infiltration to groundwater. The groundwater would then seep back to the creek after an appropriate time lag (e.g., during the low flow period of July-September) and augment streamflows.

The diversion is envisioned to be into a canal at a location that is upstream of the infiltration site. The canal would deliver water generally along a constant topographic elevation to an infiltration site. The limiting factor will be identifying the diversion point and canal alignment. It is estimated that water will have to be delivered at least one mile away from the creek in order to achieve an adequate lag time for return of the recharged water via groundwater to the stream (e.g., three months between recharge and streamflow augmentation). Because the canal alignment will have to approximately follow topographic gradients to get to the infiltration site, the actual alignment will be greater than one mile. The alignment of the canal is expected to include several stream crossing and require easements.

OPTION 4 – STORMWATER/GRAVEL PIT INFILTRATION (WRIA 55)

This option involves using existing non-operational gravel pits that have not yet been reclaimed in order to store and infiltrate stormwater. All sand and gravel pits tracked by the Department of Natural Resources were screened and eight gravel pits were initially identified as having potentially favorable locations for capturing and infiltrating stormwater run-off.

Of the eight identified gravel pits four were found to either: 1) have been reclaimed; 2) be in the process of being reclaimed for landfill purposes; or, 3) exist in the vicinity of a significant density of drywells (using gravel pits to infiltrate stormwater is assumed to be duplicative).

Both Spokane County and the Washington Department of Transportation were contacted to determine if run-off estimates to county roads or highways in the area had been completed and if so, if the volume of run-off was significant for storage and infiltration purposes. Spokane County indicated that stormwater analysis is only completed for higher density areas or where there are stormwater related problems. The Washington Department of Transportation indicated that there could potentially be stormwater estimates or culvert sizing available but the only contact who knew the information was on vacation. The Department of Natural Resources indicated that the remaining potential infiltration pits were mostly gravel and therefore would be suitable for infiltration, but that getting a significant amount of stormwater into the pits might be a problem.

The remaining sand and gravel pits include:

- 10127, T29N R43E Sec. 14;
- 11589, T28N R43E Sec. 28;
- 12312, T29N R43E Sec. 14; and,
- 12626, T29N R43E Sec. 14.

OPTION 5 – DRAGOON LAKE DAM RAISE (WRIA 55)

This option was evaluated in the "First Step" storage assessment and removed for two main reasons: 1) its small size – existing normal storage is 147 AF; and, 2) its limited expansion potential – a railroad runs alongside the reservoir potentially restricting expansion. In the First Step assessment it was assumed that only 10 additional feet could be added to the dam which provides an additional 420 AF. If this dam raise is possible (which has not been determined and may not be possible given the adjacent railroad) this could result in streamflow augmentation to Dragoon Creek of, for example, over 3 cfs for 2 months or more than 6 cfs for 1 month. The benefit would apply to a significant length of stream. Additionally, the current owner appears to be interested in selling (he has previously contacted the planning unit), and the dam is currently sitting idle.

OPTION 6 - ASR FROM SVRP TO LOWER LSR (WRIA 55/57)

Aquifer Storage and Recovery (ASR) in this option is envisioned as withdrawing groundwater from the SVRP or southern part of the Hillyard Trough during the winter months (during high flows), transporting the water through existing municipal distribution facilities and injecting the water into a suitable aquifer. A suitable aquifer would either: 1) hold the water sufficiently that summer withdrawals in the area would use injected water; and/or, 2) slowly release the water to the lower Little Spokane River or Deadman Creek for streamflow augmentation during the summer.

Stored water could be used to meet existing and/or future summer peaking demand, and/or minimize impacts to streamflow from peak summer withdrawals. Any leakage of stored water would result in the augmentation of streamflows. The effect of leakage of artificially recharged water to augment streamflow depends on how quickly the recharge water is discharged to the river (return flow). Augmentation of instream flows would affect flows at the USGS stream gage at Dartford, which is used for instream flow compliance monitoring and enforcement. However, the length of stream that would benefit is relatively short. Additionally, habitat downstream of Dartford is considered to be good as a result of the large groundwater discharge from the SVRP Aquifer through the Hillyard Trough to the Little Spokane River. If providing water to serve continuing growth in this area is shown to further deplete Little Spokane River flow, then this option may provide a remediative and/or preventative measure.

Geology of Potential Receiving Aquifer

The area evaluated for ASR is in the region of the confluence of the Little Spokane River and Deadman Creek. Unconsolidated sediments in this area are on the order of 400 feet thick and include: 1) an upper sand and gravel (USG) unit of the SVRP; 2) a middle glaciolacustrine silt and clay layer; and 3) a lower sand and gravel (LSG) unit of the SVRP. Recharge is primarily being considered to the LSG aquifer.

The lower sand and gravel aquifer (LSG) is relatively continuous across the northern portion of the Hillyard Trough and is believed to be about 50 to 150 feet thick. The hydraulic properties, aquifer boundaries, and hydraulic connection with the upper portion of the SVRP and Little Spokane River are not well understood.

The available information indicates that the LSG aquifer may be favorable for ASR development. The aquifer appears to be moderately to highly permeable with the overlying glaciolacustrine layer acting as a confining unit. This layer could contain recharge water injected into the LSG with limited upward seepage or discharge to surface water.

There several uncertainties that will require additional evaluation to fully assess the feasibility of ASR in the LSG including:

- Thickness and extent of the LSG and the overlying glaciolacustrine layer;
- The aquifer hydraulic properties and aquifer boundaries of the LSG, including continuity with the Little Spokane River and the overlying portion of the SVRP aquifer;
- The storage capacity of the aquifer that can be realized;
- The chemical compatibility of the recharge water and the native groundwater, aquifer mass, and other waters in the distribution system; and
- The suitability of the existing infrastructure including interties, pressure zones, distribution systems, and wells for ASR.

Existing Distribution Infrastructure

Delivery of water from the SVRP Aquifer through existing municipal infrastructure would be dependent on interties between water systems extending from the source area to the recharge area, including the City of Spokane and Whitworth WD#2 and Spokane County WD#3. Interties currently exist between these systems:

Existing Interties

(Source: City of Spokane Water Comprehensive Plan 1999-2000)

Purveyor	#	Intertie Location	Capacity (inches)	Purpose
SCWD #3	1	1500 N. Theirman Road	10	I
	2	2000 S. Carnahan Road	6	I, F
	3	5400 South Perry Street	8	F, CR
	4	02 N. Havana Street	12 and 8	I
	5	6300 North Wall (Wall and Francis)	8	I
Whitworth WD #2	1	6300 N. Monroe Street	6	E, F
	2	Hawthorn and Nevada	12	E, F

Note: E – Emergency; F – Fire Flow; I - Intermittent Retail; and, CR – Continuous Retail

These interties are on an "as needed basis" or verbal agreements. All agreements are based on the capacity of the City's water system and the amount of water required by the purveyor. City needs are met first.

Larger capacity wells suggest a larger aquifer storage capacity, and will minimize implementation costs as a result of requiring fewer wells and more efficient use of facilities. Possible candidate wells include the following:

- Whitworth Water District (WWD) #1;
- WWD#2a, tested at 2,250 to 4,000 gpm;
- WWD #3; and,
- WWD Mayfair

Additional wells or the advisability of new wells could be evaluated as a part of this option.

OPTION 7 –PUMP & DUMP FROM THE SVRP AQUIFER TO LSR (WRIA 55 & 57)

This option consists of pumping groundwater from below the clay lens in the Hillyard Trough, either within WRIA 55 or 57, and discharging it to the Little Spokane River to increase streamflows during low flow years. This option is expected to be feasible because the SVRP Aquifer is sufficiently transmissive that the aquifer will fully recharge during the winter and will not be overdrawn by seasonal pumping. However, habitat along the reach of the Little Spokane

River below Dartford is considered to be good, and not be in need of increased flows. Existing water distribution infrastructure could only transport water to the lower reach of the Little Spokane River, potentially allowing the river to meet regulatory instream flows, but neglecting upstream reaches were flow augmentation would also be beneficial.

OPTION 8 – RECLAIMED WATER USE (WRIA 57)

The developing TMDL plan may limit the discharge of waste water directly to the Spokane River. This may affect the waste water plant at Liberty Lake (currently ~0.8 cfs), the future planned Spokane County Regional Treatment Plant (SCRTP; up to 30 cfs at full build out in 2030), and other dischargers. Alternative discharge points that are being considered and discussed below include direct recharge to groundwater, and discharge to wetlands.

Standards have been codified for some but not all reclaimed water uses in Chapter 90.46 RCW. Guidelines for the use of reclaimed water are summarized in Water Reclamation and Reuse Standards, September 1997 (Ecology, 1997). These guidelines were created by the Departments of Ecology and Health in accordance with RCW 90.46. All reclaimed water generation and use must be covered under a permit that is issued jointly between the Departments of Ecology and Health. Class A reclaimed water requires the highest level of treatment and is suitable for most reclaimed water uses (Ecology, 1997).

