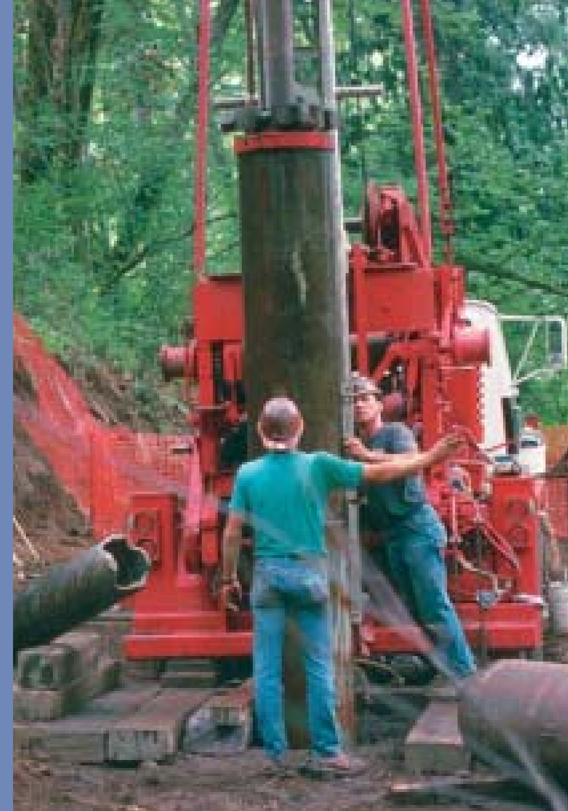
Prepared for

WRIA 55 and 57 Planning Unit



DRAFT

First Step Storage Assessment

Little and Middle Spokane Watersheds

JULY 2004

Golder Associates

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July 8, 2004

Our Ref.: 013-1372-001

Spokane County Purchasing Department
721 N. Jefferson
Suite 303
Spokane, Washington 99260

Attention: Robert Lindsay

RE: WRIA 55/57 MID-PROJECT STORAGE ASSESSMENT REPORT

Dear Rob:

Please find enclosed five hardcopies of the Mid-Project Storage Assessment Report and two CDs with the report in pdf format. The focus of this work was guided by the Initial Storage Options Memorandum in which we summarized our understanding of options that the Planning Unit wished to have considered. We also subsequently added several options that we recognized as we conducted the work. The report identifies options for increasing the storage in the watershed, and how it may be used in the management of water resources.

We will make a presentation of this report at the Planning Unit meeting on July 21, 2004 at the Spokane County Conservation District. At that meeting we will discuss our findings and lead a discussion with the Planning Unit. The goal of this discussion will be to identify selected options for more in-depth evaluation in the second step of this assessment. The range of options is not restricted to those included in the report, and additional options may be introduced.

As always, we appreciate everyone's input and help providing information to make this document part of your planning process. We look forward to meeting with you.

Sincerely,

GOLDER ASSOCIATES INC.

Chris V. Pitre
Associate, Water Resources

Tim White for
Sara Marxen
Water Resources Engineer

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.

July 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. "

In general water storage can be used for several purposes:

1. To offset current demands on existing systems.
2. To offset future demands on existing systems.
3. To apply to new water uses in new or expanded systems.
4. To enhance streamflows.

Enhancement of streamflows or prevention of further impacts to streamflows is typically a benefit of managing storage for existing or future uses.

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 provide 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.

WRIA 55:

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

WRIA 57

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

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 is included as Appendix A.

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 and is provided in Appendix B.

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.

2.0 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.

<u>Prevent the interruption of exercise of junior water rights during dry years in WRIA 55</u>

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 anticpated given that minimum instream flow regulations were based on flows that were historically met four our 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 control points.

A conservative estimate of storage necessary volume can be developed by assuming the instantaneous flow rate for each water right is used continuously and for fully consumptive purposes throughout the low flow period (July 15 to Sep 15). This assumption results in a total storage need of approximately 1,000 AF annually on the Little Spokane River.

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 length. 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.

<u>Offset potential impacts from future water supply development under existing water rights</u>

Water supply development under existing water rights is evaluated in the Phase 2 Watershed Assessment in two forms: 20-year growth projections and full use of municipal and domestic water rights (Figure 2-2). Watershed model simulations show that impacts on stream flow are less than the full rate of groundwater withdrawals. Therefore mitigation of impacts may require less water than is withdrawn.

In order to evaluate the impact on stramflow and groundwter elevation due to these development condtions the Spokane Watershed Model was used. The model results (currently in draft) predict changes in streamflow and groundwter over time due to changes in withdrawals and land use changes associated with growth.

Model-predicted streamflow changes on the Little Spokane River and Spokane River were converted to a total volume assuming supplemental storage was needed for either a 2 month (August and September) or 4 month (July through October) period. The period was selected based on the timing of low flows in the watersheds (Table 2-2).

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 flows. A delivery point higher in the watershed would provide the greatest stream reach of benefit.

Offset potential impacts of future allocations

This objective 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. Storage designed to fulfill this objective may be used for direct water supply and/or for mitigation of impacts associated with the allocation of additional water rights. While the volume of future water right allocations is unknown, current applications for new water rights in WRIA 55 and 57 provide context (Table 2-3 and Figure 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 tne instream flow assessment, and have reccommendations 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 Stree 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 durng the controlled period (June – September) under Avista's FERC license.

Improve flow related surface water quality problems

Surface water quality problems exist in several reaches of the WRIA 55 and 57. Draft State Water Quality Assessment results provide an indication of where these problems exist and are shown in

Figure 2-4. 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".

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.

Total Maximum Daily Loads (TMDLs) are being developed for dissolved metals (cadmium, lead, and zinc), phosphorus, and biochemical oxygen demand on the Spokane River. Additionally, there is a draft Use Attainability Analysis for dissolved oxygen in the Spokane River.

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 location outfall location in the Spokane River, but there is interest in reclaiming this water for aquifer injection with the potential benefit being streamflow (augmentation indirectly through recharge to groundwater and subsequent seepage to stream channels) and/or maintaining the groundwater balance in concert with groundwater withdrawals. "Reclaimed water" means effluent derived in any part from sewage from a wastewater treatment system that has been adequately and reliably treated, so that as a result of that treatment, it is suitable for a beneficial use or a controlled use that would not otherwise occur and is no longer considered wastewater (RCW 90.46.010).

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. In this area, an abandoned gravel pit at Broadway and Havana Streets has been identified as a potential locaton of infiltration and recharge to the Spokane Valley Aquifer. The planned initial maximum-month capacity of the SCRTP is 8.5 mgd (~ 13 cfs) in 2007, and a full build out capacity of 12.6 mgd (~ 19 cfs) for future growth (projected between 2015 and 2022).

This option would entail determing the location for recharge which provides the greatest benefit with the least impacts to existing uses, including wellhead protection considerations.

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

Groundwater monitoring in the Deer Park aquifer show elevated levels of nitrates in both the shallow and deep basalt aquifers. Recharge of surface water may be used to reduce the concentrations of nitrates in the affected groundwater by diversion or replacement of the flow of groundwater to drinking water wells. The point, timing and quantity of delivery would be determined by groundwater gradients.

3.0 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.

3.1 Reservoirs and Impoundment Concepts

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, not being a barrier to fish passage and needing smaller spillways and outlet works. Drawbacks may include the need to construct infrastructure to convey water to and from the reservoir, and higher construction, operations and maintenance costs, and reservoir leakage and 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, have a catchment or conveyance infrastructure large enough to reliably refill the reservoir, and provide 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).

Appendix A contains a variety of useful information and terminology related to dams and impoundments. The Water Storage Task Force Report to Legislature in Appendix A.

3.2 Availability of "Excess" Surface Water for Storage

A preliminary estimate of the amount of water available for storage can be 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.

The flow records for the Little Spokane River and the Spokane River were analyzed for the range in volumes 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 source of water in WRIA 57. Though the majority of water used in the watershed is not withdrawn from the Spokane Valley Aquifer, the aquifer is in close hydraulic continuity with the river. Therefore surface water withdrawals can quickly affect groundwater levels and vice versa.

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 streamflows 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.

Daily volumes of water 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-volumes of water available in "excess" of instream flows between April and June range 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). Comparisons 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 abandoned Elk gaging station, Chattaroy, at Dartford, and 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 Spokane Aquifer through the Hillyard Trough.

3.2.2.1 Little Spokane River near Dartford, WA

Daily volumes of water 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

Daily volumes of water 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

Daily volumes of water 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 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 lake. 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: Option includes 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.

3.3.1 <u>Treatment and Conveyance Requirements</u>

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.

3.3.2 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, deign and legal fees). Potential permits and approvals that may be required include:

- SEPA or NEPA (State/National Environmental Policy Act; WDOE);
- Hydraulic Project Approval;
- 401 Water Quality Certification;
- US Army Corps of Engineers 404 Permits (Discharge of Dredge and Fill);
- Washington Department of Fish and Wildlife mitigation;
- Water Quality Modification (WDOE);
- Water Rights (WDOE);
- Dam Safety (WDOE);
- Hydraulics Permit (WDFW);
- 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.

3.3.3 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. 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.

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).

3.4 Potential Surface Water Storage

This section looks at specific potential surface storage in WRIAs 55 and 57 including existing dams and natural lakes, new surface water storage locations, wetlands and small impoundments.

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. The dates of the topographic quads referenced range from the 1970s to the 1990s, and are important with respect to the resolution and accuracy of the data.

Several factors were taken into account when evaluating a site for additional storage. The following 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.

Additional considerations that were noted for remaining dams and lakes include the size, location of roads and railroads, and whether the dam is likely in continuity with the local aquifer, which would indicate that leakage might be a problem. While leakage from a reservoir can be serious impediment for a water supply facility, it could represent a potential for infiltration and streamflow augmentation.

USGS 7.5' Topo quads (contour interval of 20 ft or 40 ft above current stage) were used to evaluate site topography at each potential dam location and estimate the following:

∉ 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. The range of identifiable storage needs, as discussed in Section 2, range from 1,600 to 4,700 AF (ignoring new water right applications) in WRIA 55 and 19,000 to 51,000 AF in WRIA 57 (ignoring potential new water right applications). 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 can sustain a flow of approximately 8.5 cfs for approximately two months.

3.4.1 Existing Dams

A summary of existing dams in WRIA 55 and 57 is provided in Table 3-1. This table provide 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.

The equivalent flow that would have to be diverted from each creek to incrementally fill each dam is shown in Table 3-3. The values given are the continuous flow that would have to be diverted to achieve 20 or 40 feet of additional 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 a storage reservoir would likely be filled between March and June when the highest flows are available.

Brief descriptions of the dams reviewed are presented below along with any additional information that is considered relevant.

3.4.1.1 Ponderosa Lake

Ponderosa Lake is located in Stevens County on Beaver Creek a tributary of the West Branch Little Spokane River. The recorded owner is Kedric Baker. Estimated storage for this lake ranged from 2,090 to 6,630 AF and the dam crest length to storage capacity ratio is the lowest of all the options, which is favorable. The National Inventory of Dams (NID) indicates this dam is used for recreation and no structures or docks are visible near the lake shore. 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.

3.4.1.2 Newman Lake

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.

3.4.2 New Dams

Potential new dam locations were evaluated using: 1) locations of existing natural lakes; 2) new off-channel locations where aquatic habitat was not recorded as critical (Figure 2-1) with crystalline basement as the surficial geology.

3.4.2.1 Natural Lakes

Existing unregulated lakes are summarized in Table 3-2. 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). Expansion of in-channel storage may present a more difficult permitting process. If a lake is at the end of a stream or river it is labeled as a "Terminal Lake" and presents an opportunity for facilitated permitting. 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. The remaining three showed low structure densities around the lakes, few roads and the surrounding geology was crystalline basement. Descriptions of the lakes and potential development are described below.

3.4.2.1.1 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 center 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). 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.

3.4.2.1.2 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 and increased elevation would either require two dams on each channel or the water could expand into the channels on either side of a ridge and a single dam could be built closer to Eloika Lake. The volume of water shown would cause flooding of roads which cross the two channels. 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.

3.4.2.1.3 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 30 feet it would flood back up into Spring Heel Creek towards Sacheen Lake. 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.

3.4.2.1.4 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. 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.

3.4.2.2 New Dams in non-major, dry or intermittently fed valleys.

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 finding a location that would provide the greatest benefit. The higher in the watershed that water can be stored and provided to the stream, the more length of stream that can benefit from its storage. Conversely, the further up in a watershed a dam is located the less natural run-off is available (simply based on drainage area) and either the reservoir is smaller or water needs to be pumped to the reservoir. Additionally, if the new reservoir is meant to be used directly for water supply purposes it is possible that areas that could most benefit from the storage provided by a new reservoir would not provide a suitable location because most of the population is in the lower part of the watershed.

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 Spokane Valley Aquifer where water infiltrates too rapidly to store water for more controlled release for water supply or instream flow augmentation. Some of these areas are also rapidly developing which provides complications in locating 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 or elsewhere 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.

Some snapshot gaging data is available from Ecology for the upper reaches of Little Deep Creek and the 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. Flows in Buck Creek were record between 1987 and 1990 approximately monthly, but with higher density in the summer. Maximum recorded flows for Buck Creek ranged from 8 to 56 cfs. These flow measurements may represent a drainage area that is larger or smaller than a new reservoir in that sub-basin may have but they can provide some indication of whether flow is available during the wet season in the upper reaches of these rivers. 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.

3.4.3 Infiltration using Existing Lakes or Natural Depressions

There were many small lakes and reservoirs which were estimated to overlie sands and gravels associated with the upper aquifers of Diamond Lake, Deer Park or the Little Spokane Aquifer. Many of these lakes have intermittent streams which supply inflow and/or outflow, are located close to a river and are likely in continuity with it. 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.

3.4.4 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) to watershed 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.

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.

The distribution of wetlands systems in each WRIA is described in Table 3-4. 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.

Saltese Flats was once a shallow lake encompassing approximately 1,600 acres. The land was diked and dammed 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.

A significant portion 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.

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.

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 and duration of rill and streams within the watershed (Demissie & Khan, 1993). 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).

3.5 Surface Water Storage Conclusion

In evaluating existing reservoirs and natural lakes, the most common restriction 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,
- Evaluation of new dam in off-channel, dry or intermittently wet valleys.

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:

- Small impoundments for infiltration and storage are an option much throughout much of the central part of WRIA 55 as well as Deer Park and Diamond Lake. There are many lakes which may be in direct continuity with groundwater and are located adjacent to rivers. An evaluation of return flow and volume impacts would be necessary; and,

- 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.

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. Typical applications of artificial recharge consist of using excess water usually during peak flow periods, and releasing it during critical low flow periods. This provides benefits of minimal impacts by seasonal diversions, because they are a smaller fraction of total flow, and increasing low streamflows either as a result of augmenting flows or replacing water that might have direct impacts. 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 (Appendix B). 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 σg/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 of 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. First 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. Thickness 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 Spokane Valley. 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 Spokane River as a Source of Recharge Water

4.2.2.1 Artificial Recharge to Augment Spokane River Flow

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 decrease is 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 which 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 acts as a filter of the surface water and withdrawal of groundwater avoids problems of suspended sediment and associated metal contamination that might otherwise require pre-treatment.

The extensive infrastructure capacity in the form of wells and transmission pipelines in the Spokane Valley provides 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 Little Spokane River as a Source of Recharge Water

The Little Spokane River has flows above regulatory levels (WAC 173-555) during the wet season that may be available for artificial recharge applications. Though continuous gaging records do not exist on major tributaries of the Little Spokane River, it is assumed based on existing gaging data as wells as basin characteristics that stream flows would be available during the wet season. If surface water is used for recharge by direct injection, it is assumed that treatment to drinking water quality standards would probably be required. Because there are no existing surface water treatment facilities in WRIA 55, the cost of new facilities is considered prohibitive. Therefore only surface infiltration of surface water is considered feasible at this time. One specific option (at Deer Park) and one conceptual option (gravel pits) are developed below.

4.2.3.1 Surface Water Spreading in the Deer Park Area

Groundwater quality in the Deer Park area contains relatively high levels of nitrate (Figures 4-4 through 4-10). The source of the nitrate is believed to be agricultural fertilizers, and groundwater concentrations over the period appear to have peaked above 10 mg/L around 1997 and have been decreasing since then. Naturally occurring background concentrations of nitrate in groundwater are typically les than 1 mg/L.

The state drinking water MCL for nitrate as nitrogen (herein referred to as nitrate) is 10 mg/L. Nitrate monitoring is required annually by Group A public water systems and every three years for Group B systems. The Washington Department of health (DOH) requires quarterly follow-up sampling for all nitrate concentrations exceeding 5 mg/L. Any nitrate result exceeding 10 mg/L requires confirmation sampling within 24 hours.

Nitrate itself is generally not harmful to human health. However, nitrate in drinking water can be transformed in the human body into nitrite. Elevated levels of nitrite in infants less than six months old can lead to blue-baby syndrome (methemoglobinemia). Nitrite reduces the blood's ability to carry oxygen, which results in a bluish color in the infant's skin. This condition can be life threatening, however this syndrome is rarely diagnosed in the U.S.

The City of Deer Park has six drinking water wells, of which five are in the shallow aquifer and one is in the deeper aquifer. Nitrate concentrations of wells in both aquifers have historically been above 10 mg/L, although more recent concentrations have been below 5 mg/L.

Artificial recharge of surface water from Dragoon Creek to groundwater immediately upgradient of the City's drinking water wells may further reduce and control nitrate concentrations in the drinking wells. Infiltration could be achieved through a series of infiltration trenches oriented roughly east-west, perpendicular to the ambient groundwater flow direction. Detailed mapping of groundwater gradients should be conducted to determine the most effective locations of such trenches.

Recharge from ground surface may reduce nitrate groundwater concentrations in the shallow wells. Reducing concentrations in the deep well is expected to only be achievable through the direct injection of water into the deep aquifer. Because this would require pre-treatment of water to reduce suspended sediment and control bacterial growth, and because there are no existing surface water treatment facilities, this is not considered economically feasible at this time.

Groundwater recharge to control nitrate concentrations in drinking water wells would also help raise low streamflows in Dragoon Creek and at the instream flow compliance point at Dartford on the Little Spokane River. Increased baseflows in Dragoon Creek may also alleviate water quality concerns in the lower reaches near the confluence with the Little Spokane River, where dissolved oxygen, temperature, ammonia and fecal coliform are parameters of concern (Figure 2-4).

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.

A drawback of using gravel pits that are located away from stream channels is that a pipeline 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.

Plan maps of selected gravel pits in WRIA 55 that are located away from streams are contained in Appendix D. The Washington Department of Natural Resources classifies sand and gravel pits as archived or current (Table 4.1; Figure 4-11). 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.

Gravel pits in the WRIA 57 (Table 4-2) were not considered in greater depth because of the anticipated lack of a significant lag time between recharge and streamflow augmentation. More detailed screening of gravel pits as potential recharge sites will be presented at the mid-project workshop.

4.3 Reclaimed Water

Preliminary site development studies and environmental analysis have been completed for the new Spokane County Regional Treatment Plant (SCRTP). The plant is planned to provide a maximum-month capacity of 8.5 mgd (~13 cfs) by 2007 and a maximum-month capacity of 12.6 mgd (~19 cfs) for future growth (projected between 2015 and 2022). The wastewater treatment plant has selected membrane bioreactor (MBR) with nitrification/denitrification (NDN) and primary clarifiers. This treatment alternative will facilitate future 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 4-12). 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 is 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 4-13). This recharge site is located immediately upgradient of a gaining reach of the Spokane River. Reclaimed water recharged at this site is expected to travel through the unsaturated vadose zone to the water table and then travel horizontally to the river. At this point, groundwater discharges to the river, including a portion of the reclaimed water that might be introduced to groundwater at the original recharge site. 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, further diluting the concentration of portion of reclaimed water that enters back into the groundwater.

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 streamflows of 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. Much 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 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 is 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 has 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 (Figure 2-4).

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: Costs for enlargening 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. The existing dam is base 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.

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 New Dams In-Channel 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 Off-Channel Dams in Channel Dams

Concept: New off-channel dams may be constructed in bedrock areas to 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 of 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. 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. More detailed screening of WRIA 55 gravel pits will be presented at the workshop.

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.

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TABLES

TABLE 2-1

WRIA 55 Water Rights Junior to Instream Flows (WAC 173-555)

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.

TABLE 2-2

Predicted impacts on Streamflow from 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	3949	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	16	7	21,790	1,421	1,063,907	355,607
57	27	-	34,588	< 1	56,258	18,804

Note: *assumes year round application of Qi

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 and Lakes 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

Potential Surface Water Storage Alternatives

	WRIA	Current			
		Crest Length (ft)	Height (ft)	Max Storage (AF)	Normal Storage (AF)
Ponderosa Lake Dam	55	412	55	710	357
Newman Lake Flood Control Dam[1]	57	8,400	10	11,300	8,700
Chain Lake[2]	55	-	-		-
Horseshoe Lake[3]	55	-	-	-	-
Lake of the Woods					
Trout Lake[4]	55	-	-	-	-

				Flow (cfs) Necessary to fill reservoir over a	
	Crest Length (ft)	Additional Storage (AF)	Crest Length/Additional Capacity Ratio	Year	Month
Additional 20 ft Dam of Height					
Ponderosa Lake Dam	560	2,090	0.3	3	36
Newman Lake Flood Control Dam[1]	8,500	35,040	0.3	42	497
Chain Lake[2]	600	2,939	0.4	2	27
Horseshoe Lake[3]	2,600	14,660	0.2	20	242
Lake of the Woods	112	494	0.2	1	8
Trout Lake[4]	1,100	3,831	0.3	5	63
Additional 40 ft Dam of Height					
Ponderosa Lake Dam	750	6630	0.1	9	112
Newman Lake Flood Control Dam[1]	8,600	81,120	0.1	110	1313
Chain Lake[2]	-	-	-	-	-
Horseshoe Lake[3]	2,800	45,880	0.1	63	758
Lake of the Woods	777	2,221	0.0	3	36
Trout Lake[4]	2,340	12,489	0.2	17	204

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 3-4

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 4-1

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)

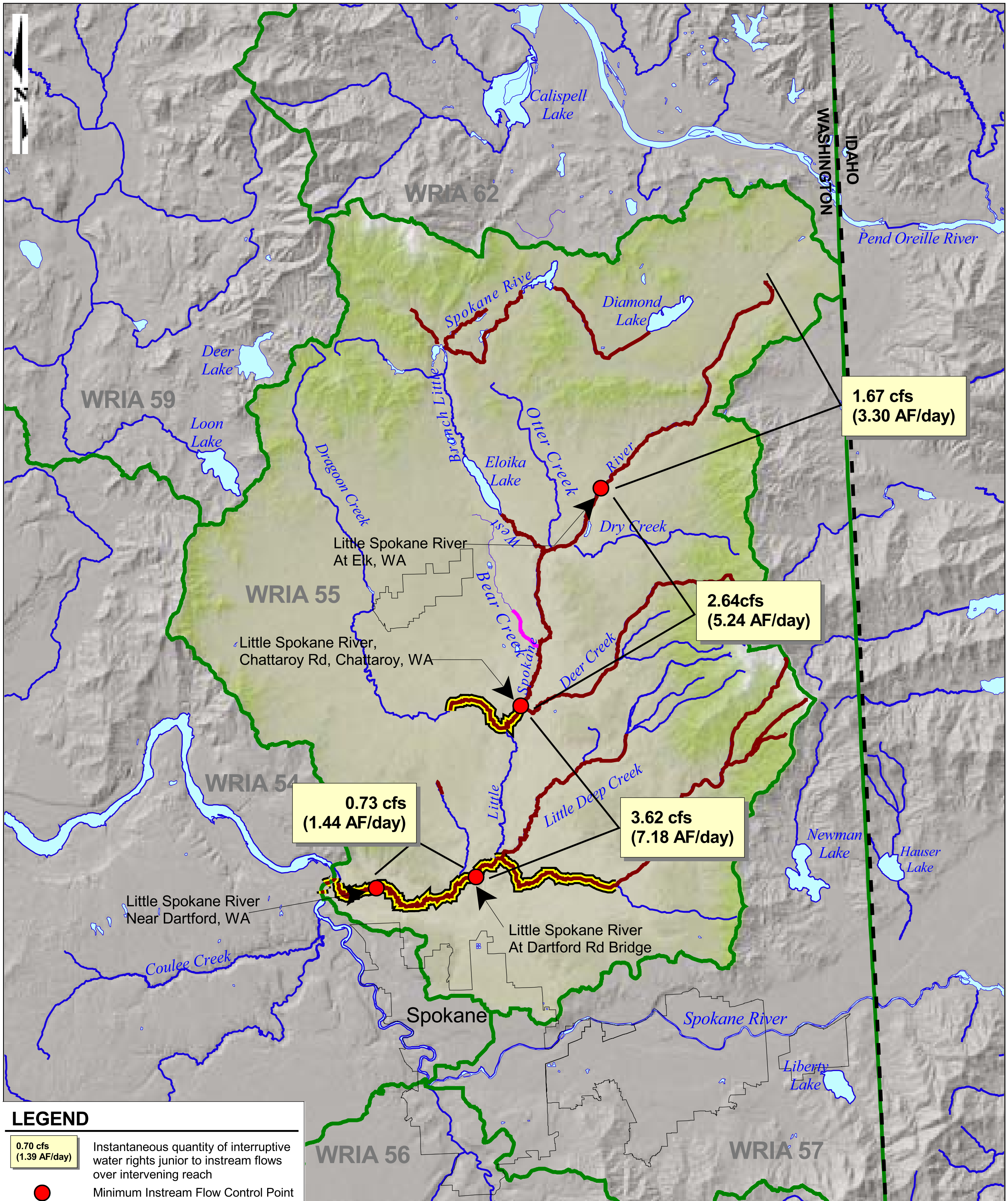
TABLE 4-2

Sand and Gravel Pit Locations
WRIA 57

Id	Permit	Acres	Name	Common Name	Twn	Rge	Section	County	X_coord	Y_coord
Archived										
70012778	12778	59	J TIM JACKSON	MICA TOPSOIL	24	44 E	14	Spokane	2812074	834124
70010204	10204	27	INLAND ASPHALT CO	THIERMAN RD	25	43 E	13	Spokane	2786058	864803
70010274	10274	65	CENTRAL PRE MIX CONCRETE CO	YARDLEY PIT	25	43 E	14	Spokane	2779612	866092
70010405	10405	6	ACME MATERIALS & CONSTR CO	BROADWAY	25	43 E	14	Spokane	2779612	866092
70010404	10404	17	ACME CONCRETE CO	HEIDENREICH	25	43 E	23	Spokane	2779822	860844
70010185	10185	8	INLAND ASPHALT COMPANY	SULLIVAN RD	25	44 E	2	Spokane	2810864	877888
70011166	11166	15	DEPT OF TRANSPORTATION	PS-C-144	25	44 E	11	Spokane	2811083	872639
70011460	11460	4	SPOKANE COUNTY PUBLIC WORKS	54-11	25	44 E	11	Spokane	2811083	872639
70010030	10030	5	DEPT OF TRANSPORTATION	PS-C-75	25	45 E	1	Spokane	2847801	879466
70010529	10529	9	DEPT OF TRANSPORTATION	PS-C-189	25	45 E	2	Spokane	2842511	879236
70011916	11916	25	HEDLUND & ETTER		25	45 E	6	Spokane	2821421	878332
70012611	12611	129	EAST FARMS GENERAL PARTNERSHIP	CHARLES POTTS	26	45 E	25	Spokane	2847343	889963
Current										
70010226	10226	98	ACME MATERIALS & CONSTR CO	PARK ROAD	25	43 E	13	Spokane	2786458	864641
70012929	12929	17	ACME MATERIALS & CONSTR CO	HEIDENREICH	25	43 E	23	Spokane	2780485	860076
70011189	11189	25	SPOKANE COUNTY PUBLIC WORKS	FLORA #54-12	25	44 E	12	Spokane	2818444	873362
70011179	11179	130	CENTRAL PRE MIX CONCRETE CO	SULLIVAN	25	44 E	12	Spokane	2815288	871505
70011730	11730	40	DEPT OF TRANSPORTATION	PS-C-293	25	45 E	7	Spokane	2819781	873580
70011986	11986	40	JAY INVESTMENT COMPANY	BARKER	25	45 E	19	Spokane	2823719	859975
70012720	12720	300	CENTRAL PRE-MIX CONCRETE CO	IDAHO ROAD PIT	26	45 E	24	Spokane	2847892	891396
70012936	12936	20	DEATLEY COMPANY, INC.	MILLWOOD	25	44 E	4	Spokane	N/A	N/A

Information from WDNR SURFMINES database (http://www.dnr.wa.gov/geology/smgis.htm)
N/A = Information not available from WDNR database

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 Control 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

DRAFT

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

Original Data Source: Washington Department of Ecology, USGS, WSDOT

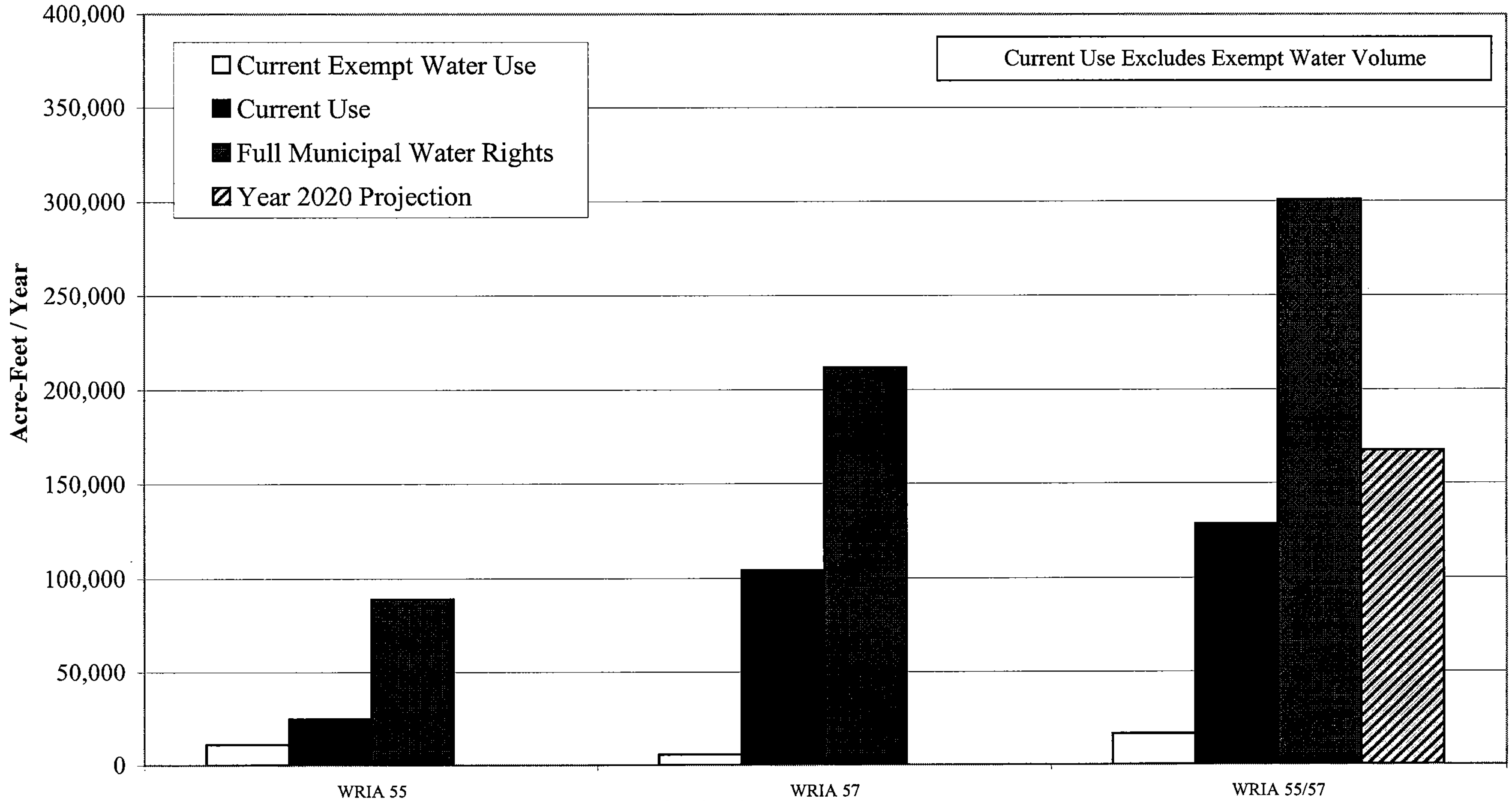
This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Golder Associates

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



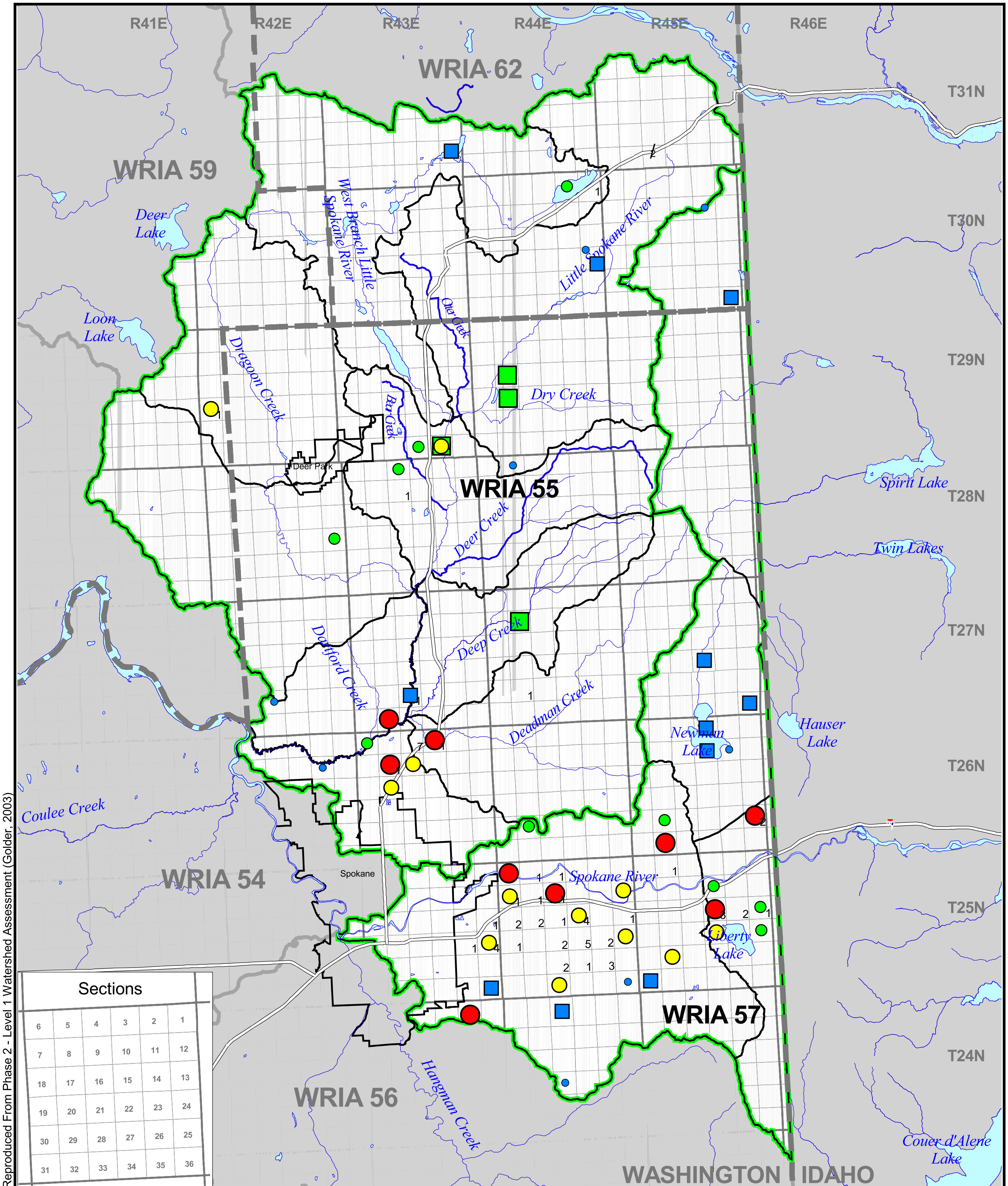
Note: Data developed for Spokane Watershed Model Scenarios (Golder, in

Golder Associates

TITLE **Current, Projected, and Allocated Water Use Comparison**

WRIA 55 & 57/ WATERSHED PLANNING/ WA

DRAWN	JM	DATE	June 2004	JOB NO.	013-1372
CHECKED		SCALE		DWG. NO.	
REVIEWED		FILE NO.		FIGURE NO.	2.2



Reproduced From Phase 2 - Level 1 Watershed Assessment (Golder, 2003)

01313725100_062104

LEGEND

- WRIA Boundaries
- WAU Boundaries
- Townships
- Sections
- City Limits
- County Boundaries
- Roads
- Rivers and Streams

Applications for new groundwater rights (gpm)

- 5 - 50
- 50 - 500
- 500 - 2,000
- 2,000 - 10,000

Applications for new surface water rights (cfs)

- 0.01 - 0.1
- 0.1 - 1.0
- 3 Number of change applications

DRAFT

N

0 6

Scale 1" = 6 Miles

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

Original Data Source: Washington Department of Ecology Water Rights Application Tracking System (WRATS) database (April, 2001). Annual quantities calculated as described in text, and aggregated by section.