The current design of the proposed Spokane County Regional Treatment Plant (SCRTP) does not include treatment to Class A reclaimed water standards but it is recognized that when a reclaimed water program is put in place additional disinfection can be completed to meet this standard (Draft Spokane County Wastewater Treatment Facilities Plan Amendment, June, 2004).

Groundwater Recharge through Surface Percolation

Reclaimed water that is discharged for surface percolation requires that the water be treated to at least Class A level and that secondary treatment be provided to reduce nitrogen prior to discharge (Ecology, 1997).

Groundwater recharge criteria are defined in RCW 90.46.010 and are effectively “the drinking water quality standards adopted by the state board of health pursuant to chapter 43.20 RCW and the department of health pursuant to chapter 70.119A RCW.” Reclaimed water at a point of withdrawal must meet the groundwater recharge criteria.

The combination of Class A treatment (with nitrogen removal) and natural treatment during surface percolation are expected to produce water quality that meets drinking water standards (WAC 246-290) and groundwater quality requirements, including the State’s antidegradation policy (WAC 173-200), at the point of withdrawal. This assumption would need to be verified during design and monitored through an established monitoring program. There is currently no guidance regarding retention time or separation distance, which presumably allows for a flexible and negotiable permitting process.

Groundwater Recharge through Direct Recharge to a Potable Aquifer

Direct recharge to groundwater is generally achieved using an injection well that delivers the water directly to the aquifer.

Standards for direct recharge using reclaimed water have been developed in accordance with RCW 90.46.042. Direct recharge to a potable groundwater source requires that the water is at least Class A water and is additionally treated with reverse osmosis. Additionally, the water must "meet the water quality criteria for primary contaminants (except nitrate), secondary contaminants, radionuclides, and carcinogens listed in Table 1 in chapter 173-200 WAC" (groundwater quality criteria) "and any other maximum contaminant levels pursuant to chapter 246-290 WAC" (drinking water criteria). The requirement for coliform has been amended to be no more than 5 CFU per 100 mL in any sample. Additional limits for turbidity, total nitrogen, and total organic carbon (TOC) are:

- Turbidity: < 0.1 NTU (average), 0.5 NTU (maximum)
- Total nitrogen: < 10 mg/L
- TOC: ≤ 1 mg/L

In addition, injected water must have a retention time of at least a 12 months, the injection point must be located at least 2,000 ft from a drinking water withdrawal point, and an effluent and groundwater monitoring program are required (Ecology 1997).

These standards can be met with additional and more costly treatment processes than are currently planned.

Reclaimed Water to a Natural or Constructed Wetlands

Requirements for discharging water to wetlands are dependant on the type of wetlands and the application. The categories of wetlands are as follows:

- ***"Category I Wetland"*** – Wetlands that provide a documented significant life support function for threatened or endangered species, represent a high quality example of a rare wetland type, are rare within a given region, or are relatively undisturbed and contain ecological attributes that are impossible to replace within a human lifetime. Discharge of reclaimed water to these wetlands is not permitted. Saltese Flats is probably not a Category 1 wetland because it current requires restoration.
- ***"Category II Wetland"*** – Wetlands that provide habitat for very sensitive or important wildlife or plants that are difficult to replace, or provide very high functional quality, particularly for wildlife habitat.
- ***"Category III Wetland"*** – Wetlands that provide important functions and values, but are smaller, less diverse, and/or more isolated in the landscape than Category II wetlands.
- ***"Category IV Wetland"*** – Wetlands that are small, isolated, and lack vegetation diversity, and may be able to be enhanced, restored, or replaced (Ecology 1997).

Reclaimed water released to a wetland must meet hydraulic, water quality and biological criteria. All three criteria require comparison with the background or current conditions of the wetland. If background conditions are unavailable site specific limits will be determined by Ecology and the Department of Health, and certain criteria may not be enforced until the wetlands are re-established (Ecology 1997).

Hydraulic Criteria

Hydraulic criteria effectively limit the amount of water that can be discharged to a wetland through hydraulic loading rate and water level fluctuation. Hydraulic loading rate is based on the ratio of the annual average amount of additional water entering the wetland and the "effective wetted area of the wetland."

The hydraulic loading rate is not to exceed an additional 3 cm/day over background of average annual hydraulic loading rate to Category III and IV wetlands and 2 cm/day to Category II wetlands. For constructed beneficial use wetlands, the maximum annual average hydraulic loading rate is 5 cm/day (Ecology 1997). This equates to 4 cfs for a 10 acre Category II wetland, and 6 cfs for a 10 acre Category III or IV wetland.

The average monthly water level is not to increase by more than 10 cm over background/pre-augmentation average monthly water level. The frequency of water level fluctuations above the pre-augmentation water levels may be restricted under certain conditions. In general, these restrictions are for wetlands with high vegetation species richness, high quality bog or fen component, and inhabited by breeding native amphibians (Ecology 1997).

Water Quality Criteria

Water quality criteria set guidelines for not only the concentration of certain constituents in the wetlands but also the rate at which the constituents are added to the wetland. Reclaimed water released to a natural wetland must meet, at a minimum, Class D standards. If the natural wetland provides potential non-contact recreational or educational beneficial uses through restricted access, the water must be at a minimum Class C. Class B water is required for natural and constructed beneficial use wetlands that provide fisheries or potential human non-contact recreational or education beneficial uses. If the wetlands (natural or constructed beneficial use) will provide potential human contact, the discharge shall meet Class A standards (Ecology 1997).

Additional limits on water quality criteria, beyond the Class A, B, C, or D requirement, have been established for wetlands. Un-ionized ammonia concentrations in reclaimed water discharged to a wetland must not exceed Washington chronic toxicity standards (WAC 173-201A-040(3)) for freshwater systems. Metal concentrations in reclaimed water discharged to a wetland must not exceed Washington surface water quality standards (WAC 173-201A). Additional average annual limits are as follows:

- 5 Day Biochemical Oxygen Demand (BOD5) - 20 mg/L
- Total Suspended Solids (TSS) - 20 mg/L
- Total Kjeldahl Nitrogen (as nitrogen) - 3 mg/L
- Total Phosphorus (as phosphorus) - 1 mg/L
- Un-ionized ammonia less than Washington's chronic toxicity standards
- Metals concentrations less than Washington's surface water standards

Mass loadings on an annual average basis are not to exceed:

- BOD5 5 kg/ha/d
- TSS 9 kg/ha/d
- Total Nitrogen (as nitrogen) 1.2 kg/ha/d
- Total Phosphorus (as phosphorus) 0.2 kg/ha/d

Additional limits for phosphorus will be established if it is determined that the wetland is contiguous with a phosphorus-limited lake.

Sufficient hydrogeologic evaluation must be performed to determine if the wetland occurs in an area that provides groundwater recharge at any time of the year. If there is evidence of recharge, further evaluation is required as follows:

- If the concentrations of parameters in the reclaimed water are 50 percent or lower than the groundwater quality criteria, no additional groundwater evaluation or follow-up action is required.
- If the reclaimed water has parameter concentrations greater than 50 percent of the groundwater quality criteria, a site-specific hydrogeologic investigation is required to show that hydrogeologic conditions are adequate to prevent degradation of groundwater quality.
- If the concentrations in reclaimed water exceed the ground water quality criteria, additional treatment may be achieved in the wetlands (and may be all the additional treatment required). In all cases, groundwater monitoring and analysis for sufficient length of time is required to determine that the application of this reclaimed effluent will not degrade existing groundwater quality.

Biological Criteria

Biological criteria provide protection for the existing or planned structure and function of the wetland (Ecology 1997). Biological criteria includes an anti-degradation clause stating that the existing beneficial uses of the wetlands (such as vegetative cover, plant diversity, fish and bird populations, etc.) will be protected and not further degraded through the use of reclaimed water.

In general, biological criteria will not be lowered by more than 25 percent compared to the reference condition over the entire area of the wetland, and by no more than 50 percent at any individual station. Acceptable sampling methods and numbers of stations to quantify these biological criteria will be determined on a case-by-case basis and will be the minimum necessary to demonstrate compliance.

OPTION 9 – SALTESE FLATS RESTORATION

This option involves restoring Saltese Flats, a drained wetlands located in the eastern portion of WRIA 57 just west of Liberty Lake. The flats are approximately 1,200 acres in size and historically acted as a shallow lake, estimated from topographic data to have been as much as 20 feet deep. The lake was drained and ditched for agriculture in the late 1800's or early 1900's. Approximately 53 properties overly the drained wetlands, with the majority of the land concentrated in 11 properties.

Washington Department of Fish and Wildlife Restoration Efforts

WDFW's intent was to purchase all properties overlying Saltese Flats that weren't developed. This may have included easements on the lower half of some lots or total purchase, depending on individual land owners. At the start of this project WDFW determined that there was a particular property without which the Saltese Flats restoration would not be successful. This is due to its location near the natural wetland outlet, in the deepest part of the lake and its ownership and water rights control of the ditch that runs across the property draining the wetlands. WDFW had this single property appraised and offered the owner the appraised value. The owner agreed to sell the land (346 acres) for the appraised value (~$500,000) but requested an additional $1,000,000 for the water rights. WDFW is limited to the appraised value for land purchases and therefore was not able to purchase the property. No other properties were appraised and no other evaluation of the wetlands has been completed. Since the land purchase failed the project has been on hold, effectively considered “dead” unless a new development occurs. The WDFW eastside lands manager, Brian Trickle, has a good relationship with the land owner and indicates that the owner may still have interest in selling.