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

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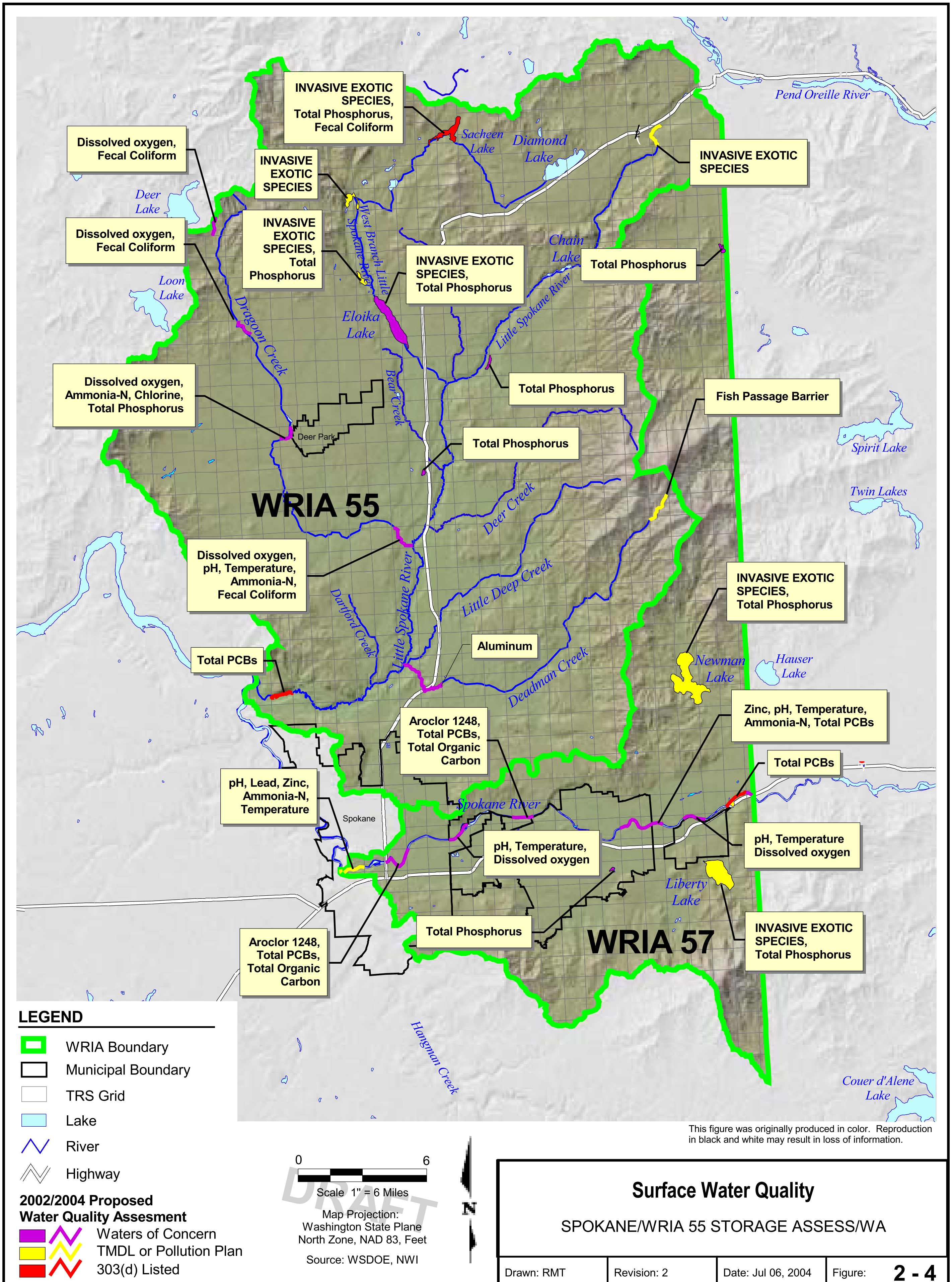
Applications for New Water Rights

Drawn: GKL	App'd:	Date: July 06, 2004	Figure: 2-3



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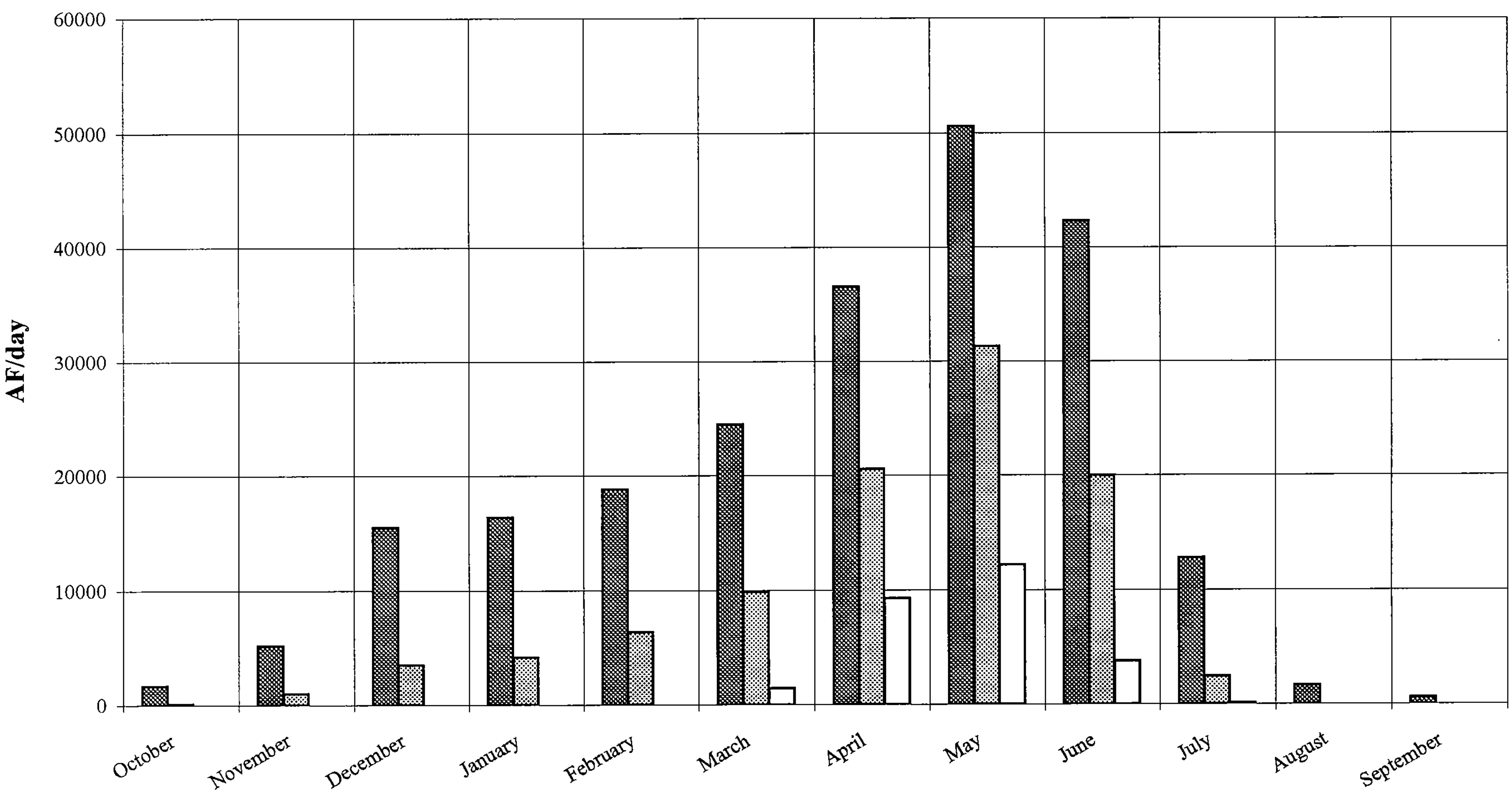
Golder Associates



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

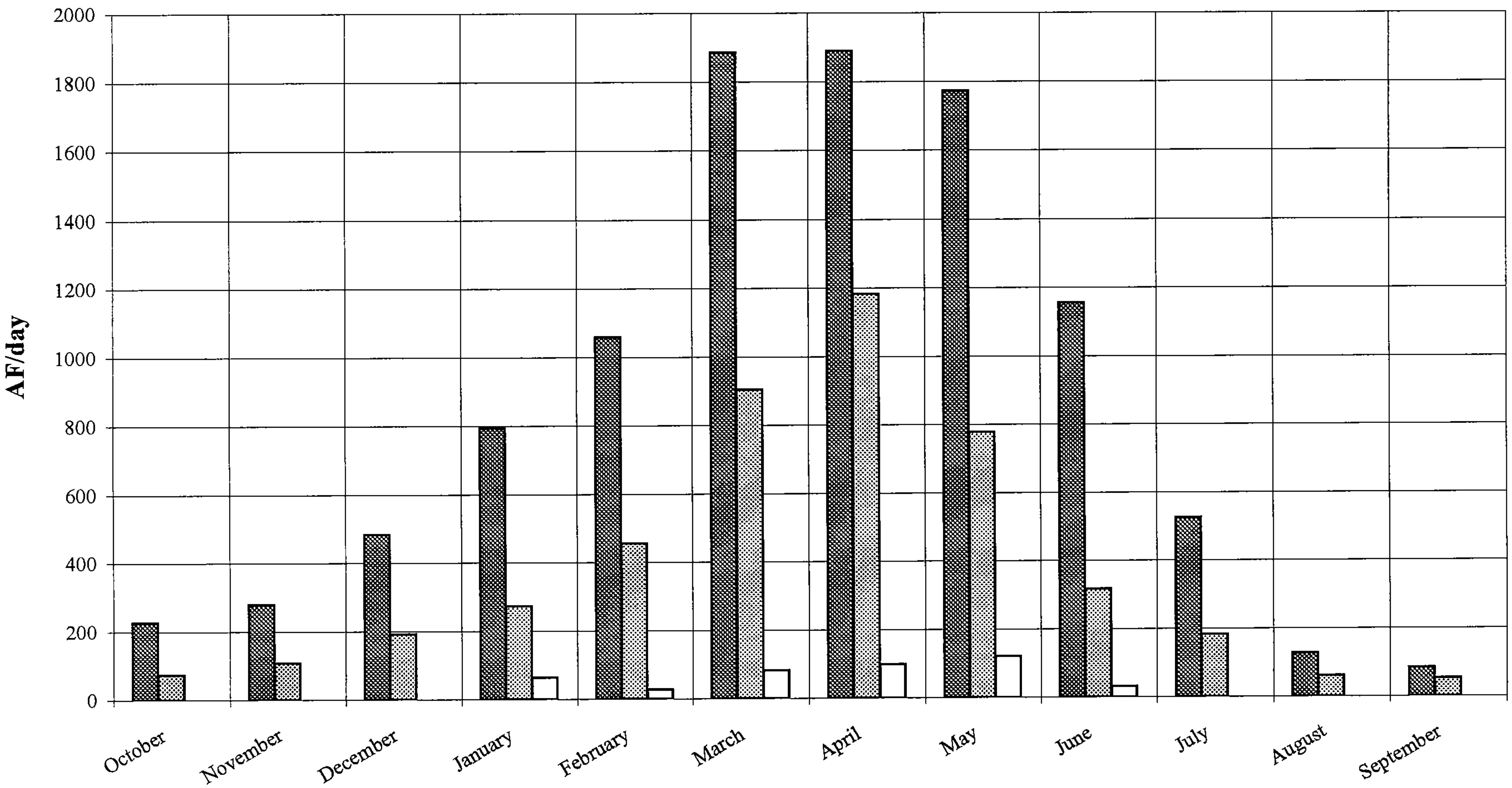
FIGURE 3.1:
Average Daily Volume above WDFW Suggested Minimum Flow (1999) - Spokane River at Spokane, WA

volume available.xls

Golder Associates

013-1372.001.4100 June 7, 2004

volume available.xls/Spok R at Spokane Graph - 1999



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

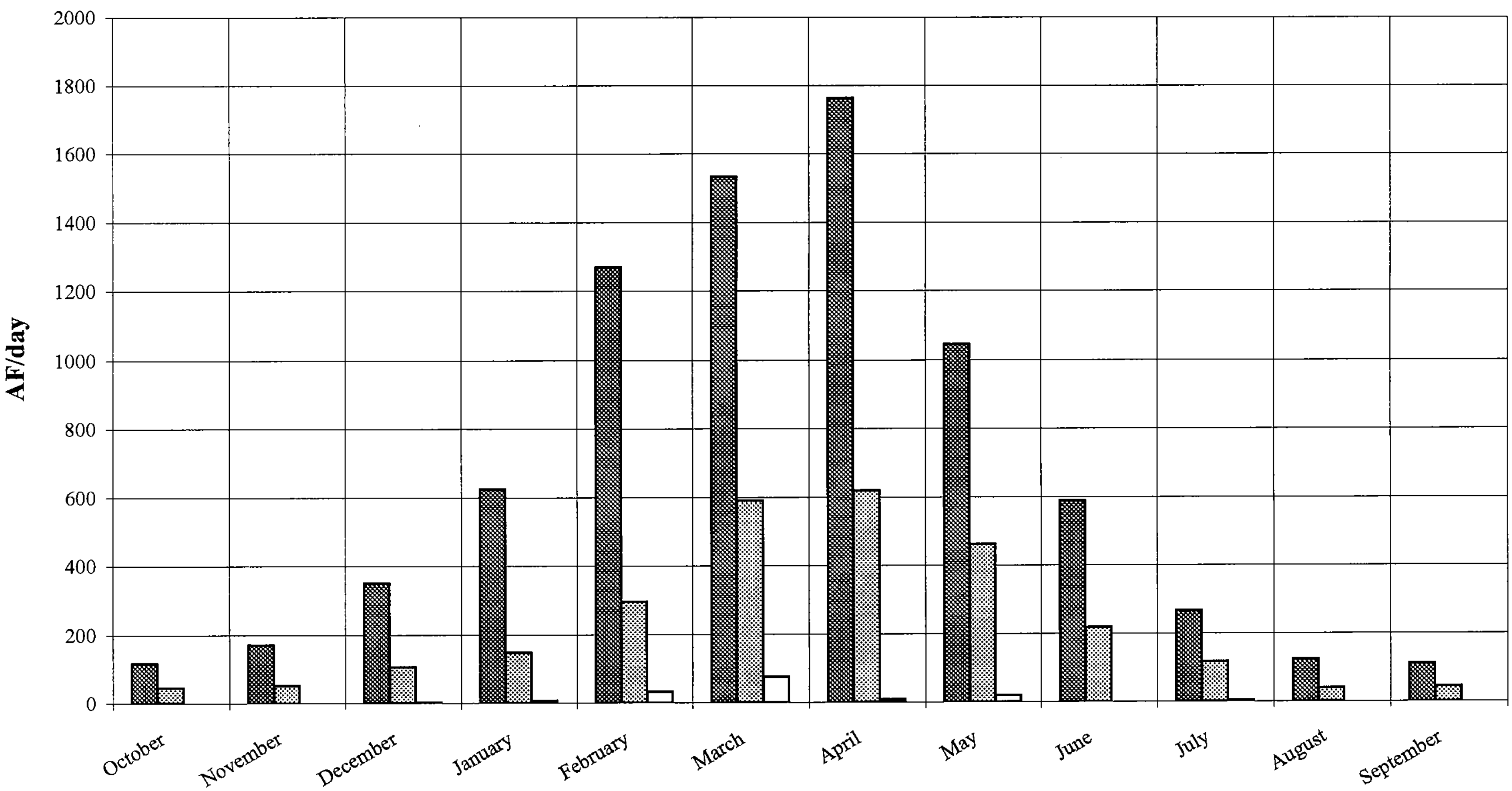
FIGURE 3.2:
Average Daily Streamflow Volume above MISF - Little Spokane River near Dartford, WA

volume available.xls

Golder Associates

013-1372.001.4100 June 7, 2004

volume available.xls/LSR nr Dartford Graph



Data Source: USGS
Period of Record : 1930-1932, 1948-1999
Station Name: Little Spokane River at Dartford
Station ID: 12431000