WDFW’s funding for the Saltese Flats restoration was obtained from the IEC (Interagency Committee for Outdoor Recreation) for ~$1.5 million. This money is available for approximately 2 more years. This particular funding is transferable to public entities.

WDFW did not do water rights evaluation. The project manager indicated that they could have gone ahead with the purchase without the water rights but they were concerned he would then use the water for development in the area.

Existing Water Rights

Existing active surface water rights are shown in the following table. The two largest water rights belong to Morrison (553 AF) and the Saltese Farm Syndicate (460 AF). Morrison’s water rights are designated for irrigation purposes for use between April 15 and October 15. The Saltese Farm Syndicates water rights have multipurpose use designation of domestic, stock watering and irrigation. Portions of Morrison’s property on the historic lake bed is still irrigated (per WDFW) and harvested for hay and therefore the water right is assumed to be valid. These water rights may be transferred into trust, sold and transferred to other parties, or transferred to another location for continued use by the current water right holder, as permitted by the Water Code (RCW 90.03).

Existing Development

Saltese Flats is designated as wetlands under the Spokane County Critical Areas Ordinance. This signifies that building cannot occur within between 25 and 200 ft of the boundary of the wetlands depending on the category (Category 1 – 4 per Spokane County Critical Areas Ordinance Chapter 11.20) designation of that wetland.

Some formerly agricultural properties have been subdivided into large tract lots that have some upland portions and some lowland portions. It appears that all housing has been developed in the upland portions of these properties (per WDFW conversations and aerial photos). WDFW indicated that many owners use the lowland areas of their lots for recreational purposes, such as horseback riding.

OPTION 10 – NEWMAN LAKE WETLANDS RESTORATION

Newman Lake was historically surrounded to the north and south by palustrine, seasonal, emergent wetlands. These were ditch drained for agriculture in the early 1900’s. This option involves restoring some or all of those areas.

Existing Land Use and Value

Aerial photos from the mid-1990's indicate the land is used mostly for agriculture. The land is zoned "rural conservation" and a land use survey completed in 1999 notated almost all of the land as either vacant or agriculture with some single family housing near the northern edges of the historic wetlands. The Spokane County Assessors office describes land to the north as residential (undivided or divided), designated forest land or agriculture. Current assessed and sale values of property surrounding Newman Lake range from $1,500 up to $10,000 per acre depending on the location, designated use and existing development or development potential.

Current Status of Newman Wetlands Restoration

The Newman Lake Flood Control District has stated it's in their best interest to remove land around the lake from agriculture in order to improve lake water quality and reduce flooding problems. They have identified wetlands restoration as one of their goals for the areas surrounding the lake.

The Natural Resources Conservation Service (NRCS) has restored one 209 acre parcel on the south side of the lake as part of the Wetland Reserve Program (WRP) administered by the NRCS. The restoration process involved de-leveling and restructuring the landscape to provide more ponding areas. Soils were excavated to approximately a three foot depth in areas. The NRCS attempted to obtain another 300 acre parcel of land (to the north near Thompson Creek) for the Conservation Reserve Program (CRP) but the land owner pulled out of the contract after signing due to liability concerns.

Spokane County Parks and Recreation is also doing restoration work (for habitat and potentially some wetlands) on the northwest side of the lake. A contact for this program was not available in time for this memo.

Conversations with the NRCS indicate that additional wetlands restoration work is feasible and desirable in the area. The main road block is generally funding to complete projects as well as education of land owners on the options and funding available to them. In general, the NRCS does not recruit land owners with restorable land but waits for land owners to approach them with the desire to sell. A successful restoration generally comes down to economics. Funding through the NRCS is available for such projects, but it is competitive as they can usually only fund 20% to 40% of the wetland reserve program applications that they get in a year.

APPENDIX C

MEMORANDUM REGARDING BAKER (PONDEROSA) DAM SITE VISIT AND FUTURE DIRECTION

MEMORANDUM

TO:	Rob Lindsay; Reanette Boese, Spokane County	**DATE:**	August 31, 2004
FR:	Sara Marxen, Chris Pitre, Golder Associates Inc.	**OUR REF:**	013-1372-001.4320
RE:	Draft Baker (Ponderosa) Dam Site Visit Results and Suggested Direction		

This memo is intended to briefly summarize the result of communication with the owner of Baker Dam (also referred to as Ponderosa Dam) – Jay Baker – and supply a suggested direction for the remainder of the funds designated for Baker Dam.

The WRIA 55/57 Planning Unit directed Golder to contact the owner of Baker Dam to determine the willingness of the owner to a dam raise. The goal was to prevent unnecessary technical analysis of a dam raise if the owner was not amenable to the project. The Planning Unit indicated that if the owner was not willing to entertain the option of raising the dam, Golder was to pursue the WRIA 55 wetlands restoration option rather than the option of Baker Lake Dam raise.

Mr. Baker stated that while he is interested and supportive of efforts to increase storage in the basin he is not willing to allow the existing dam to be raised, or for the lake to fluctuate more than 3 feet in elevation; a lake level fluctuation of 3 ft would provide approximately 200 AF of live storage. Unfortunately, this significantly diminishes one of the "best" currently recognized storage options in WRIA 55 from further consideration. However, Mr. Baker would be willing to allow construction of a dam on Beaver Creek upstream of the existing dam, and recommended a location on his property. The location suggested by Mr. Baker would essentially constitute a new dam. The suggested dam site appears to be a feasible and beneficial opportunity, but it follows that if new dams are considered there may be other locations that would provide a better opportunity for storage in a new dam.

Therefore, though the Planning Unit directed Golder to proceed with evaluation of WRIA 55 wetlands if raising Baker Dam was not feasible, further consideration should be given to storage in new surface reservoirs. In addition to a new dam as suggested by Mr. Baker, an option for a new dam that was briefly discussed in the First Step Storage Assessment is Buck Creek, located just north of Beaver Creek and drains into Horseshoe Lake. Additionally, Mr. Baker mentioned the marshy stretch between Fan Lake and Horseshoe Lake (also discussed in the report).

The following points briefly summarize the benefits and drawbacks of these options.

New dam on Beaver Creek:

- Drawbacks: A smaller storage reservoir is available (potentially between 900 and 2,000 AF depending on operations and climate variations). Mr. Baker indicated that this area has a wetter microclimate and is lusher than the surrounding areas, so there is some potential that actual streamflows are higher than estimated, but there is no quantitative data to support this.
- Benefits: There is a single owner and he is interested in cooperating. Stream habitat should not be an issue because a man made barrier already exists downstream (Baker Dam). Construction materials appear to be available nearby.

New dam on Buck Creek

- Drawbacks: The prospective reservoir may extend across the Kanisku National Forest boundary and trigger the National Environmental Policy Act (NEPA) process. The best site for the associated dam is on private land immediately outside of the national forest.
- Benefits: Streamflow on Buck Creek appears to be at least 3 times that of Beaver Creek. Therefore if a suitable location can be found the storage potential would be greater. The creek is also high in the watershed increasing the total stream length benefit. Natural fish passage barriers exist in the lower reach so negative habitat impacts may not be a significant permitting issue. Available topographic and geologic data appear supportive of a large storage structure. Pend Oreille County, within which this prospective project is located, has expressed support for such a project.

New dam on side channel near Horseshoe:

- Drawbacks: Some sort of diversion conveyance would likely be required. The marshy ground surface may not support a structure or may increase leakage issues. Multiple land owners may be involved.
- Benefits: The reservoir would be on a side channel, and so habitat may not be a significant permitting issue. Flow in West Branch Little Spokane River is great enough to support a large storage volume. High in watershed, stream length benefit is great.

WRIA 55 wetlands:

- Drawbacks: The total storage available and streamflow augmentation benefit is not clear. Drainage may be a problem (based on Planning Unit meeting notes). Purchase of land and displacement of several to many land owners would be required. In order to operate the wetlands for storage, without affecting downstream areas, several control and containment structures may be required.
- Benefits: Habitat would be created. Water quality may be improved. This area is also high in the watershed therefore stream length benefit is great.

In evaluating the benefits and drawbacks Golder feels that continuing to evaluate a surface storage structure provides a greater potential storage benefit than that of wetlands restoration. Of the original list of surface storage options considered, Beaver Creek and Buck Creek appear to be feasible and beneficial locations to evaluate a storage structure for two different reasons: Beaver Creek involves a single willing owner and suitable location, while Buck Creek has a greater amount of available streamflow than any other new dam location evaluated in the First Step Storage Assessment. Both are located high in the watershed and will provide environmental benefits to a large part of the watershed. Therefore Golder recommends evaluating these two options with slightly less detailed analysis. Evaluating two apparently feasible options will allow the Planning Unit to compare their benefits and drawbacks.