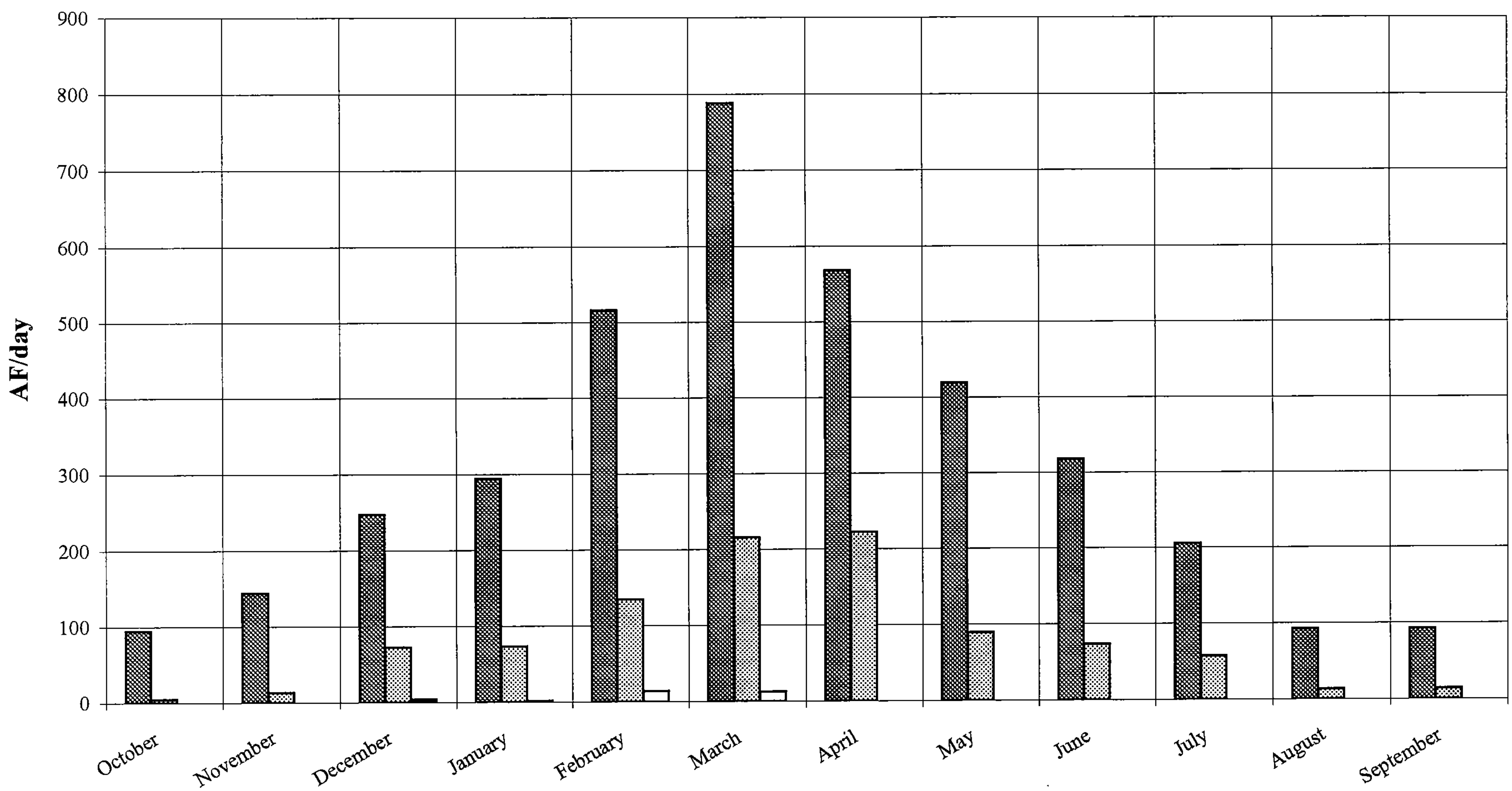
10% Exceedance
50% Exceedance
90% Exceedance

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:

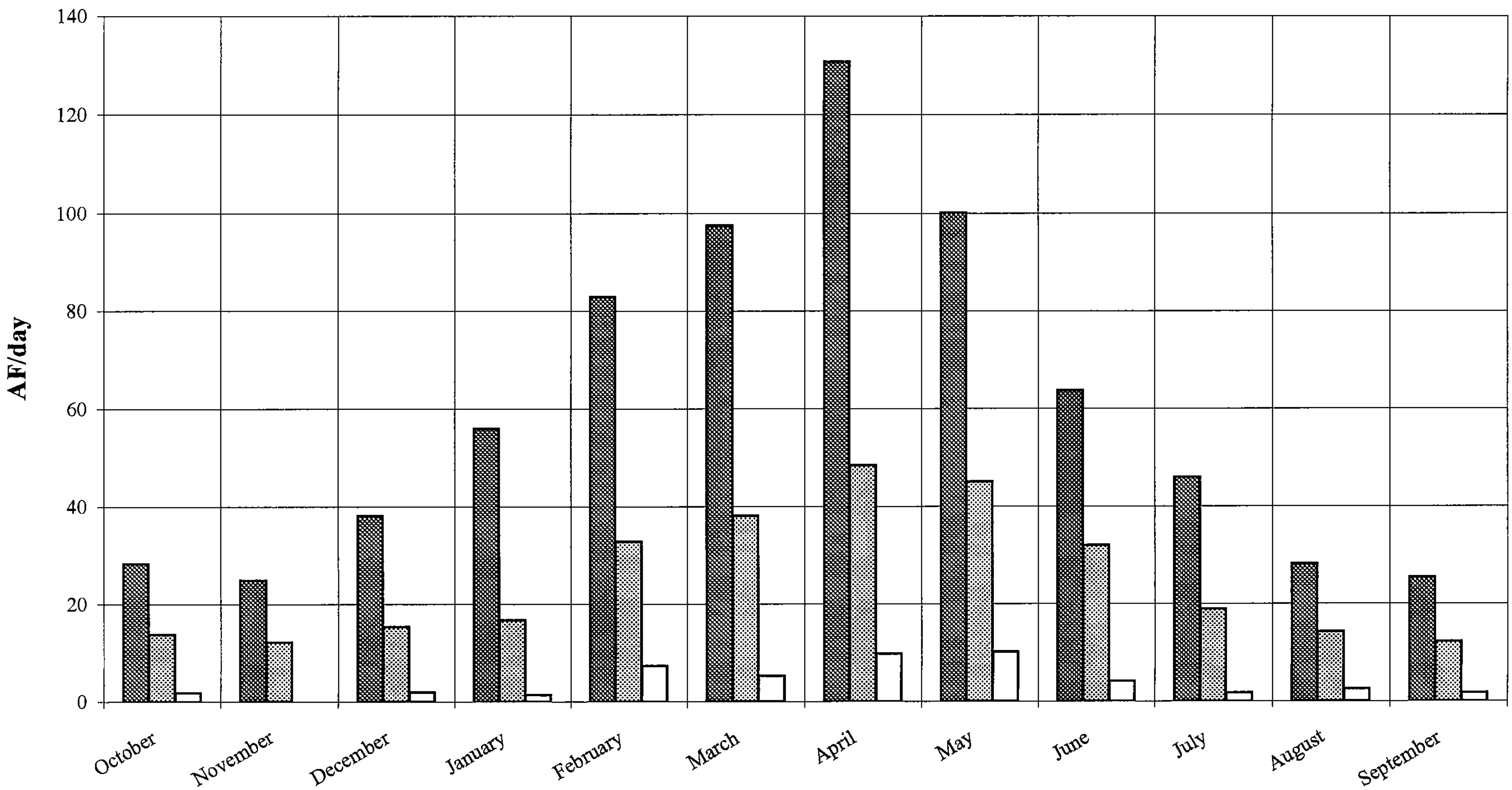
Calculated Using
- 10% Exceedance
- 50% Exceedance
- 90% Exceedance

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



Data Source: USGS
Period of Record : 1949-1971
Station Name: Little Spokane River at Elk
Station ID: 12427000

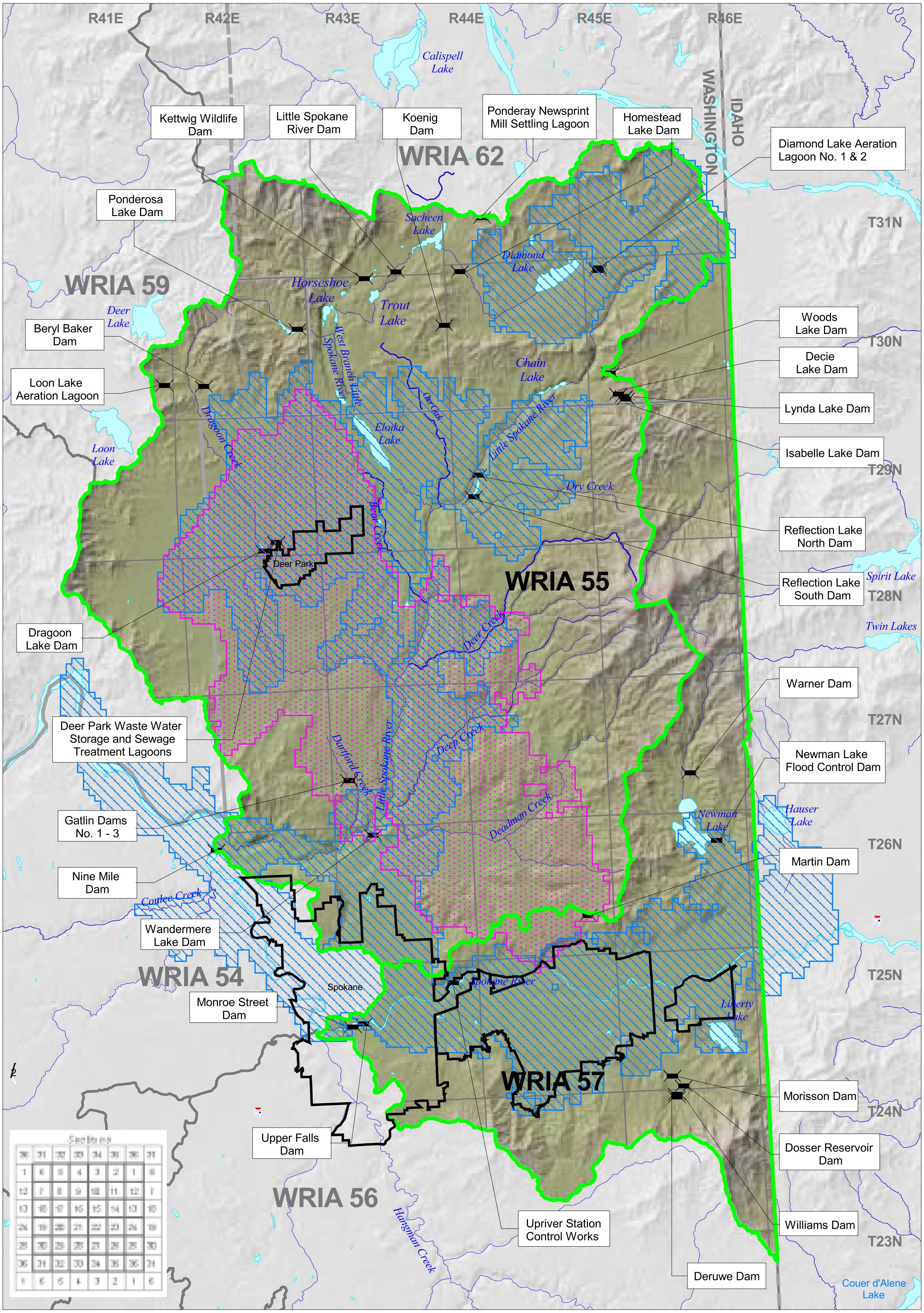
Calculated Using
- 10% Exceedance
- 50% Exceedance
- 90% Exceedance

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



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

Legend

- WRIA Boundaries
- Municipal Boundaries
- Basalt and Latah
- Sands and Gravels
- Sections
- Dam
- Rivers and Streams
- Lakes
- County Boundaries

0 4
Scale 1" = 4 Miles

Original Data Source: Washington Department of Ecology, USGS, U.S. Army Corps of Engineers

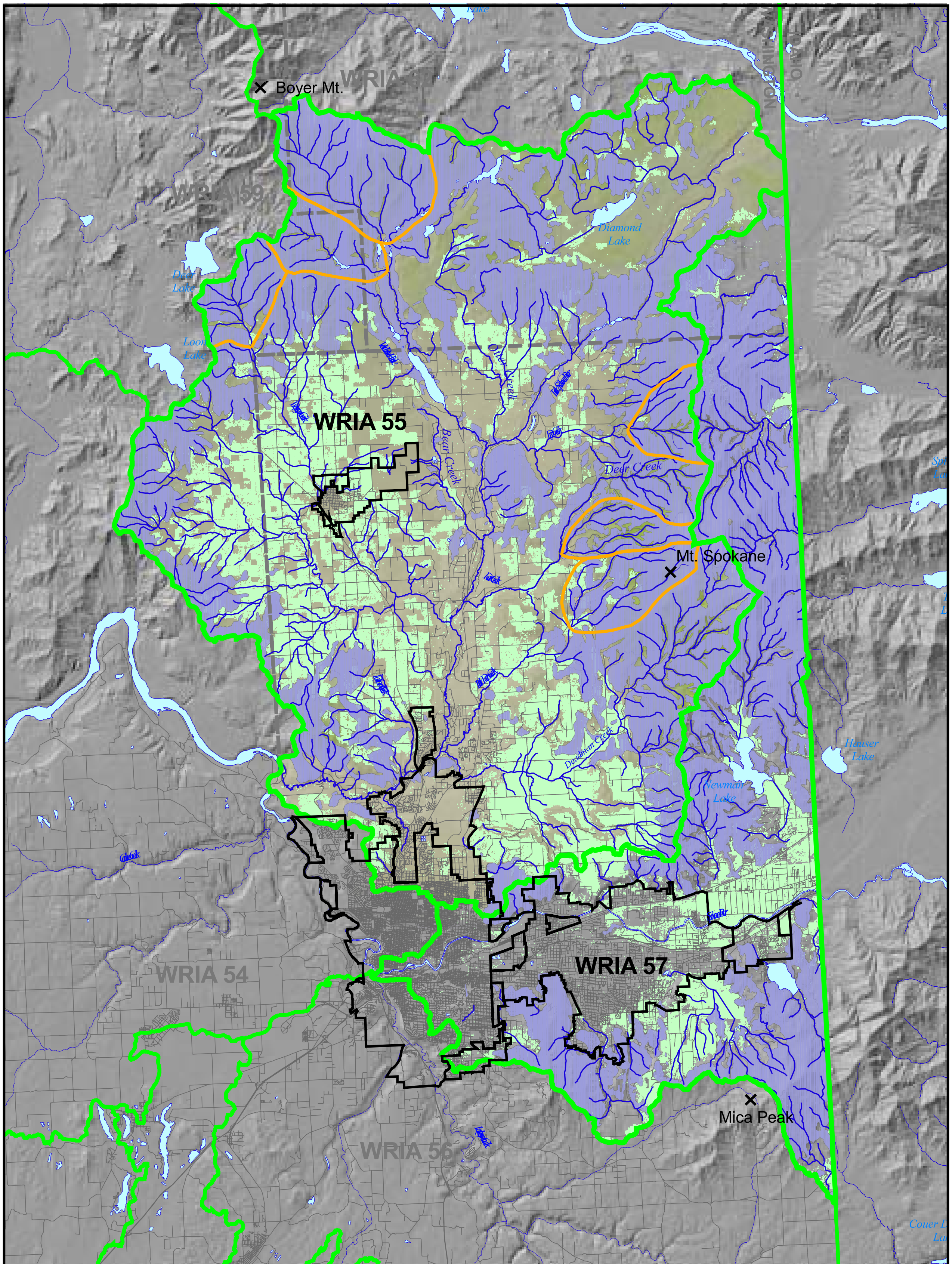
Map Projection: Washinton State Plane North Zone, NAD83, Feet

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.shp
- 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

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

N

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

Source: National Land Cover Database (1980) USGS, WSDOE, Golder Associates Inc.