APPENDIX D

GEOLOGIC ASSESSMENT OF BEAVER AND BUCK CREEK SITES

Geologic Assessment of Beaver and Buck Creek Sites

1.1 Geologic Setting

The proposed Beaver Creek and Buck Creek dam sites are located in northwest Washington State, in the Northern Rocky Mountains physiographic province. The Northern Rocky Mountains in northeastern Washington include the Selkirk, Chewelah and Huckleberry ranges, characterized by rounded mountains, with elevations reaching 8,000 feet above mean sea level (amsl), which are separated by relatively narrow valleys.

The cores of the mountains are made up of the oldest sedimentary and metamorphic rocks in the state of Washington (WSDGER, 2001; Waggoner, 1990). The oldest of these rocks are Precambrian (about 600 million to 1,500+ million years old), and belong to the Windermere Group, Deer Trail Group, Priest River Group, and Belt Supergroup (Stoffel and others, 1991; Waggoner, 1990). The Precambrian rocks include metamorphosed sedimentary strata such as phyllite, argillite, slate, dolomite, siltite, conglomerate and quartzite, as well as metamorphosed volcanic rock such as greenstone and andesite (Waggoner, 1990; Miller, 1974). The Precambrian rocks are overlain by, or in fault contact with Paleozoic (320 million to 570 million years old) metamorphosed sedimentary rocks such as dolomite, limestone, phyllite, quartzite, slate, argillite and siltite (Waggoner, 1990).

The mountain core rocks were extensively intruded by late Cretaceous and early Tertiary (about 60 to 170 million years old) plutonic igneous rocks. The igneous rocks include granite, granodiorite, monzogranite, and monzonite (Stoffel and others, 1991). Early Tertiary (about 45 to 55 million years ago) volcanic rocks (e.g., andesite flows, volcaniclastic sediments) covered most of the region, and were subsequently eroded and preserved in localized faulted, down-dropped structural depressions called grabens.

The bedrock of the Northern Rocky Mountains is locally covered by Quaternary (the present to about 1.6 million years ago) surficial deposits. The primary surficial deposits include late Pleistocene (about 12,000 to 20,000 years ago) glacial sediments and glacier outburst flood sediments, and Holocene (past 10,000 years) alluvium in stream valleys (Stoffel and others, 1992; Waggoner, 1990).

1.1.1 Regional Structure/Tectonics

The Northern Rocky Mountains in the region of the dam sites are cut by a number of north-northeast- to northeast-striking thrust faults and low angle normal faults, such as the Newport, Jumpoff Joe, Lane Mountain, and Huckleberry Range faults (Stoffel and others, 1991). In addition, there are numerous north- and northeast-trending bedrock folds (e.g., anticlines and synclines), resulting in bedrock dips that commonly range from 30 to 80 degrees, and may locally be overturned (Waggoner, 1990).

Based on investigations compiled by the U.S. Geological Survey (2002b, 2004b, 2004c), there are no mapped active faults within about 75 miles of the dam sites. The nearest mapped active faults are the Pinto fault, near Soap Lake, more than 90 miles southeast, and the Pine Creek Valley, Bull Lake, Savage lake, and O’Brien Creek faults located near Troy, Montana, more than 75 miles east.

1.1.2 Historical Seismicity

Based on the catalog of historical seismicity from 1568 to the present (U.S. Geological Survey, 2004a), the region of the dam sites is characterized by a low level of earthquake activity. The there have been only 86 recorded or reported earthquakes within 93 miles of the dam sites since 1568, and most of these (62) were greater than 62 miles from the sites (U.S. Geological Survey, 2004a). The magnitudes (M) of these earthquakes ranged from M 2.0 to M 4.1, and were distributed among the following magnitude ranges:

- Magnitude Range 2.00 to 2.99 – 47 earthquakes
- Magnitude Range 3.00 to 3.99 – 37 earthquakes
- Magnitude Range 4.00 to 4.99 – 2 earthquakes

The closest earthquake to each site was an M 2.6 event that occurred on December 12, 2000, about 6 miles and 7.5 miles from the Beaver and Buck Creek dam sites, respectively. The largest earthquake was an M 4.1 event that occurred on August 17, 1994, about 90 miles southeast of the dam sites being considered.

Only 17 earthquakes were recorded within 31 miles of the dam sites. The majority of these (13) was associated with the 2001 Spokane earthquake swarm that occurred about 28-31 miles south of the dam sites (University of Washington, 2001).

The low level of earthquake activity and the lack of active faults in the region of the dam sites, are reflected in the results of seismic hazard mapping of this region of the United States by the U.S. Geological Survey (2002a). Low peak ground accelerations (PGA) at the dam sites, as derived from the U.S. Geological Survey (2002a), are 0.07 g and 0.16 g, respectively, for the 475-year return period PGA, and for the 2,475-year return period PGA. For comparison, Seattle, Washington (an area of relatively high seismicity) has 475-year, and 2,475-year return period PGAs of 0.33 g and 0.64 g, respectively. Thus, the expected intensity of future earthquake shaking at the dam sites is only about 20-25 percent of what would be expected in the Seattle, Washington area.

1.1.3 Dam Site Geologic Conditions

Based on the geologic mapping of Miller (1974), Waggoner (1990), and Carrara and others (1995), valley bottoms are underlain primarily by Holocene (past 10,000 years) alluvium that may be from 3 to 33 feet thick. The alluvium consists of stratified to unstratified boulders, cobbles, gravel, sand, silt and clay. It locally includes alluvial fan, lacustrine (lake), organic and, eolian (wind blown) deposits.

Based on the available geologic mapping of the areas of the proposed Beaver Creek and Buck Creek dams, the geologic conditions at the sites are such that the dams appear to be feasible from a geologic perspective. There are no faults mapped at either site and there appear to be no significant adverse geologic conditions that would preclude siting dams at the two locations. Nevertheless, there are geotechnical issues at each site that will need to be addressed during a feasibility level assessment. For example, potentially thick, granular (e.g., gravel, cobbles, boulders) may underlie the proposed dam axes. These soils may have negative impacts on foundation stability, and on the potential for leakage beneath the dams, which could be addressed with a grout curtain.

1.1.3.1 Beaver Creek Dam Site Geologic Conditions

Carrara and others (1995) also indicate that about 800 feet upstream of the proposed dam axis there are organic deposits underlying the valley that consist mainly of peat, woody peat, muck, and organic silt and clay. These organic deposits range from 3 to 33 feet thick, and are mapped to extend another 4,000 feet upstream (Carrara and others, 1995). These organic deposits would have to be excavated to avoid settlement of the foundation.

The bedrock underlying the slopes along the valley is late Cretaceous (70 million to 80 million years old) quartz monzonite and monzogranite of the Little Roundtop pluton (Stoffel and others, 1991; Waggoner, 1990; Miller, 1974). This igneous rock is deeply weathered and very coarse grained with crystals from 0.5 to 1 inch diameter.

There are no faults mapped in the Little Roundtop pluton, but there are faults mapped in the Precambrian Belt Supergroup rocks to the south, west and northeast of the dam site (Waggoner, 1990; Miller, 1974). The intrusion of the Little Roundtop pluton truncates the faults, and post dates them. Although there may be fractures such as joints in the intrusive igneous rocks of the Little Roundtop pluton, none are indicated on the available geologic maps (Waggoner, 1990; Miller, 1974).

1.1.3.2 Buck Creek Dam Site Geologic Conditions

The valley wall on the north side at the dam site is underlain by bedrock of the late Cretaceous Little Roundtop pluton. On the south side of the valley, the slope is underlain by bedrock of both the Little Roundtop pluton, and the Precambrian Prichard Formation. The quartz monzonite and monzogranite of the Little Roundtop pluton extend upslope to about an elevation of 2,400 to 2,440 feet amsl, while the Prichard Formation is present at elevations above this. The Prichard Formation is a low-grade metamorphic rock that consists primarily of argillite, siltite and quartzite. The Prichard Formation also has metamorphosed diabase igneous sills that have intruded the formation (Miller, 1974; Stoffel and others, 1990). One such sill is located at about elevation 2,600 feet amsl on the south side of the valley. The sill is about 500 feet wide and trends east-west. Stoffel and others (1990) consider the Prichard Formation to be about 1,500 million years old.

There are no faults mapped in the bedrock at the proposed site, and the closest mapped fault is near the mouth of Buck Creek where it enters Horseshoe Lake, more than 1.75 miles southeast of the dam site. Miller (1974) has mapped bedding structure in the Prichard Formation, and indicates that bedding strikes generally east-west, and dips to the south from 40 to 65 degrees. This bedding structure could provide flow paths for leakage around the proposed dam. Buck Creek drains east at this location, and the strike of bedding is east-west, with a moderate to steep (40-65 degrees) southerly dip. Depending on the nature, permeability and variability of the interbedded metamorphosed sediments, and the nature and permeability of the bedding contacts, there could be groundwater seepage through the abutments around the dam. Additionally, the nature and permeability of the contact on the south valley wall between the Little Roundtop pluton and the Prichard Formation are currently unknown, but may be another pathway for water around the dam. These are issues that should be addressed during the design process.

APPENDIX E

SALTESE FLATS WELL LOGS

156769

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No

Permit No.

(1) OWNER: Name Mike Porter Address Pheasant Dr Greenacres WA

(2) LOCATION OF WELL: County Spokane NE ¼ NW ¼ Sec. 5 T 25 N., R. 45 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 1
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 380 ft. Depth of completed well 380 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 39 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 39 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 40 ft. below top of well Date 5/19/87
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: 12 gal./min. with ft. drawdown after hrs.
" " " "
" Air Test Approx " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Granite, tan, very decomposed	0	25
Granite, tan, soft w/2 gpm	25	80
Granite, grey, soft; slightly frac	80	120
Granite, lt. brown, soft	120	160
Granite, grey, med, frac.	160	220
Granite, dk. brown, soft	220	240
Granite, grey frac. w/water	240	270
Granite, grey, med.	270	340
Granite, grey, slightly frac. w/water	340	380

380 PVC Installed
Formation Packer set at 180

RECEIVED
JUN 17 1987
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 5/18 1987 Completed 5/19 1987

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME J+J Drilling, Inc. (Person, firm, or corporation) (Type or print)

Address S. 5613 Linke Rd, Greenacres, Wa

[Signed] Keith D. Vermillion (Well Driller)

License No. 1079 Date 5/21, 1987

4/14/[illegible]

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

149873

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 18425
UNIQUE WELL I.D. #
Water Right Permit No.

(1) OWNER: Name Bob Chadduck Address 12605 E Skyview Ave. Spokane, WA 99216

(2) LOCATION OF WELL: County Spokane SW 1/4 SE 1/4 Sec 32 T. 25 N., R. 45 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Owl Rd. Greenacres, WA

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 420 feet. Depth of completed well 420 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 39 ft.
Welded [X] 4" Diam. from ft. to 420 ft.
Liner installed [X]
Threaded [ ] " Diam. from ft. to ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 100 ft. below top of well Date 2/28/94
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: 60 gal./min. with ft. drawdown after hrs.
" Air test approx. 60-G.P.M."

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil	0	1
Clay-brn.	1	5
Granit-soft	5	30
Granit-med.	30	44
Granit-soft	44	284
Granit-med. w/fracts.	284	325
Granit-hard	325	387
Granit-med.	387	397
Granit-highly fract.-water-60-G.P.M.	397	403
Granit-med.	403	420

RECEIVED APR - 4 1994 DEPT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 2/25/94, 19. Completed 2/28/, 19 94

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S 5613 Linke Rd. Greenacres, WA 99016
(Signed) [signature] (WELL DRILLER) License No. 1447
Contractor's Registration No. JJDRII-177KU Date 3/7/ , 19 94

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 346 269 ~~090945~~
UNIQUE WELL I.D. # AAL 194
Water Right Permit No. ______

(1) OWNER: Name Don Driscoll Address 15821 E 4th Apt#1248 Veradale WA 99037

(2) LOCATION OF WELL: County Spokane ___ 1/4 SE 1/4 Sec 32 T. 25N N., R. 45E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 4204 S Saltese Lake Rd.

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 500 feet. Depth of completed well 500 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 19 ft.
Welded [X] Liner installed [ ] Threaded [ ]
___ " Diam. from ___ ft. to ___ ft.
___ " Diam. from ___ ft. to ___ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ___ Slot size ___ from ___ ft. to ___ ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level - ft. below top of well Date 11/4/97
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ______
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" Air Test 0"G.P.M. " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ______
Temperature of water ___ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	3
Granite, Medium to Hard	3	45
Granite, Medium	45	190
Granite, Hard	190	500

WELL DEVELOPMENT BY HYDROFRACTURING
Pre-frac yield:____ Post-frac yield:____
Hydrofractured at depths of:
378 - bottom 126 - 210
294 - 378 42 - 126
210 - 294
This well was hydrofractured under my jurisdicti
Name Northwest Hydrofracturing
Address W 14010 Lincoln Rd
Spokane WA 99224
Signed Lynn Bartholomew Date 12-1-

RECEIVED
DEC 2 1997
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 11/3/97, 19 Completed 11/4/97, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S. 5613 Linke Greenacres WA 99016
(Signed) Marty Russo Jr (WELL DRILLER) License No. 2038
Contractor's Registration No. JJDRII-177KU Date 11/6/97, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

59551

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 090945
UNIQUE WELL I.D. # AAL 194
Water Right Permit No. ____

OWNER: Name Don Driscoll Address 15821 E 4th Apt#1248 Veradale WA 99037

LOCATION OF WELL: County Spokane ____ 1/4 SE 1/4 Sec 32 T. 25N N., R. 45E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 4204 S Saltese Lake Rd.

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 500 feet. Depth of completed well 500 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 19 ft.
Welded [X] ____" Diam. from ____ ft. to ____ ft.
Liner installed [ ] ____" Diam. from ____ ft. to ____ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ____
Type ____ Model No ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level - ft. below top of well Date 11/4/97
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" Air Test 0-G.P.M. " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top Soil	0	3
Granite, Medium to Hard	3	45
Granite, Medium	45	190
Granite, Hard	190	500

5 -98

Work Started 11/3/97, 19 Completed 11/4/97, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S. 5613 Linke Greenacres WA 99016
(Signed) Marty Rugo Jr (WELL DRILLER) License No. 2038
Contractor's Registration No. JJDRII-177KU Date 11/6/97, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

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ECY 050-1-20 (9/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 090945
UNIQUE WELL I.D. # AAL 194
Water Right Permit No. ____

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(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 500 feet. Depth of completed well 500 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 19 ft.
Welded [X] Liner installed [ ] Threaded [ ] ____ Diam. from ____ ft. to ____ ft. ____ Diam. from ____ ft. to ____ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level - ft. below top of well Date 11/4/97
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
"Air Test 0"G.P.M. " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

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Granite, Medium to Hard	3	45
Granite, Medium	45	190
Granite, Hard	190	500

WELL DEVELOPMENT BY HYDROFRACTURING
Pre-frac yield: ____ Post-frac yield: ____
Hydrofractured at depths of:
378 - bottom 126 - 210
294 - 378 42 - 126
210 - 294
This well was hydrofractured under my jurisdicti
Name Northwest Hydrofracturing
Address W 14010 Lincoln Rd
Spokane WA 99224
Signed [signature] Date 12-1-..

RECEIVED
DEC 2 1997
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 11/3/97, 19 Completed 11/4/97, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S. 5613 Linke Greenacres WA 99016
(Signed) [signature] (WELL DRILLER) License No. 2038
Contractor's Registration No. JJDRII-177KU Date 11/6/97, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 159526

Permit No. ....

(1) OWNER: Name Tim Franz Address E 13221 Main ave. Spokane

LOCATION OF WELL: County Spokane NE ¼ SE ¼ Sec 32 T 25 N., R 45 W.M.

ng and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 246 ft. Depth of completed well 246 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 41 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☑ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☑
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☑ No ☐ To what depth? 40 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P.....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 2200 ft.
Static level 150 ft. below top of well Date 12-9-76
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?.....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test.....
Bailer test 3 gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
overburden	0	6
Granite Decomposed	6	38
Quartzite - Black	38	85
Quartz Green & wh.	85	90
" Black Layered	90	110
Granite Decomposed	110	120
Granite	120	130
Sedimentary - Tan	130	140
Granite Blk & wh	140	149
" Purple	149	154
Granite softer	154	179
Quartz milk white	179	194
Granite	194	246

RECEIVED
JAN - 4 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 12-1, 1976. Completed 12-9, 1976

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Graham Drilling (Person, firm, or corporation) (Type or print)

Address Nine Mile Falls Wa.

[Signed] Leo C Graham (Well Driller)

License No. 156 Date 12-13, 1976

1/4/77

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

Copy to K.F.O. - #7 - 99206 - H. Casey   155203

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) OWNER: Name Jorgens, Casey, Smith, et al. Address Spokane Wa

(2) LOCATION OF WELL: County Spokane SE ¼ NW ¼ Sec 33 T 25 N., R 45 E W.M.

Bearing and distance from section or subdivision corner 200 E N + 200 E E of SEC. C.L.