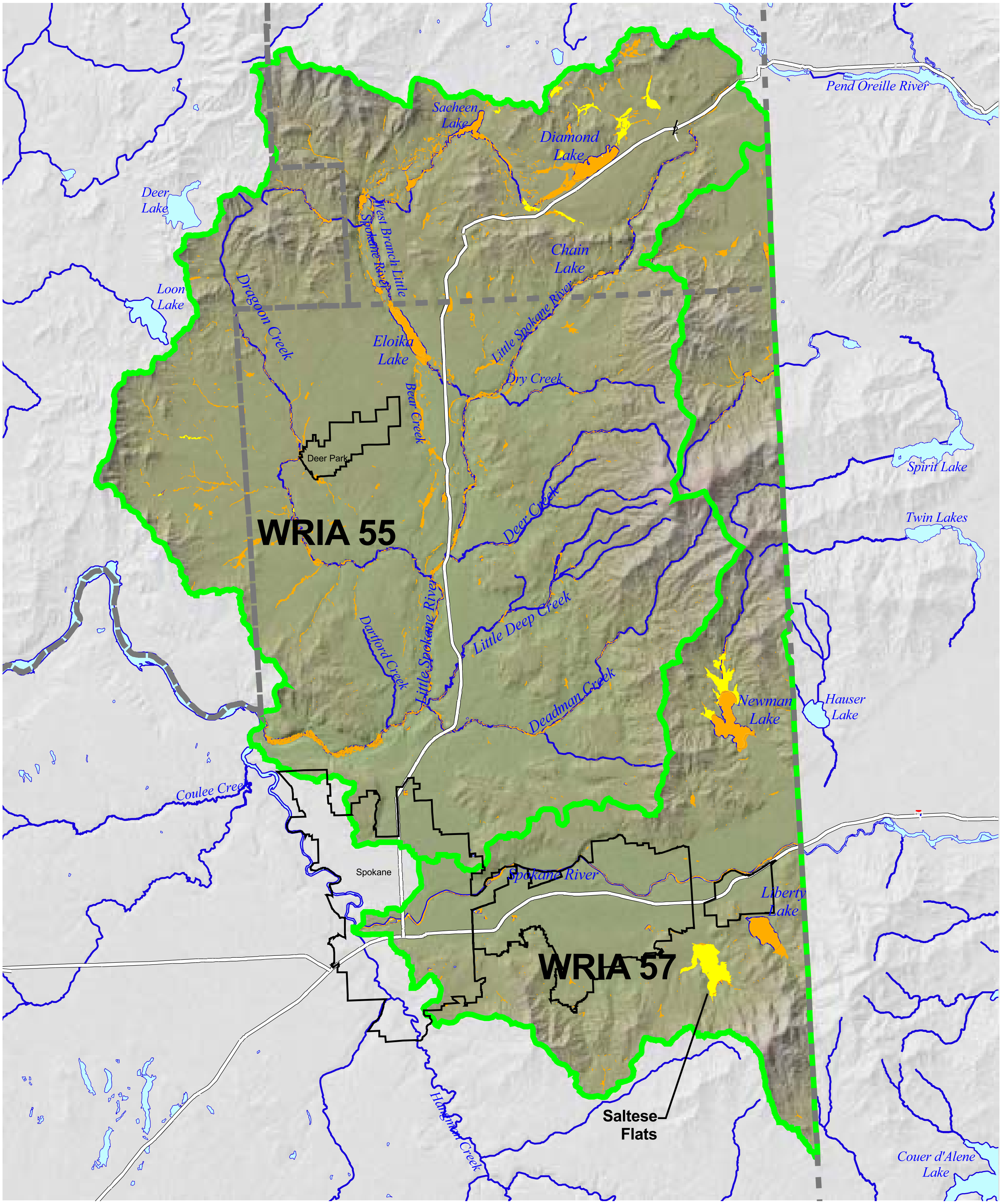
Sub-basins with Storage Potential for New Dams

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: RMT	Date: July 2, 2004	Figure: 3-7

01313725100_062104.apr

Golder Associates



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

LEGEND

- WRIA Boundary
- Wetland
- Drained Wetland
- Municipal Boundary
- County Boundary
- Highway
- WAU Boundary
- Lake
- River

0 6
Scale 1" = 6 Miles

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

Source: WSDOE, NWI

N

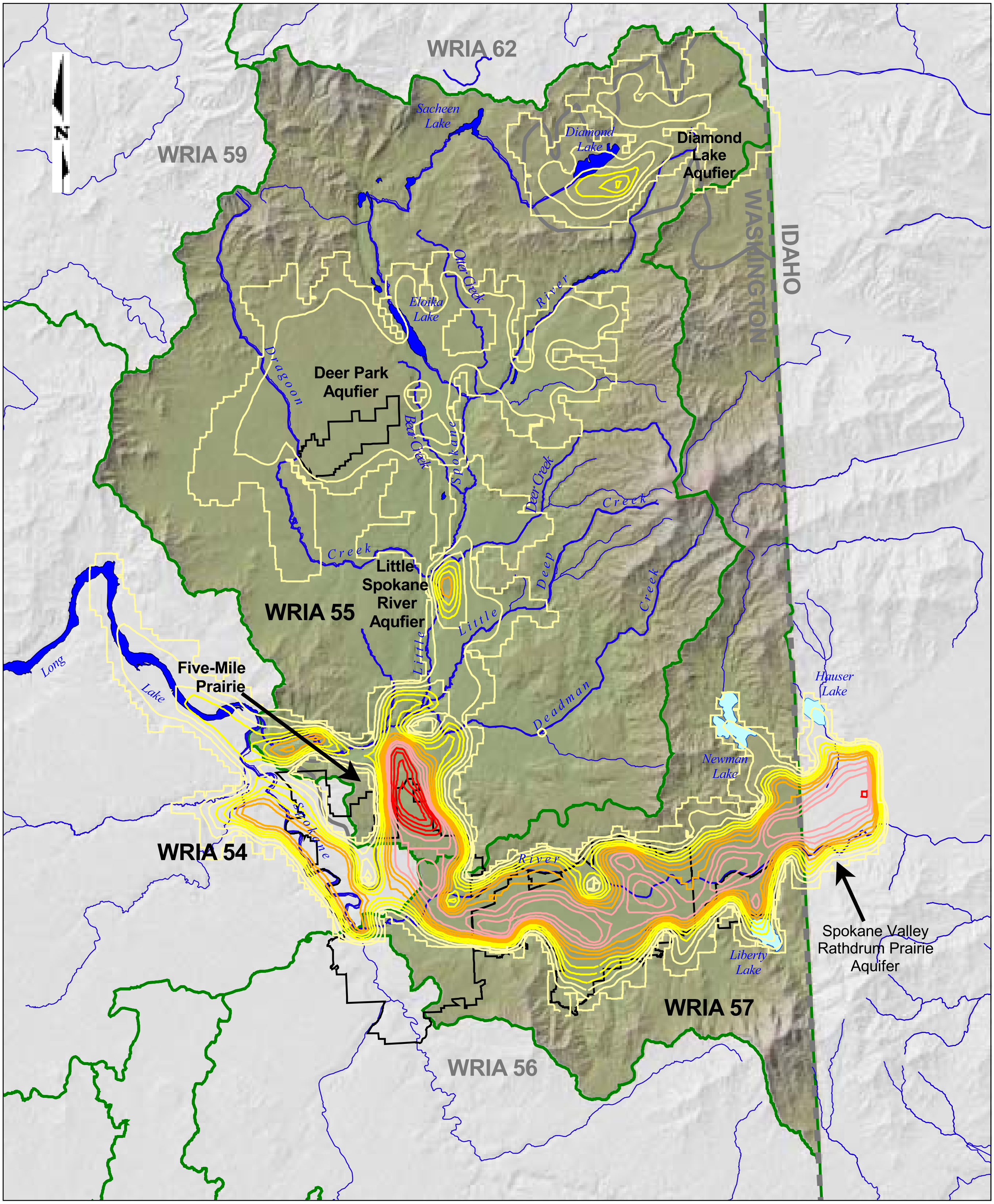
NATIONAL WETLANDS INVENTORY

SPOKANE/WRIA 55 STORAGE ASSESS/WA

Drawn: RMT	Revision: 2	Date: Jul. 06, 2004	Figure: 3 - 8

013137245100_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.

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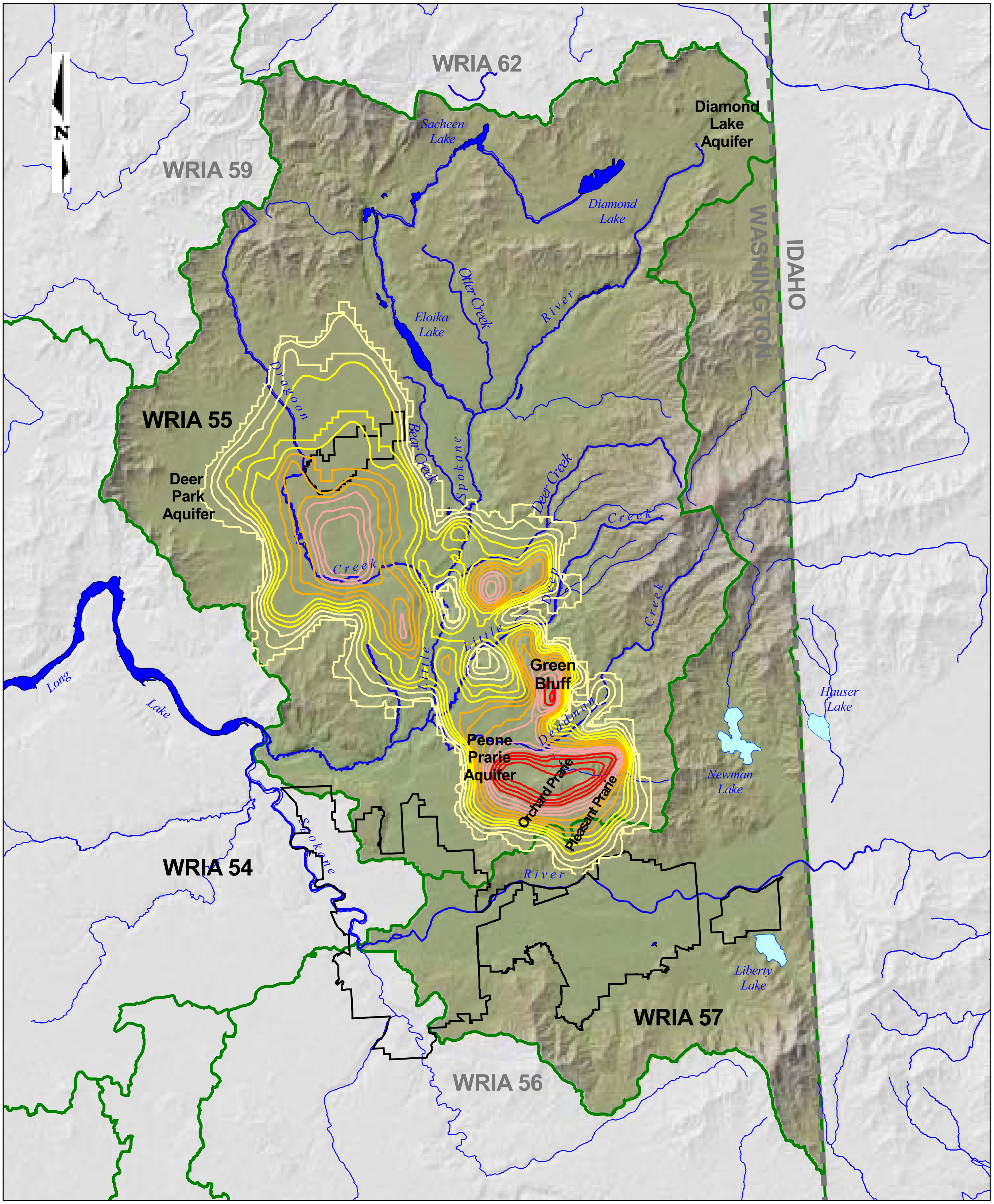
Thickness of Glaciofluvial Sediments (Sands and Gravels)

WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: 3	Date: June 21, 2004	Figure: 4-1

01313725100_062104.apr

Golder Associates



LEGEND

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.

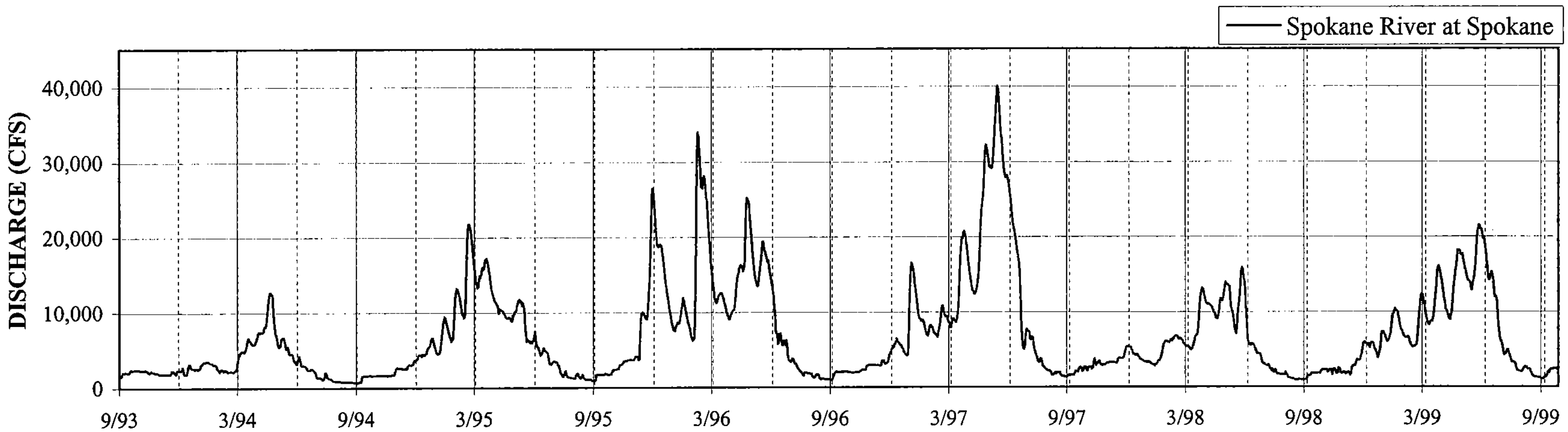
Thickness of Basalt and Latah Formations

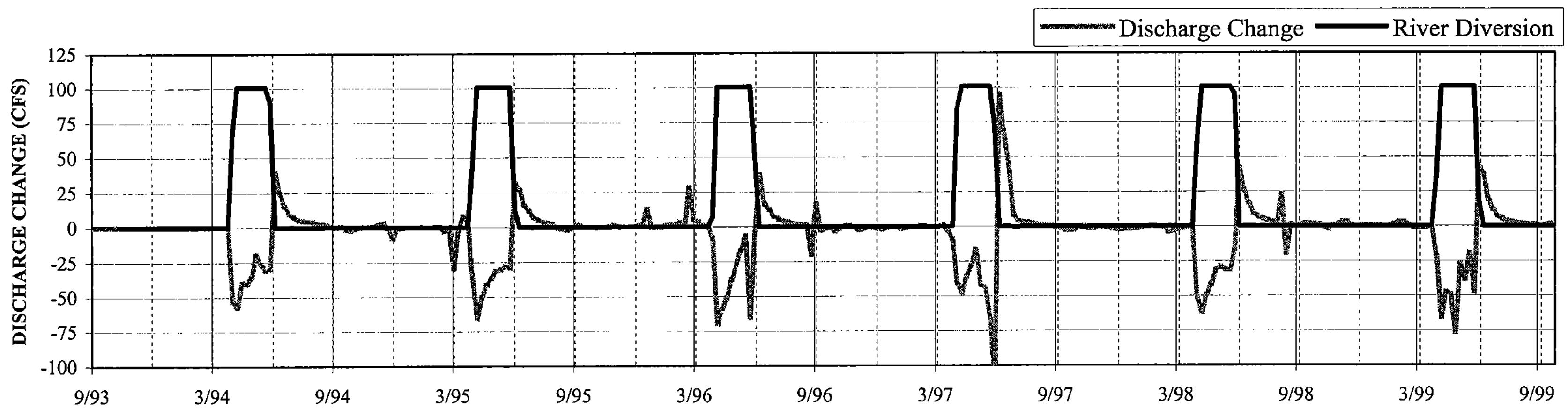
WRIA 55&57/STORAGE ASSESMENT/WA

Drawn: RMT	Revision: RMT	Date: June 21, 2004	Figure: 4-2

01313725100_062104.apr

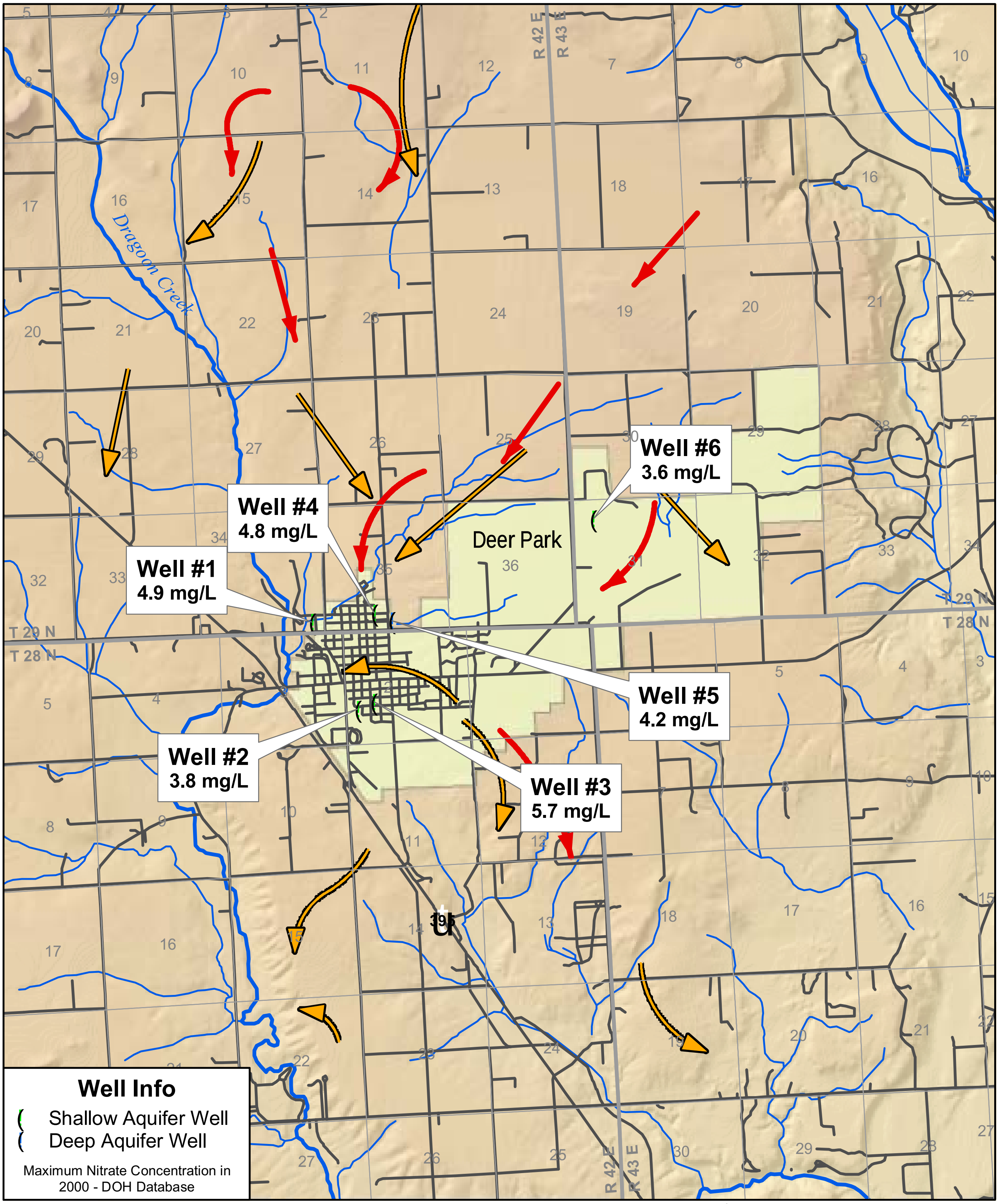
Golder Associates





Note: Model Outliers Removed

Golder Associates	TITLE **SCENARIO 2 : CHANGE IN DISCHARGE SPOKANE RIVER AT SPOKANE**		
WRIA 55 & 57/ WATERSHED PLANNING/ WA	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