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☑ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☑ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 242 ft. Depth of completed well 241 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 224 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☑ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☑
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☑
Manufacturer's Name ....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☑ No ☐ To what depth? 25 ft.
Material used in seal BENT
Did any strata contain unusable water? Yes ☑ No ☐
Type of water? BRACKISH Depth of strata 18 TO 105
Method of sealing strata off PIPE

(7) PUMP: Manufacturer's Name X
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level ..... ft.
Static level ..... ft. below top of well Date .....
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

NO

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? .....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

X

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

NO

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

8/1/77

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top Soil - Black	0	3
Peat Moss - Black	3	18
Peat + Clay - Drk. Brn.	18	24
Clay - Blue - Soft	24	40
" " "	40	50
Sand - Fine - Water	50	62 water
Granit Sand - Med. Fine	62	79
Granit Rock Flour	79	100
" " "	100	110
Granit Gravel + Sand	110	150
" "	150	153
Clay - Soft - Brown	153	162
Fine Sandy Clay - Brown	162	170
Sandy Clay - Grey	170	180
Sandy Clay Lt. Brn. Very Fine	180	183
Sand Med. Fine - Some Gravel	183	190 water
Coarse Sand - Water	190	200
Sand V. Fine - Brown	200	210
Sand Gray - V. Fine	210	224
" "	224	232
Sandy Mud - White	232	242

Pipe Scedual

21' - 21' ...
20' - 20' - 16' 5" - 16' 3"
6' - 7' - 7' 9" ...
6' 6" 7' 6"
12 ...

RECEIVED
AUG - 2 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 1 - 20, 1977. Completed 2 - 9, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B & B. Co (Person, firm, or corporation) (Type or print)

Address 11924 E Sprague

[Signed] G. Benander (Well Driller)

License No. 0033 Date 2 - 10, 1977

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

156 057/058

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 060483 #2

Water Right Permit No. ____

(1) OWNER: Name Logan H Jorgens Address E 12516 12th Ave. Spokane, WA 99216

(2) LOCATION OF WELL: County Spokane, ¼ NE ¼ Sec. 33 T. 25 N., R. 45 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Henry Rd. & Molter Rd. Greenacres, WA

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 160 feet. Depth of completed well 160 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 41 ft.
Welded [X] 4 " Diam. from ____ ft. to 160 ft.
Liner installed [X]
Threaded [ ] ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level + 1½ ft. below top of well Date 5-26-93
Artesian pressure + 1 ½ lbs. per square inch Date 5-26-93
Artesian water is controlled by Cap (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ____
Yield: 15 gal./min. with ____ ft. drawdown after ____ hrs.
Air test approx. 15-G.P.M.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil	0	1
Granit-decomposed	1	36
Granit-med. w/fracts.	36	137
Granit-fract.-water-5-G.P.M.	137	138
Granit-med. w/fracts.	138	154
Granit-fract.-water-10-G.P.M.	154	155
Granit-med.	155	160

RECEIVED JUN 15 1993 DEPT OF ECOLOGY ... REGIONAL OFFICE

Work started 5/26/93, 19 . Completed 5/26/, 19 93

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address S 5613 Linke Rd. Greenacres, WA 99016

(Signed) [signature] (WELL DRILLER) License No. 1962

Contractor's Registration No. JJDRII-177KU Date 5/27/, 19 93

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 060462 #1

Water Right Permit No. ______

(1) OWNER: Name Logan H Jorgens Address E 12516 12th Ave. Spokane, WA 99216

(2) LOCATION OF WELL: County Spokane ¼ NE ¼ Sec 33 T. 25 N., R. 45 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Henry Rd. & Molter Rd. Greenacres, WA

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 85 feet. Depth of completed well 85 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 34 ft.
Welded [X] 4 " Diam. from ______ ft. to 80 ft.
Liner installed [X]
Threaded [ ] ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level +1/2 ft. below top of well Date 5/26/93
Artesian pressure 1/2 PSI lbs. per square inch Date 5/26/93
Artesian water is controlled by Cap (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ______
Yield: 5 gal./min. with ______ ft. drawdown after ______ hrs.
Air test approx. 5 G.P.M. " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil	0	8
Granit-decomposed	8	27
Granit-med. w/fracts.	27	85
Water-48'-53'		

RECEIVED
JUN 15 1993
DEPT OF ECOLOGY
SPOKANE OFFICE

Work started 5/25/93, 19. Completed 5/26/, 19 93

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S 5613 Linke Rd. Greenacres, WA 99016
(Signed) [signature] (WELL DRILLER) License No. 1962
Contractor's Registration No. JJDRII-177KU Date 5/27/, 19 93

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

156060

Start Card No. W 06455

UNIQUE WELL I.D. #

Water Right Permit No.

(1) OWNER: Name Logan Jorgens Address E 12516 12th Ave. Spokane, WA 99216

LOCATION OF WELL: County Spokane NE ¼ NE ¼ Sec 33 T. 25 N., R. 45 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Saltese Flats, Greenacres, WA

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 400 feet. Depth of completed well 400 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from +1 ft. to 39 ft.
Welded ☒ 4 " Diam. from ft. to 400 ft.
Liner installed ☒
Threaded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 1 ft. below top of well Date 7/30/93
Artesian pressure 2 lbs. per square inch Date 8/2/93
Artesian water is controlled by cap valve (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: 8 gal./min. with ft. drawdown after hrs.
" Air test approx. 8-G.P.M. "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil	0	1
Granit-decomposed	1	9
Granit-soft	9	31
Granit-med.	31	62
Granit-med. w/fracts. ½-G.P.M.	62	238
Granit-fract.-1-G.P.M.	238	239
Granit-med. w/fracts.	239	382
Granit-fract.-water-6½-G.P.M.	382	383
Granit-med. w/fracts.	383	400

RECEIVED AUG 18 1993

Work started 7/29/93, 19. Completed 7/30/, 19 93

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S 5613 Linke Greenacres, WA 99016
(Signed) [signature] (WELL DRILLER) License No. 2139
Contractor's Registration No. JJDRIL-177KU Date 8/2/, 19 93

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 149610

Permit No. ....

(1) OWNER: Name Barry Hulsizer Address Route 1, Box 137, Fairfield, WA 99012

(2) LOCATION OF WELL: County Spokane — ¼ SW ¼ Sec 27 T. 25 N., R. 45E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic [X] Industrial [ ] Municipal [ ] Irrigation [ ] Test Well [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well [X] Method: Dug [ ] Bored [ ]
Deepened [ ] Cable [ ] Driven [ ]
Reconditioned [ ] Rotary [X] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 305 ft. Depth of completed well 305 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 39 ft.
Threaded [ ] ....." Diam. from ..... ft. to ..... ft.
Welded [X] ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes [ ] No [X]
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes [ ] No [X]
Manufacturer's Name.....
Type..... Model No.....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes [ ] No [X] Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes [X] No [ ] To what depth? 39 ft.
Material used in seal bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ..... Depth of strata .....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level... 2500
Static level 60 ft. below top of well Date 2/01/84
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?.....
Yield: 25 gal./min. with ..... ft. drawdown after ..... hrs.
" ESTIMATED AIRLIFT " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow..... g.p.m. Date .....
Temperature of water..... Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Clay, brown	0	5
Clay, tan	5	25
Basalt, gray, medium	25	60
Basalt, gray, slightly fractured with water	60	100
Basalt, gray, medium	100	293
Basalt, gray, fractured with brown clay seams with water	293	305
300' PVC Liner Installed		
6" Drive Shoe Installed		

Work started 1/30 19 84 Completed 2/01/ 19 84

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME PONDEROSA DRILLING & DEVELOPMENT INC.
(Person, firm, or corporation) (Type or print)

Address E. 6010 Broadway, Spokane, WA 99212

[Signed] Lynnwood Hendrick
Lynnwood Hendrick (Well Driller)

License No. 1351 Date 2/01/ 19 84

2/14/84

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

144433

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 18487

UNIQUE WELL I.D. #

Water Right Permit No.

(1) OWNER: Name Angel Harris Address E 10220 Broadway, Spokane, WA 99206

(2) LOCATION OF WELL: County Spokane 1/4 S1/2 1/4 Sec 5 T. 24 N., R 45 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Campbell Rd. Saltese

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 660 feet. Depth of completed well 660 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 47 ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ]
Threaded [ ] " Diam. from ft. to ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 178 ft. below top of well Date 7/16/94
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: 2 gal./min. with ft. drawdown after hrs.
Air test approx. 2-G.P.M.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Granit-decomposed	0	25
Granit-med. to hard	25	165
Granit-slightly fract. 2-G.P.M.	165	190
Granit- med. to hard	190	210
Granit-hard	210	660

RECEIVED SEP - 6 1994 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 7/14/94, 19. Completed 7/16/, 19 94

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S 5613 Linke Rd. Greenacres, WA 99016
(Signed) [signature] (WELL DRILLER) License No. 1447
Contractor's Registration No. JJDRII-177KU Date 7/20/, 19 94

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

156737

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 057622

Water Right Permit No. ____

(1) OWNER: Name Mike Lowdon Address E 22105 Wellsley, Otis Or. WA. 99207

LOCATION OF WELL: County Spokane NE ¼ SE ¼ Sec. 5 T. 24 N., R. 45 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Campbell Rd. Saltese Flats, Greenacres, WA.