- Deep GW Flow
- Shallow GW Flow
- Road
- City Limits
- Township, Range, Section

0 6000

Scale 1" = 6000 Feet

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

Source: WAGDA, WSDOT, EMCON;1992, BTS

DRAFT

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CITY OF DEER PARK
WELL LOCATION MAP
SPOKANE/WRIA 55 STORAGE ASSESS/WA

Drawn: BBA	Revision: 3	Date: July 2, 2004	Figure: 4 - 4

01313720015100_WELLS_070204.mxd

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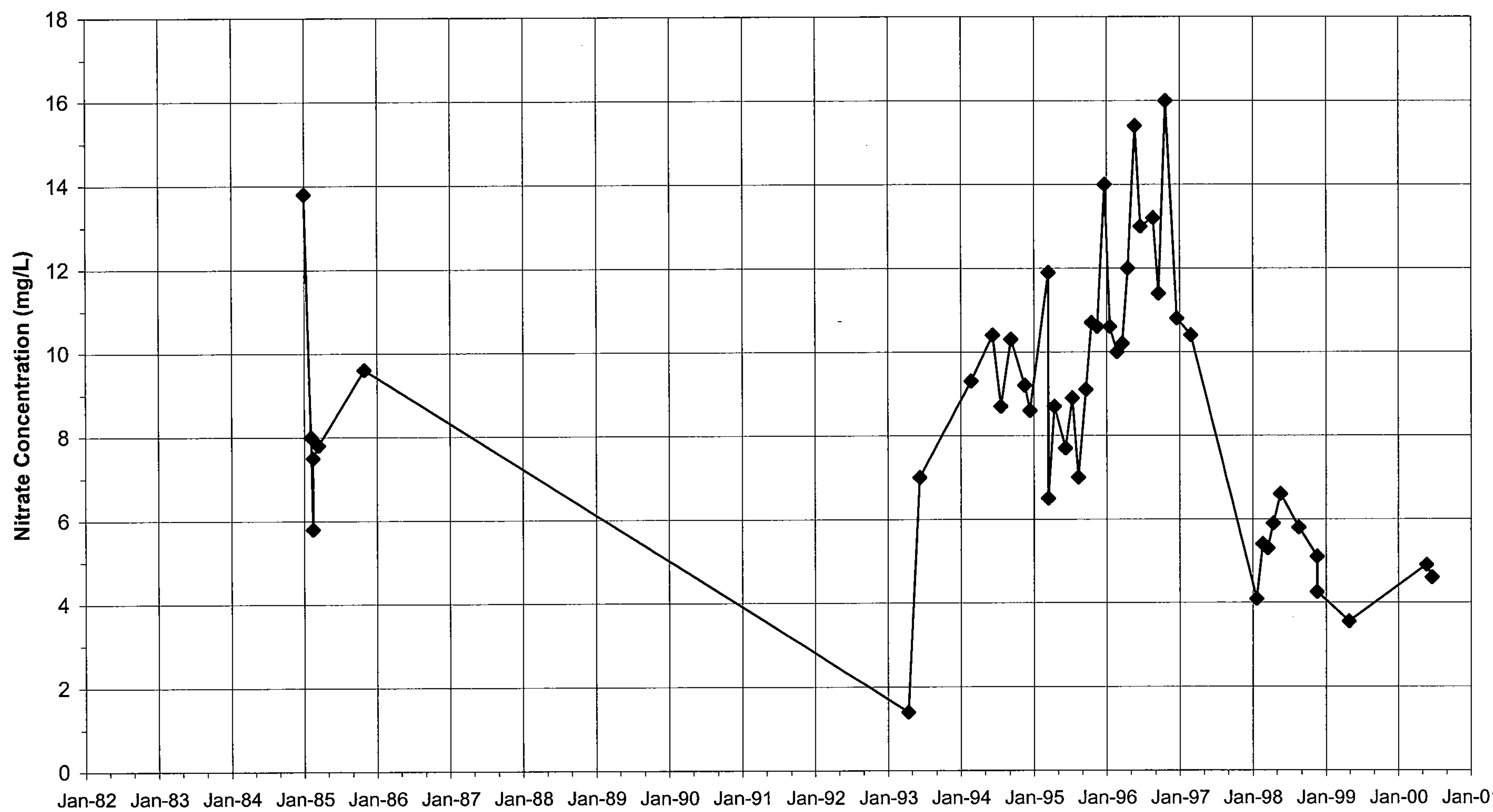


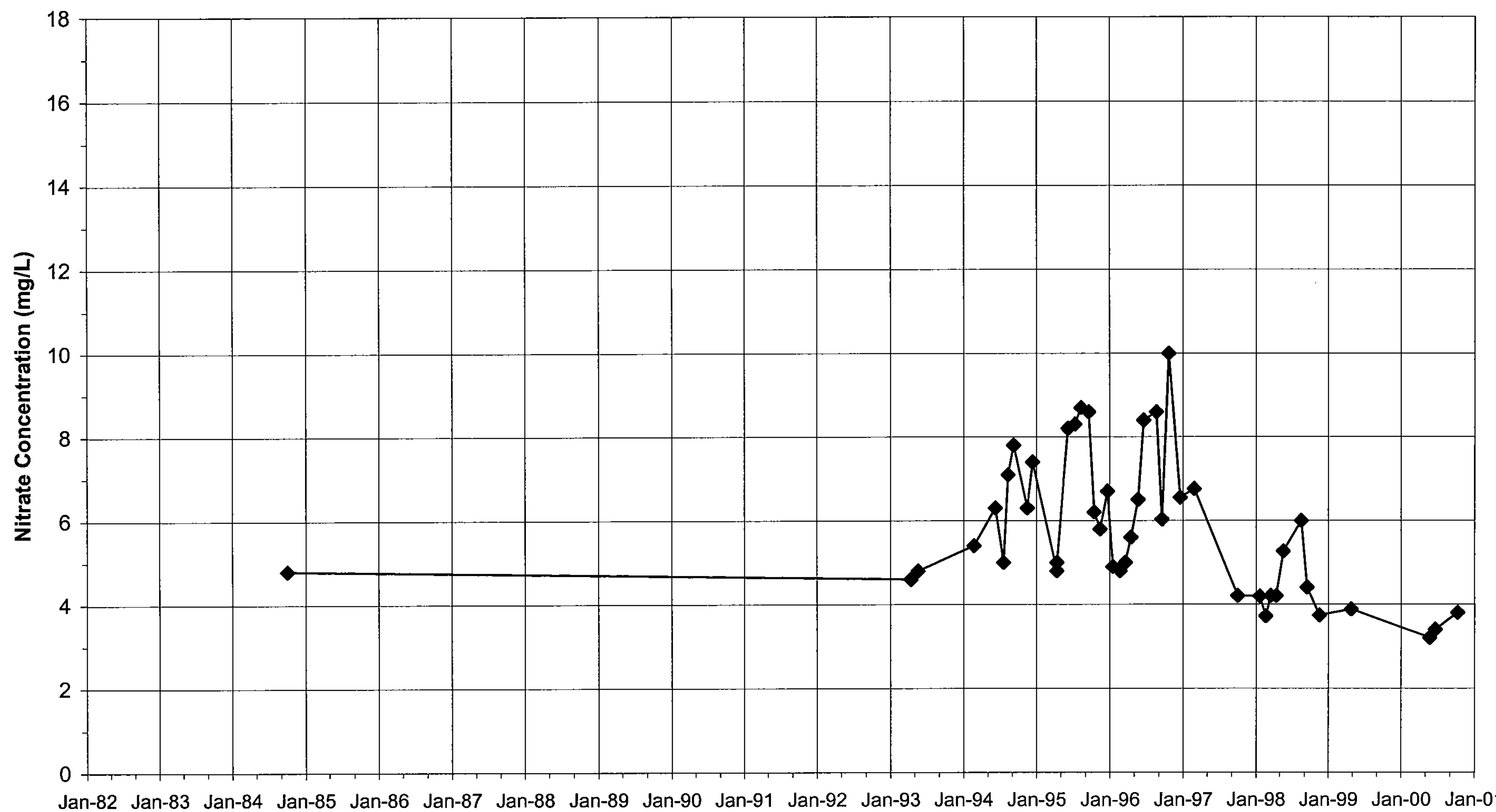
Golder Associates

WRIA 57 & 55
Spokane Watershed Planning

Well 1 is completed in the Shallow Aquifer

Deer Park Well 1 - Nitrate

DRAWN	TW	DATE	Jul-04	JOB NO.	013-1372-001.5100
CHECKED	CP	SCALE	na	DWG. NO.	na
REVIEWED	CP	FILE NO.	Deer Query.xls	FIGURE NO.	4-5



Golder Associates

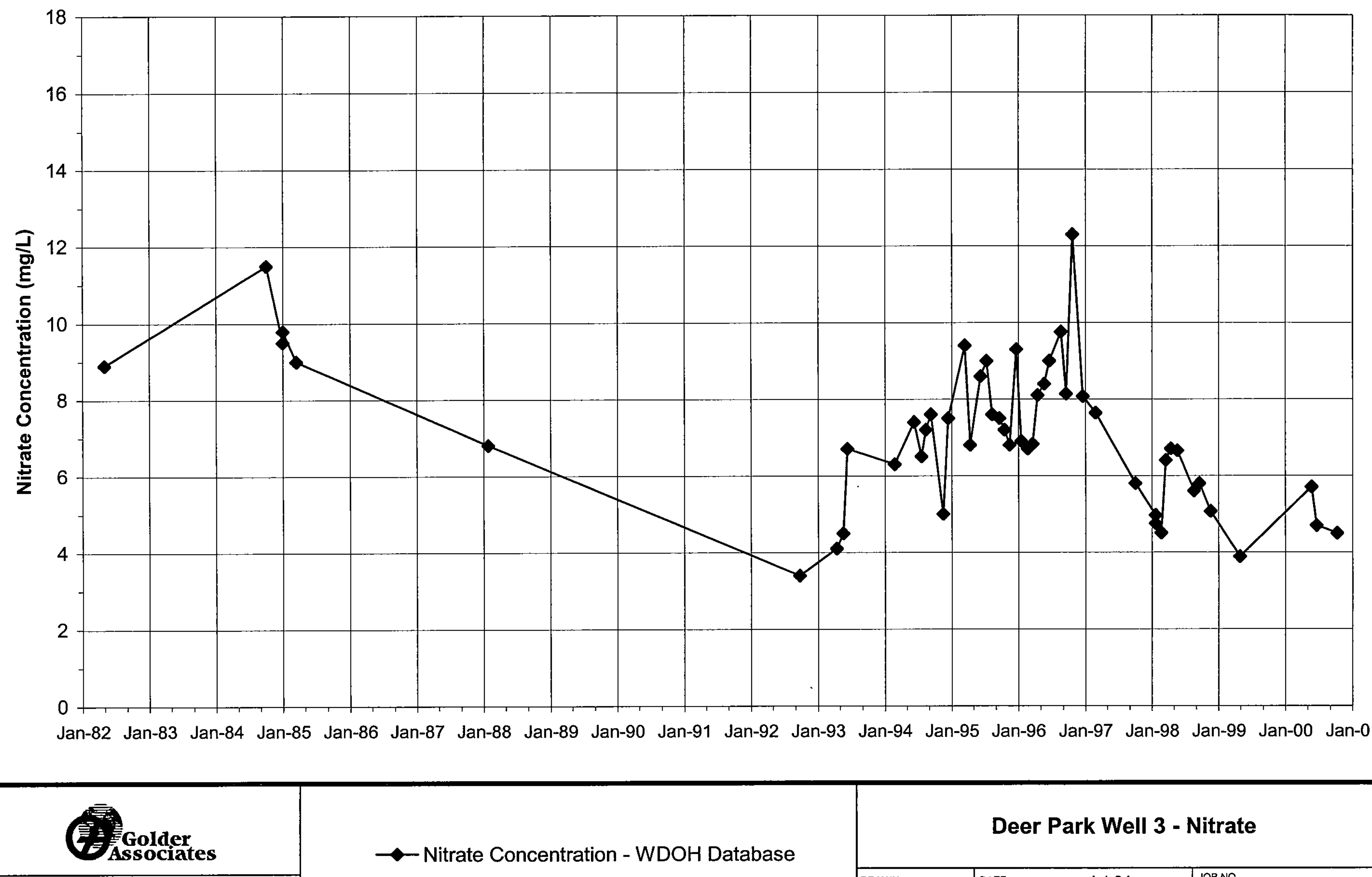
WRIA 57 & 55
Spokane Watershed Planning

—◆— Nitrate Concentration - WDOH Database

Well 2 is completed in the Shallow Aquifer

Deer Park Well 2 - Nitrate

DRAWN	TW	DATE	Jul-04	JOB NO.	013-1372-001.5100
CHECKED	CP	SCALE	na	DWG. NO.	na
REVIEWED	CP	FILE NO.	Deer Query.xls	FIGURE NO.	4-6



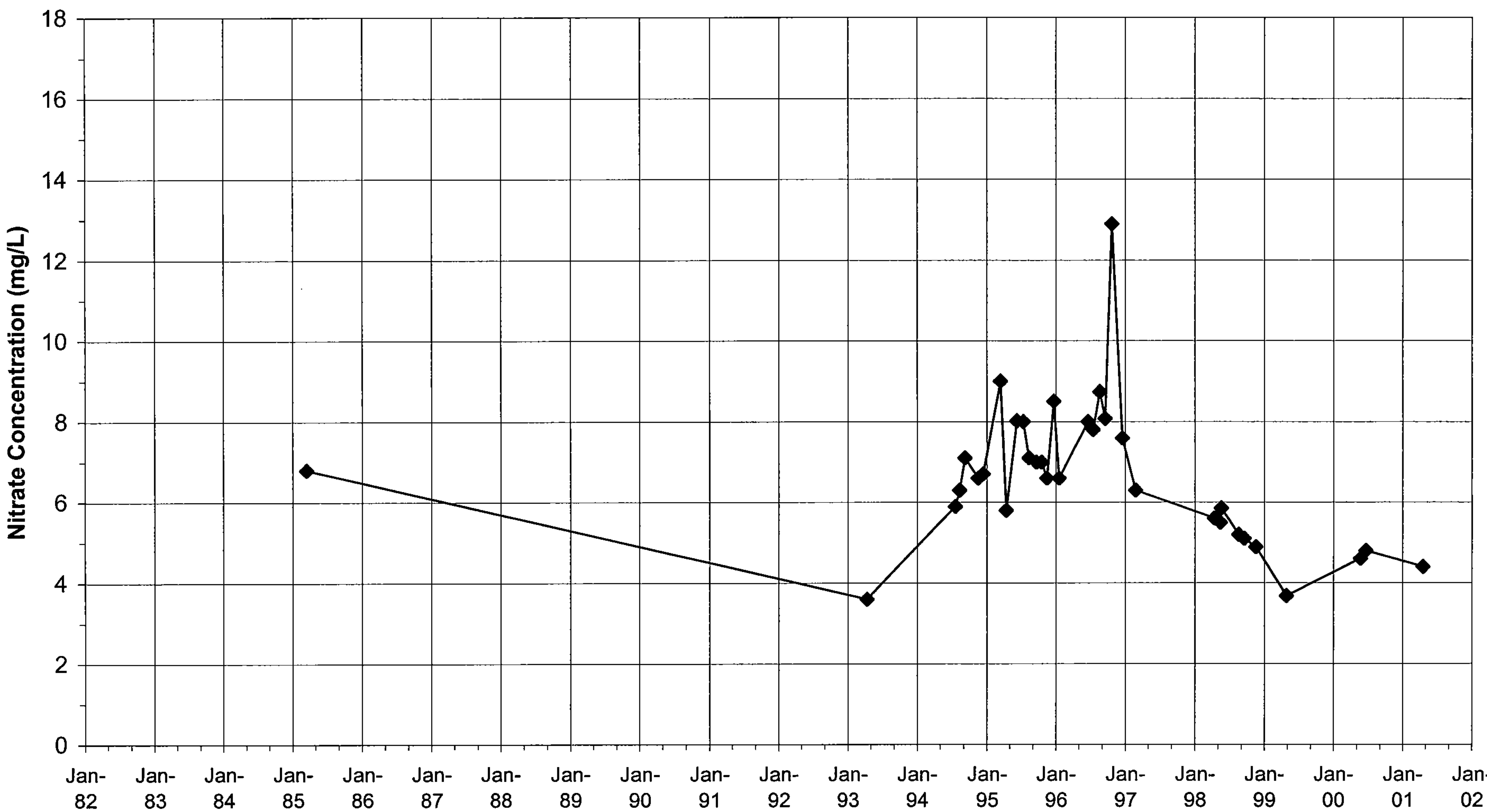
Golder Associates

WRIA 57 & 55
Spokane Watershed Planning

Well 3 is completed in the Shallow Aquifer

Deer Park Well 3 - Nitrate

DRAWN	TW	DATE	Jul-04	JOB NO.	013-1372-001.5100
CHECKED	CP	SCALE	na	DWG. NO.	na
REVIEWED	CP	FILE NO.	Deer Query.xls	FIGURE NO.	4-7



Golder Associates

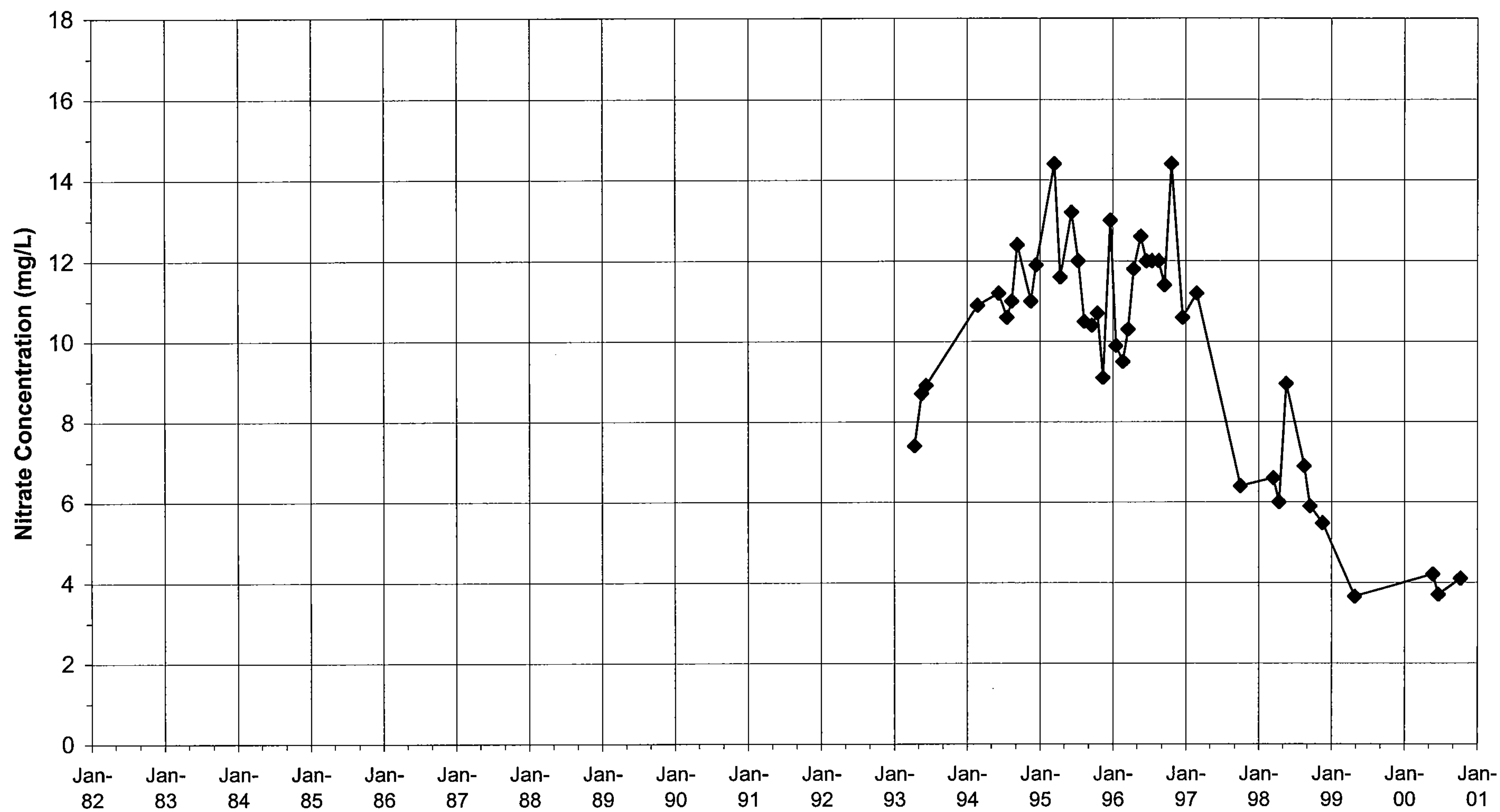
WRIA 57 & 55
Spokane Watershed Planning

—◆— Nitrate Concentration - WDOH Database

Well 4 is completed in the Shallow Aquifer

Deer Park Well 4 - Nitrate

DRAWN	TW	DATE	Jul-04	JOB NO.	013-1372-001.5100
CHECKED	CP	SCALE	na	DWG. NO.	na
REVIEWED	CP	FILE NO.	Deer Query.xls	FIGURE NO.	4-8



Golder Associates

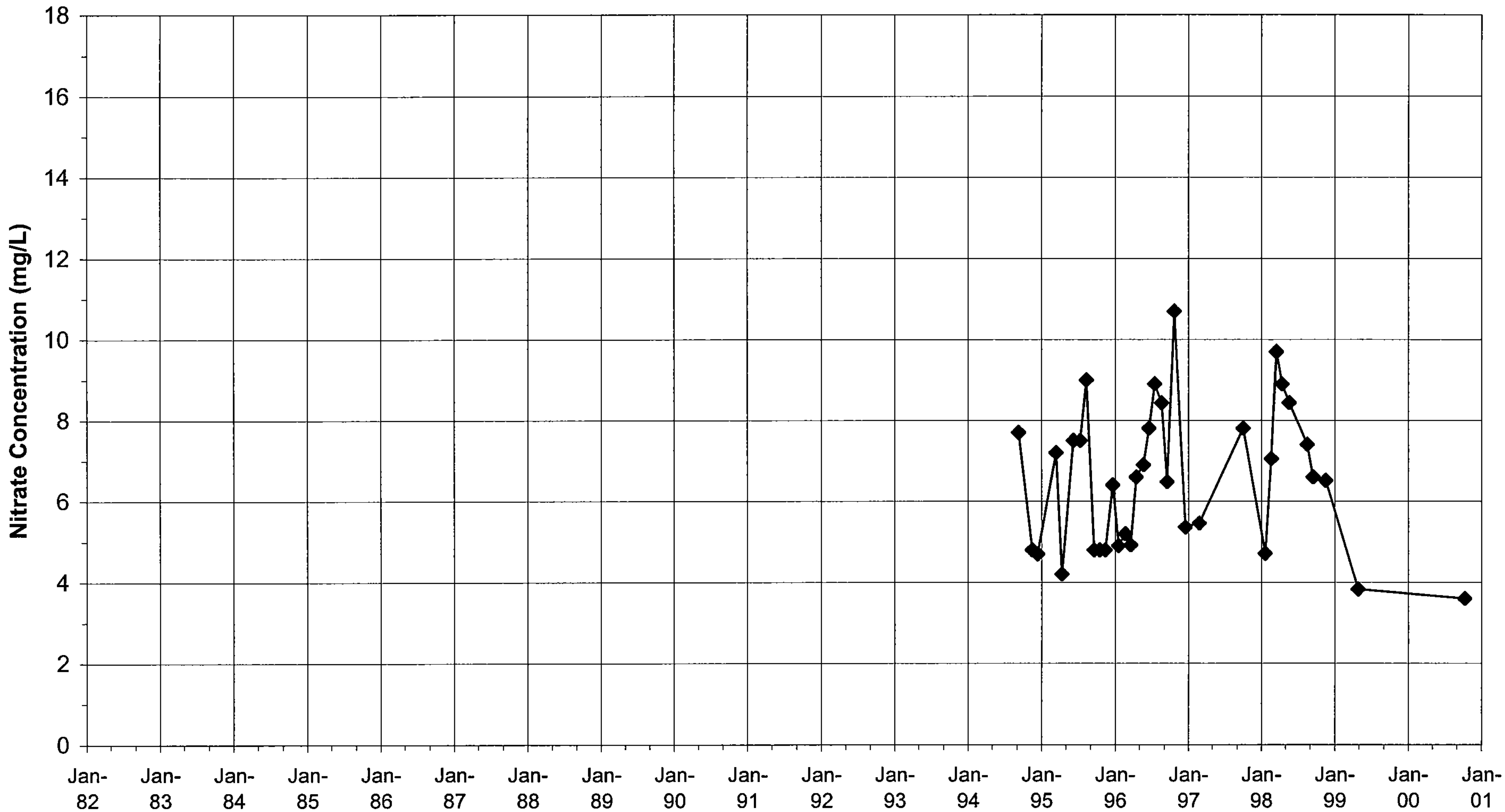
Nitrate Concentration - WDOH Database

Deer Park Well 5 - Nitrate

DRAWN	TW	DATE	Jul-04	JOB NO.	013-1372-001.5100
CHECKED	CP	SCALE	na	DWG. NO.	na
REVIEWED	CP	FILE NO.	Deer Query.xls	FIGURE NO.	4-9

WRIA 57 & 55
Spokane Watershed Planning

Well 5 is completed in the DeepAquifer



Golder Associates

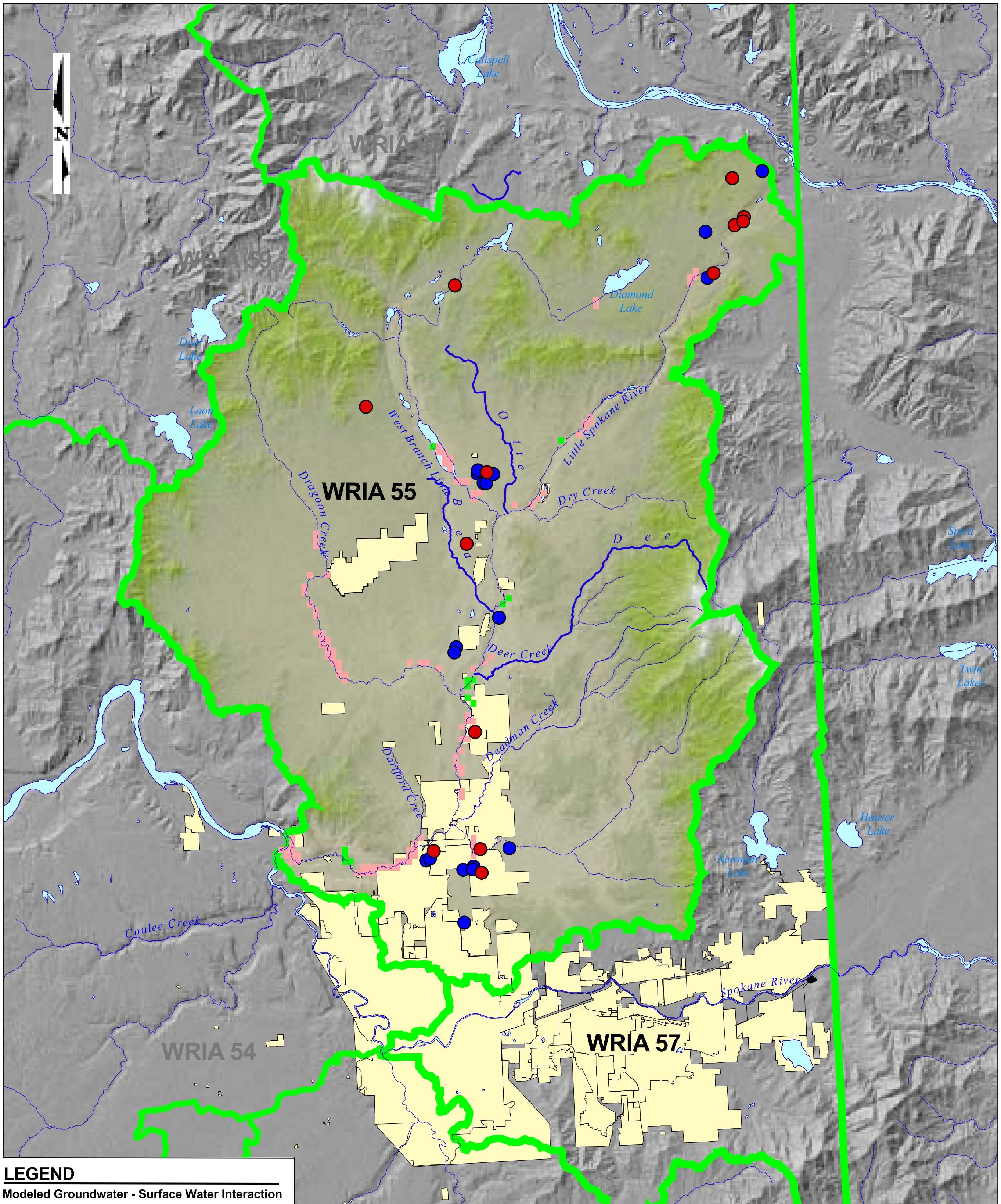
WRIA 57 & 55
Spokane Watershed Planning

Nitrate Concentration - WDOH Database

Well 6 is completed in the Shallow Aquifer

Deer Park Well 6 - Nitrate

DRAWN	TW	DATE	Jul-04	JOB NO.	013-1372-001.5100
CHECKED	CP	SCALE	na	DWG. NO.	na
REVIEWED	CP	FILE NO.	Deer Query.xls	FIGURE NO.	4-10



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: 4-11

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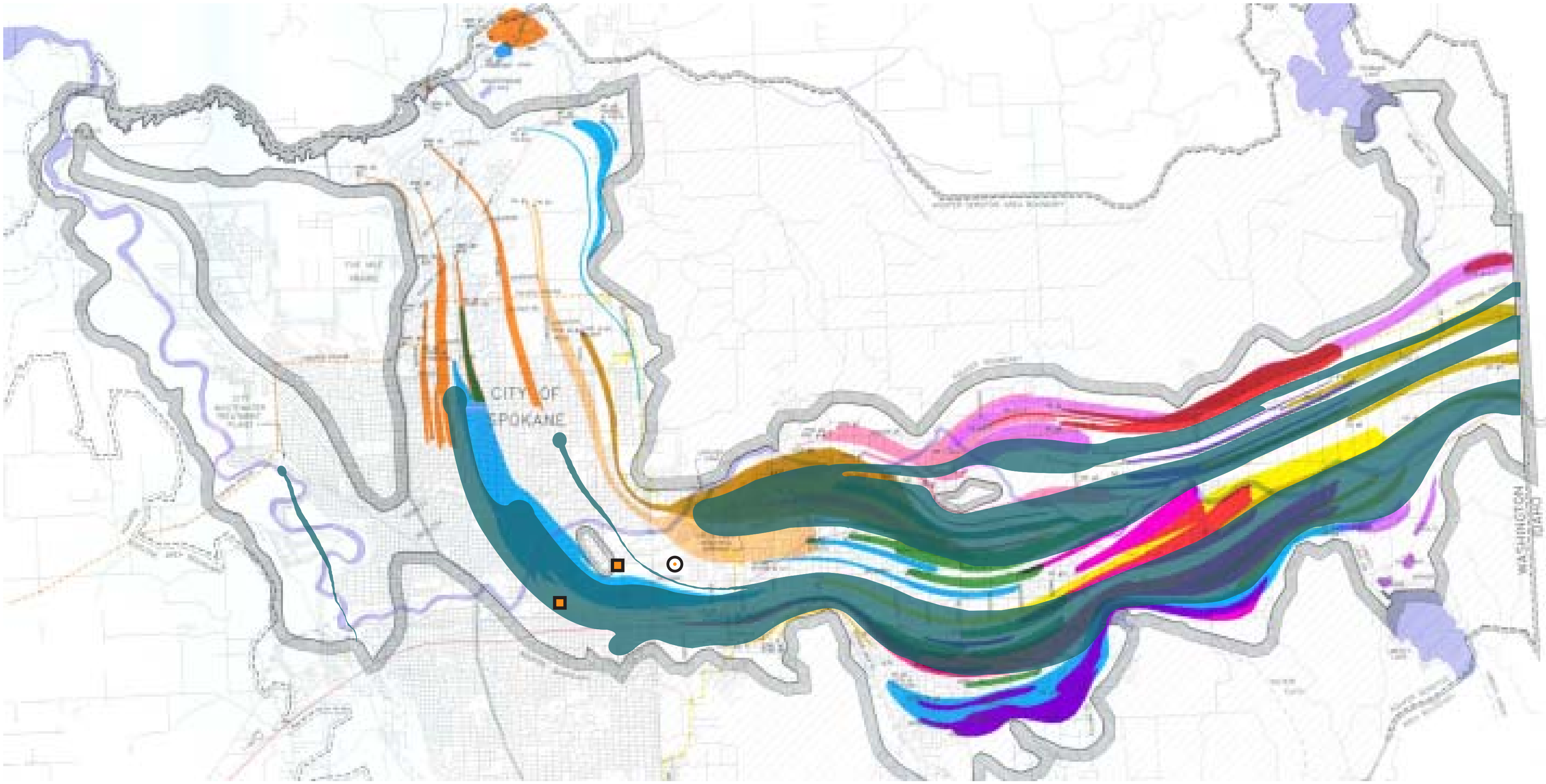