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 540 feet. Depth of completed well 540 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 19 ft.
Welded [X] Liner installed [X] 4 " Diam. from ____ ft. to 540 ft.
Threaded [ ] ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 18+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 120 ft. below top of well Date 10/16/91
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ____
Yield: 9 gal./min. with ____ ft. drawdown after ____ hrs.
Air test approx. 9-G.P.M. " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Topsoil	0	1
Granit-decomposed	1	15
Granit-med. w/fracts.	15	517
Granit-fractured	517	519
Granit-med.	519	540

Work started 10/14/91, 19__ Completed 10/16/ , 19 91

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME J & J DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address S 5613 Linke Rd. Greenacres, WA 99016
(Signed) [signature] (WELL DRILLER) License No. 1447
Contractor's Registration No. JJDRII-177KU Date 10/21/ , 19 91

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

151198

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

DARRELL CLUTE

(1) OWNER: Name ~~Dan Clute~~ Address RT 1 GREENACRES, WA 99016

(2) LOCATION OF WELL: County Spokane — SW ¼ NW ¼ Sec 4 T 24 N., R 45 W.M.

ng and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled ...... ft. Depth of completed well 275 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 20 ft.
Threaded ☐ ...... " Diam. from ...... ft. to ...... ft.
Welded ☐ ...... " Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Puddling Clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level 2150 ft.
Static level ...... ft. below top of well Date ......
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" ...... " ...... " ...... "
" ...... " ...... " ...... "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Overburden Soil	0	5
Decomposed Granite Med	5	20
Hard Granite	20	35
Decomposed Granite Med	35	50
Med Grade Granite	50	125
Med & Hard Grade Granite	125	150
Hard Grade Granite (Mica)	150	174
Soft Grade Granite (white)	174	200
Med Grade Granite	200	210
Hard Grade Granite	210	250
Med Grade Granite with Soft spots (Water)	250	275

Airtest 10 GPM.

RECEIVED
JUL 2 1979
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started Aug 24, 1979. Completed Aug 26, 1979

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME [illegible] (Person, firm, or corporation) (Type or print)

Address [illegible] WA

[Signed] [illegible] (Well Driller)

License No. 0572 Date [illegible], 1979

7/2/79

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

316488

WATER WELL REPORT

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Construction/Decommission ("x" in circle) 106055

(X) Construction

( ) Decommission ORIGINAL CONSTRUCTION Notice of Intent Number ______

CURRENT Notice of Intent No. W151338

CURRENT Notice of Intent No. W151335

Unique Ecology Well ID Tag No. AGC162

Water Right Permit No. ______

Property Owner Name Todd Jewett

Well Street Address Saltese Lake Rd.

City ______ County: Spokane

Location ____1/4-1/4 NW 1/4 Sec 4 Twn 24N R 45E EWM or WWM

Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: [X] Domestic [ ] Industrial [ ] Municipal [ ] DeWater [ ] Irrigation [ ] Test Well [ ] Other ______

TYPE OF WORK: Owner's number of well (if more than one) 1

[X] New Well [ ] Reconditioned *Method:* [ ] Dug [ ] Bored [ ] Driven

[ ] Deepened [ ] Cable [X] Rotary [ ] Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 780 ft.

Depth of completed well 780 ft.

CONSTRUCTION DETAILS

Casing Installed: [X] Welded 6" Diam from +1 ft. to 59 ft.

[X] Liner installed 4" Diam. from 0 ft. to 780 ft.

[ ] Threaded ____" Diam from ______ ft. to ______ ft.

Perforations: [ ] Yes [X] No

Type of perforator used ______

SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft to ____ ft.

Screens: [ ] Yes [X] No [ ] K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ______ Slot Size ______ from ______ ft. to ______ ft.

Diam. ______ Slot Size ______ from ______ ft. to ______ ft

Gravel/Filter packed: [ ] Yes [X] No [ ] Size of gravel/sand ______

Materials placed from ______ ft. to ______ ft.

Surface Seal: [X] Yes [ ] No To what depth? 18+ ft

Materials used in seal Bentonite

Did any strata contain unusable water? [ ] Yes [X] No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 40 ft. below top of well Date 10/10/01

Artesian pressure ______ lbs per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.

Was a pump test made? [ ] Yes [X] No If yes, by whom? ______

Yield: ______ gal./min. with ______ ft drawdown after ______ hrs

Yield: ______ gal./min with ______ ft drawdown after ______ hrs

Yield: ______ gal./min. with ______ ft drawdown after ______ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ______ gal./min with ______ ft drawdown after ______ hrs

Airtest 5+ gal./min with stem set at ______ ft for ______ hrs.

Artesian flow ______ g.p.m. Date ______

Temperature of water ______ Was a chemical analysis made? [ ] Yes [X] No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY)

MATERIAL	FROM	TO
Topsoil	0	2
Granite, Decomposed	2	13
Granite, Hard	13	26
Granite, Soft	26	44
Granite, Medium w/	44	118
slight fractures		
Granite, Soft to	118	141
Medium		
Granite, Medium w/	141	317
slight fractures		
Granite, Fractured -	317	318
Water 1gpm		
Granite, Medium w/	318	378
slight fractures		
Granite, Hard	378	421
Granite, Medium w/	421	555
slight fractures		
Granite, Hard	555	631
Granite, Medium w/	631	780
slight fractures		

Well air tested at 1gpm prior to hydro-fracturing. Well air tested at 5+gpm post hydro-fracturing. A pump tested is recommended to determine accurate gpms. Set pump at 600 feet or deeper.

Start Date 10/8/01 Completed Date 10/15/01

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

[X] Driller [ ] Engineer [ ] Trainee Name (Print) Don Anderson

Driller/Engineer/Trainee Signature Don Anderson

Driller or Trainee License No. 1447

Drilling Company J & J Drilling, Inc.

Address S. 5613 Linke Rd.

City, State, Zip Greenacres, WA 99016

330527/576

W081117

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy

111529

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent
UNIQUE WELL I D # AHC201
Water Right Permit No

(1) OWNER: Name Todd Rigby Address 17400 E Alki, Greenacres, WA 99016

(2) LOCATION OF WELL: County Spokane SW 1/4 SW 1/4 Sec 23 T 25 N R 45E WM

(2a) STREET ADDRESS OF WELL: (or nearest address)

TAX PARCEL NO.

(3) PROPOSED USE: XX Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK: Owner's number of well (if more than one)
XX New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method ☐ Dug ☐ Cable XX Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 10 - 6 inches
Drilled 378 feet Depth of completed well 378 ft

(6) CONSTRUCTION DETAILS
Casing Installed:
XX Welded 6" Diam from +2 ft to 26 ft
XX Liner installed 4" Diam. from -5 ft to 368 ft
☐ Threaded " Diam. from ft to ft

Perforations: ☐ Yes XX No
Type of perforator used
SIZE of perforations in by in
perforations from ft to ft

Screens: XX Yes ☐ No ☐ K-Pac Location
Manufacturer's Name Johnson
Type PVC Model No
Diam 4 Slot Size 020 from 368 ft. to 378 ft
Diam Slot Size from ft. to ft

Gravel/Filter packed: ☐ Yes XX No ☐ Size of gravel/sand
Material placed from ft to ft.

Surface seal: XX Yes ☐ No To what depth? 26 ft
Material used in seal Bentonite Surface Seal
Did any strata contain unusable water? ☐ Yes XX No
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H P

(8) WATER LEVELS: Land-surface elevation above mean sea level ft
Static level 30 ft below top of well Date
Artesian pressure lbs per square inch Date
Artesian water is controlled by (Cap, valve, etc)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes XX No If yes, by whom?
Yield 5.5 gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)
Time Water Level Time Water Level Time Water Level
Estimated Air Lift at Time of Drilling

Date of test
Bailer test gal /min with ft drawdown after hrs
Airtest gal /min with ft drawdown after hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? ☐ Yes XX No

ECY 050-1-20 (11/98)

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information Indicate all water encountered

MATERIAL	FROM	TO
Brown top soil	0	6
Tan decomposed granite	6	12
Medium tan granite	12	68
Hard gray granite	68	242
Tan fractured granite with water	242	267
Hard gray granite	267	362
Medium fractured granite w/quartz sand and water	362	368
Hard gray granite	368	378

RECEIVED APR 26 2002 DEPT OF ECOLOGY EASTERN REGIONAL OFFICE

Work Started 11/10/01 Completed 11/13/01

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

Type or Print Name Douglas Lane License No 1030 (Licensed Driller/Engineer)

Trainee Name License No

Drilling Company Inland Pacific Drilling

(Signed) Douglas E Lane License No 1030 (Licensed Driller/Engineer)

Address 5014 N Chase Rd, Newman Lake, WA 99025

Contractor's Registration No INLANPD066DD Date 1/25/02

(USE ADDITIONAL SHEETS IF NECESSARY)

336 574

WATER WELL REPORT

ECOLOGY Original & 1st copy Ecology 2nd copy owner 3rd copy driller

Construction/Decommission (x in circle) 115661

(X) Construction

O Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ____

CURRENT Notice of Intent No W148094

Unique Ecology Well ID Tag No AGG231

Water Right Permit No ____

Property Owner Name Babs Riggs

Well Street Address Saltese Lake Rd

City Greenacres County Spokane

Location ____1/4-1/4 SW 1/4 Sec 33 Twn 25N R 45E EWM or WWM (circle one)

Lat/Long (s t,r still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____

Tax Parcel No ____

PROPOSED USE [X] Domestic [ ] Industrial [ ] Municipal [ ] DeWater [ ] Irrigation [ ] Test Well [ ] Other ____

TYPE OF WORK Owner's number of well (if more than one) ____

[X] New Well [ ] Reconditioned *Method* [ ] Dug [ ] Bored [ ] Driven

[ ] Deepened [ ] Cable [X] Rotary [ ] Jetted

DIMENSIONS Diameter of well 6 inches drilled 360 ft

Depth of completed well 360 ft

CONSTRUCTION DETAILS

Casing Installed [X] Welded 6 Diam from +1 ft to 39 ft

[X] Liner installed 4 Diam from ____ ft to 360 ft

[ ] Threaded ____ Diam from ____ ft to ____ ft

Perforations [ ] Yes [X] No

Type of perforator used ____

SIZE of perfs ____ in by ____ in and no of perfs ____ from ____ ft to ____ ft

Screens [ ] Yes [X] No [ ] K Pac Location ____

Manufacturer's Name ____

Type ____ Model No ____

Diam ____ Slot Size ____ from ____ ft to ____ ft

Diam ____ Slot Size ____ from ____ ft to ____ ft

Gravel/Filter packed [ ] Yes [X] No [ ] Size of gravel/sand ____

Materials placed from ____ ft to ____ ft

Surface Seal [X] Yes [ ] No To what depth? 18+ ft

Materials used in seal Bentonite

Did any strata contain unusable water? [ ] Yes [X] No

Type of water? ____ Depth of strata ____

Method of sealing strata off ____

PUMP Manufacturer's Name ____

Type ____ H P ____

WATER LEVELS Land surface elevation above mean sea level ____ ft

Static level 57 ft below top of well Date 5/31/02

Artesian pressure ____ lbs per square inch Date ____

Artesian water is controlled by ____ (cap valve etc)

WELL TESTS Drawdown is amount water level is lowered below static level

Was a pump test made? [ ] Yes [X] No If yes by whom? ____

Yield ____ gal /min with ____ ft drawdown after ____ hrs

Yield ____ gal /min with ____ ft drawdown after ____ hrs

Yield ____ gal /min with ____ ft drawdown after ____ hrs

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time Water Level Time Water Level Time Water Level

Date of test ____

Bailer test ____ gal /min with ____ ft drawdown after ____ hrs

Airtest 10 gal /min with stem set at ____ ft for ____ hrs

Artesian flow ____ g p m Date ____

Temperature of water ____ Was a chemical analysis made? [ ] Yes [X] No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation Describe by color character size of material and structure and the kind and nature of the material in each stratum penetrated with at least one entry for each change of information Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY)

MATERIAL	FROM	TO
Topsoil	0	2
Clay, Brown	2	4
Granite, Decomposed	4	17
Granite, Medium	17	44
Granite, Soft to Med	44	168
Granite, Medium	168	195
Granite, Fractured -	195	197
Water 1-1/2gpm		
Granite, Medium	197	238
Granite, Fractured -	238	243
Water 1-1/2gpm		
Granite, Medium	243	251
Granite, Hard	251	335
Granite, Fractured	335	337
Granite, Hard	337	360
Well air tested at 3gpm prior to hydro-fracturing Well air tested at 10gpm post hydro-fracturing. A pump test is recommended to determine accurate gpm's		
Recommended pump set depth is 280 feet		

Start Date 5/29/02 Completed Date 5/31/02

WELL CONSTRUCTION CERTIFICATION I constructed and/or accept responsibility for construction of this well and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

[X] Driller [ ] Engineer [ ] Trainee Name (Print) Don Anderson

Driller/Engineer/Trainee Signature Don Anderson

Driller or Trainee License No 1447

If trainee, licensed driller's Signature and License no ____

Drilling Company J & J Drilling, Inc

Address S 5613 Linke Rd

City State Zip Greenacres, WA 99016

Contractor's Registration No JJDRII-177KU Date 6-3-02

Ecology is an Equal Opportunity Employer ECY 050 1 20 (Rev 4/01)

Copy to R.I.O. - #7 - 99206 H. Casey   155203

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Jorgens, Casey, Smith, et al Address Spokane Wa

(2) LOCATION OF WELL: County Spokane SE ¼ NW ¼ Sec 33 T 25 N., R 45 E W.M.

Bearing and distance from section or subdivision corner 200 E N + 200 E E. of Sec. C.L.

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 242 ft. Depth of completed well 241 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 224 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ..... Model No. ....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 25 ft.
Material used in seal BENT
Did any strata contain unusable water? Yes ☒ No ☐
Type of water? Brackish Depth of strata 18 to 105
Method of sealing strata off Pipe

(7) PUMP: Manufacturer's Name X
Type: ..... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level ..... ft. below top of well Date ....
Artesian pressure ..... lbs. per square inch Date ....
Artesian water is controlled by ..... (Cap, valve, etc.)

NO

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

NO

Date of test ....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date ....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

8/1/77

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top Soil - Black	0	3
Peat Moss - Black	3	18
Peat + Clay - Drk. Brn.	18	24
Clay - Blue - Soft	24	40
" " "	40	50
Sand - Fine - Water	50	62 Water
Granit Sand - Med. Fine	62	79
Granit Rock Flour	79	100
" " "	100	110
Granit Gravel + Sand	110	150
" "	150	153
Clay - Soft - Brown	153	162
Fine Sandy Clay - Brown	162	170
Sandy Clay - Grey	170	180
Sandy Clay Lt. Brn. Very Fine	180	183
Sand Med. Fine - Some Gravel	183	190 Water
Coarse Sand - Water	190	200
Sand V. Fine - Brown	200	210
Sand Gray - V. Fine	210	224
" "	224	232
Sandy Mud - White	232	242
Pipe Scedual		
21' - 21'		
20' - 20' 6" - 16' 9"		
6' - 7' - 7' 9"		
6' 6" 7' 6"		
12		

RECEIVED
AUG - 2 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 1-20, 1977. Completed 2-9, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B & B Co (Person, firm, or corporation) (Type or print)

Address 11924 E Sprague

[Signed] G. Benander (Well Driller)

License No. 0033 Date 2-10, 1977

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 158791
Permit No.

(1) OWNER: Name Saltese Farm Syndicate Address E. 12019 Sprague, Spokane, Wa. 99214

LOCATION OF WELL: County Spokane — NW¼ NE ¼ Sec. 29 T. 25 N., R. 45 W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 168 ft. Depth of completed well 84 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1½ ft. to 74 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name UOP Johnson
Type stainless steel Model No. 304
Diam. 6" Slot size 30 from 74 ft. to 84 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 19 ft.
Material used in seal puddling clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level... 2080 ft.
Static level 23 ft. below top of well Date 5/18/78
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 120 gal./min. with 1 ft. drawdown after 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	4
sand & gravel	4	7
grey clay, sand & gravel /w	7	31
sand & gravel (1 in.) /w	31	57
sand & gravel (3 in. -) /w	57	63
grey clay	63	64
grey sand (med. fine) /w	64	82
sand & gravel /w	82	85
grey clay sticky	85	86
sand & gravel (3 " -)	86	89
sand very fine /w	89	101
light grey clay sticky	101	117
light grey silt /w	117	131
XXX grey clay	131	142
dark grey clay & sand	142	168

RECEIVED
AUG 14 1978
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 5/11/ 1978. Completed 5/18 1978

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME E.A. HOLMAN DRILLING CO. (Person, firm, or corporation) (Type or print)
Address 601 S. Pines Rd., Spokane, Wa. 99216

[Signed] [signature] (Well Driller)

License No. 0101 Date 5/23/78, 19

8/15/78 Greenacres 7½

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

243240

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

Well 2-B

Appli. #7172

WELL LOG

No. Permit #6785

Date April 15, 1965

Record by Driller

Source Driller's Record

Location: State of WASHINGTON

County Spokane

Area N 20°30' E, 518.6' from

Map E 1/16 cor., Secs. 18 & 19

SE ¼ SE ¼ sec. 18 T. 25 N., R. 45 E.

Diagram of Section

Drilling Co. Holman Drilling Corporation

Address 3410 E. 9th Ave., Spokane, Washington

Method of Drilling Cable Date July 16, 1964

Owner U.S. Bureau of Reclamation

Address Box 937, Boise, Idaho

Land surface, datum .... ft. above / below

Correlation	Material	Thickness (feet)	Depth (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Domestic, irrigation, industrial and municipal well		
	Large gravel	0	13
	Gravel and boulders	13	32
	Gravel and sand	32	55
	Gravel	55	70
	Sand, gravel and boulders	70	100
	Gravel	100	127
	Gravel	127	146
	Small gravel	146	166
	Coarse gravel	166	170
	Gravel 3" minus	170	195
	Gravel 4" minus	195	216
	Gravel 6" minus	216	230
	Clay	230	
	Casing: 20" from 0 to 157'		

Turn up

Sheet ..... of ..... sheets