LEGEND

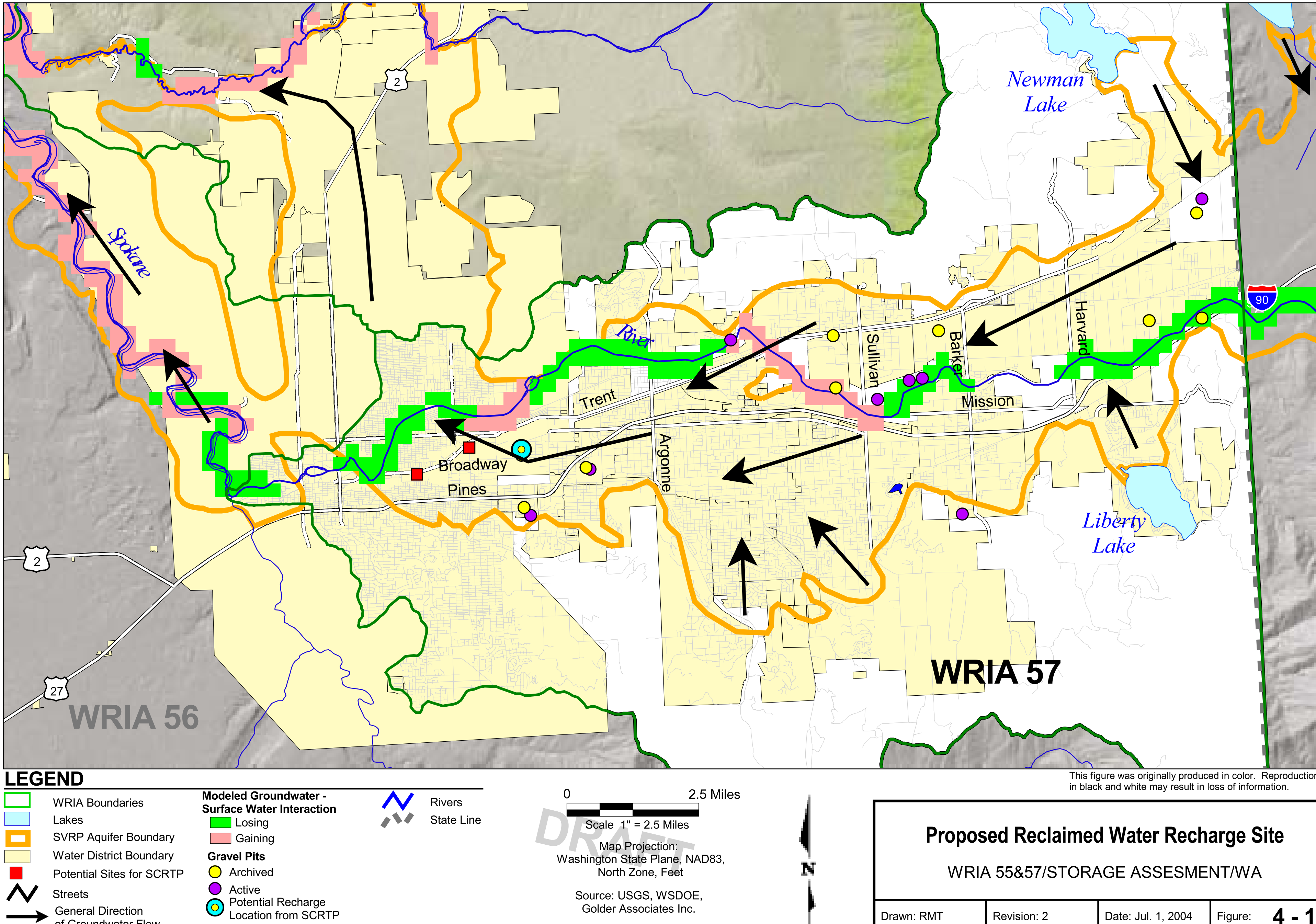
- ■ Proposed Sites For SCRTP
- ⊙ Proposed Recharge Site

Reference: After CH2M Hill (1997,2000)

FIGURE **4-12**
PROPOSED SCRTP SITES AND SPOKANE AQUIFER WELLHEAD PROTECTION AREAS
SPOKANE/WRIA 55 STORAGE ASSESS/WA

DRAWING NO. 01313720014200fg01.fh11 DATE 07/08/04 DRAWN BY AMP

Golder Associates



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

Proposed Reclaimed Water Recharge Site			
WRIA 55&57/STORAGE ASSESMENT/WA			
Drawn: RMT	Revision: 2	Date: Jul. 1, 2004	Figure: 4 - 13

01313725100_062104.apr

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APPENDIX A

WATER STORAGE TASK FORCE REPORT TO LEGISLATURE (2001)

Water Storage Task Force

Report to the Legislature

February 2001

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Publication No. 01-11-002

Water Storage Task Force

Report to the Legislature

Prepared by
Water Resources Program
Washington State Department of Ecology
under the direction of
The Water Storage Task Force

Cover photo: Judy Reservoir, Skagit County

February 2001
Publication No. 01-11-002

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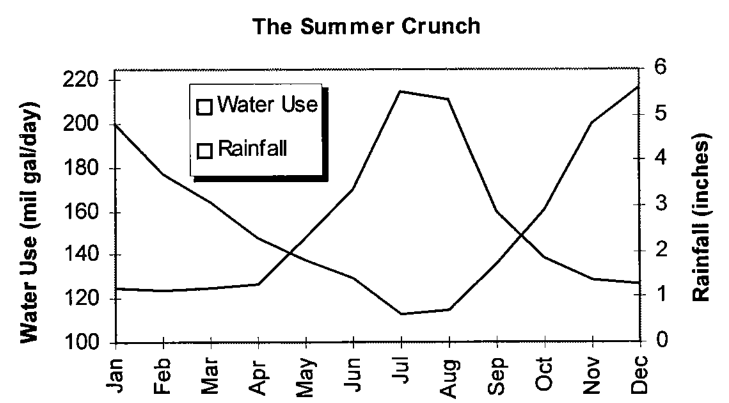
Table of Contents

The Need for Storage

Compared to many of the western states, the state of Washington would seem to have plenty of water. This water, however, is not distributed evenly across the state, nor is it available at all times of the year. Differences in climate result in an annual precipitation of over 200 inches on the coast, and less than eight inches in some areas of Eastern Washington. Furthermore, most of our precipitation comes in the late fall and winter, when demand is lowest. In the summer, when precipitation and stream flows are at their lowest, the demand for water is at its highest. Figure 1 illustrates the seasonal changes in rainfall and municipal water use in the Seattle area.



This chart shows that water availability and water use are mirror images. Water use is highest when water availability is lowest, creating a summer water supply "crunch."

FIGURE 1. *Source:* Seattle Public Utilities 1998 Accomplishment Report

The demand for water in Washington is increasing. A growing state population, a healthy economy and declines in salmon populations have each created a call for increased water supplies. These supplies are not readily available in many parts of the state, especially during the dry season. Today, approximately 350 lakes and streams in Washington are closed to further withdrawals of water. Approximately 100 more streams are partially closed, and 200 streams have stream flows set by rule. The needs for water have sharpened the competition for available supplies and have added a new urgency to the need to secure additional water supplies.

Growth and economic development have been stalled in cities and counties that don't have access to additional water. The cities of Battle Ground, North Bend, Lynden, Granger, Warden, Cle Elum, Tieton, and East Spokane are among the many communities searching for more water.

Rural economic development is also stifled by lack of water. Farmers in the Tucannon River and Pataha Creek drainages have asked for more water in an area that already doesn't have enough water to serve current requests. In Snohomish County, a large, new organic farm was recently told it could not get a new water right, as the area does not have enough water for current uses.

In many parts of the state, fish are at risk of becoming extinct, in part because they don't have enough water. There are many streams where flows are considered to be too low for fish in the summer and fall. This problem exists in streams on both sides of the Cascades and is an issue in most of the counties of the state. In addition, as we look to the future, climate models by the University of Washington indicate the potential for even less snow pack and lower summer flows over the next decade or two.

One solution for the state's water supply problem is to store water when there is excess runoff and stream flows, and deliver or release it during the low-flow period when it is needed for people and fish.

Task Force: Purpose and Process

During the 2000 legislative session, the Legislature recognized the potential for additional water storage as a solution to the water supply needs of the state. As a result, the following proviso was included in the 2000 supplemental operating budget (Chapter 1, Laws of 2000, Engrossed House Bill 2487):

> *Section 301(27). $150,000 of the general fund state appropriation for fiscal year 2001 is provided solely for creating the task force on water storage.* ***The purpose of the task force is to examine the role of increased water storage in providing water supplies to meet the needs of fish, population growth, and economic development, and to enhance the protection of people's lives and their property and the protection of aquatic habitat through flood control facilities.*** *For this purpose, increased storage may be in the form of surface storage including off-stream storage, underground storage, or the enlargement or enhancement of existing structures. The task force shall also examine means of providing funding for increased water storage.*
>
> *The department of ecology shall provide staff support for the task force and the director of the department of ecology shall convene the first meeting of the task force not less than thirty days after the effective date of this section.*
>
> *No member of the task force shall receive compensation, per diem, or reimbursement of expenses from the task force or the department of ecology for his or her activities as a member of the task force. However, each may receive such compensation, per diem, and/or reimbursement as is authorized by the entity he or she is employed by, is appointed from, or represents on the task force.*
>
> *Following its examination, the task force shall report its recommendations to the appropriate committees of the legislature by December 31, 2000.* (emphasis added)

In response to this proviso, Ecology invited agencies, organizations and individuals with a range of interests in water storage to provide representatives to serve on a Water Storage Task Force. From this invitation process, the following individuals were nominated to serve:

Bob Alberts, Pasco Public Works Department, representing WA Water Utility Council and Association of Washington Cities
John Bowman, Lakehaven Utility District
Dueane Calvin, City of Yakima
Walt Canter, Washington Association of Water and Sewer Districts
Representative Gary Chandler, House Agriculture & Ecology Committee
Lee Faulconer, Department of Agriculture
Tom Fitzsimmons, Department of Ecology, Water Storage Task Force Chairman
Senator Karen Fraser, Senate Environmental Quality & Water Resources Committee
Steve George, Hops Growers of Washington

Max Golladay, Kittitas County Commissioner, representing Washington Association of Counties, Eastern Washington
Jim Hazen, Washington State Horticultural Association
Representative Kelli Linville, House Agriculture & Ecology Committee
Ken Lisk, Washington State Water Resources Association
John Mankowski, Washington Department of Fish and Wildlife
Senator Bob Morton, Senate Environmental Quality & Water Resources Committee
Bob Pancoast, East King Co. Regional Water Association, representing Washington Water Utility Council, Western Washington
Tom Ring, for Harris Teo, Jr., Yakama Nation
Mike Schwisow, Washington State Water Resources Association
Dave Somers, Snohomish County Commissioner, representing Washington Association of Counties, Western Washington
Ginny Stern, Washington Department of Health
Judy Turpin, Washington Environmental Council

Five all-day meetings of the task force were held. Press releases were issued prior to each meeting, and the public and media were invited to attend and observe meetings. The schedule and locations of the meetings were as follows:

1.	August 1, 2000	Hyak Lodge at Snoqualmie Pass
2.	September 11, 2000	Mount Vernon, Skagit PUD offices
3.	October 5, 2000	Ellensburg, Hal Holmes Conference Center
4.	November 9, 2000	Bellevue, Ecology's Northwest Regional Office
5.	December 7, 2000	Lacey, U.S. Fish and Wildlife Service

The first two meetings were organized by Ecology staff to provide information to the task force on issues surrounding storage. Presentations were made by task force members, outside parties and Ecology staff having expertise in various water issues. Appendix A contains summaries for the presentations given during the initial meetings. Ecology also presented a draft outline for the task force report at the second meeting.

Meeting 3 largely involved discussing the issues, previous presentations and contents of the report. The task force began forming conclusions and recommendations during this meeting. Detailed discussion and editing of each recommendation was done during Meeting 4. The recommendations were reviewed, and the conclusions were discussed and completed during Meeting 5.

Reasons for Storing Water

Water can be stored to serve many different purposes, including supplies for domestic needs, municipal uses, agricultural irrigation, and fish and wildlife needs. Water storage also helps control floods, generate power and serve recreational needs. Many of the state's existing storage projects serve more than one purpose. The most common combinations for larger projects in Washington are:

- Irrigation, recreation and wildlife.
- Hydropower generation and flood control.

Increasing demand and decreasing natural storage are the major reasons for the call for increased water storage in this state.

Increasing demand

State population has grown from 1.5 million to over 5 million in the last 80 years, and is estimated to reach 7 million by the year 2010.

- <u>Population growth</u> increases the need for domestic water supplies, commercial and industrial water supplies, power generation and food production.

- <u>Fish populations</u> are in decline in a number of streams and rivers. All but one county in the state has a salmon, trout and/or steelhead species with a current Endangered Species Act designation. ESA listings have spurred the call for increased stream flows to assist in the recovery of these species.

Decreasing natural storage

Water stored under ground and water in the form of snow represent the largest sources of stored water in the state: "natural storage." This naturally stored water is often the only source of stream flows during the late summer and early fall, as the snow melts and the ground releases water to maintain surface streams. Underground water (also called ground water) is also the only source of water for many communities around the state.

- <u>Loss of ground-water recharge</u>. Urbanization that creates larger areas with impervious surfaces will divert storm flows and decrease ground-water recharge. Development that narrows the floodplain will reduce the recharge of ground water that would normally occur during routine flooding.

- <u>Climate change</u>. Most scientists agree that the earth is warming, either from natural causes and/or increased greenhouse-gas emissions from human activity. A small increase in temperature would result in less snow and an earlier melt, reducing the natural storage benefits of the snow pack and producing higher flows in the spring and lower flows in the late summer. A small increase in temperature will also raise the freezing level. Some areas that currently have a snow pack may no longer have any snow after the winter months.

Methods for Storing Water

Storing water can be done in several ways. Water can be stored above ground in a surface-water reservoir, usually behind a dam. Water can also be stored underground in aquifer storage and recovery sites.

Surface Water Reservoirs

- The most common method for storing water is creating a surface reservoir behind some sort of dam or dike.

- There are currently more than 1,100 dams in Washington State that store more than 10 acre-feet, with about 380 dams used primarily for water supply storage. However, most projects are rather small, and only 80 dams are greater than 50 feet in height.

- On-channel dams and reservoirs are sited on major streams and are filled directly by flow from the upstream watershed. These are typically large projects that impound many thousands of acre-feet of water.

- Off-channel dams are sited outside the main river valley, on an intermittent stream or completely off-stream. There is typically minimal inflow provided by the tributary drainage. Water to fill the reservoir is usually diverted by gravity or pumping from a much larger adjacent basin.

- New dams can be built to create new water reservoirs, or existing reservoirs can be enlarged by raising existing dams.

Aquifer Storage and Recovery

- Aquifer storage and recovery is defined as capturing usable excess water and storing it underground for later use.

- Potential sources of water for underground storage include excess surface water in winter, stormwater runoff, and high-quality, treated/reclaimed water.

- Methods for getting water into aquifer storage include direct injection via wells, surface spreading by irrigation or use of ponds, and infiltration by piping the water just beneath the land surface.

- Recovering the stored water is typically done by using wells. Under the right conditions, aquifer recharge can also be done to help recover base flows for a nearby stream, spring, or wetland.

- Unlike surface reservoirs, aquifer storage does not require significant commitment or changes in use of the land surface.

- Aquifer storage may restore declining water levels due to over-withdrawals from the aquifer.

- Aquifer storage has the potential to improve water quality of native underground water.

- Aquifer storage requires locating an aquifer in a geologic formation where most of the water will stay in place long enough for it to be recovered.

- Reclaimed water shows promise as a source of "new" water for storage in underground reservoirs, but there remain public perception issues with potential contamination of ground waters.

The major benefits and drawbacks of these water storage methods are outlined in Table 1.

Table 1: Comparison of Different Methods of Storage

New On-Channel Dams	
Benefits	***Drawbacks***
• Large reservoirs can be filled by direct runoff from the drainage basin using the stream as the conveyance system. • Can provide substantial flood control benefit. • Usually less expensive construction, operations and maintenance costs than for large off-channel reservoirs.	• Can requires relocation of people and infrastructure. • Can drown significant riparian habitat. • Barrier to fish passage. • Sediment load can eventually fill in reservoir. • Requires large spillways and outlet works.
New Off-Channel Dams	
• Generally do not represent a barrier to fish passage. • Can be sited in a non-environmentally sensitive area, and may not require extensive mitigation. • Less water quality harm on main river than for on-channel dams • Much smaller spillways and outlet works needed.	• Require extensive conveyance infrastructure (canals, pipes) to get water into and out of reservoir. • Construction, operations and maintenance costs can be much higher than on-channel reservoirs. • Leakage and seepage may require a liner to be placed in the reservoir.
Raise Existing Dams	
• New environmental effects are relatively fewer and smaller compared to a new dam. • The unit cost for increased water storage is typically much lower than for new dam projects. • Significant storage volume can typically be added for a relatively small increase in dam height.	• Existing development around the reservoir has to be relocated or purchased. • Potential risk to downstream lives and property increased, may require extensive dam safety upgrading. • Wetlands and riparian habitats created by the existing reservoir may be displaced.
Aquifer Storage & Recovery	
• Minimal construction is required. • Reduced land surface effects. • Little or no loss of environmental habitat. • No evaporation losses. • Better protection from surface contaminants. • Potential improvements in water quality, streamflow and aquifer levels.	• Limited technical, management and regulatory experience with this storage method. • Possible contamination of existing groundwater by introduced water. • Ownership and/or management of lands over the aquifer may be required similar to Wellhead Protection Areas. • Favorable geology required to limit aquifer leakage.

Water Storage in Washington

Early residents in Washington recognized that the water supply from natural stream flows was limited in the summer months, especially in Eastern Washington. Numerous small dams and reservoirs were built in the late 19th and early 20th centuries to store water from the spring runoff to release water later in the summer to meet the specific needs of irrigation, stock watering and cities.

The first major storage dam project in Washington was the 68-foot-high Nine Mile Dam on the Spokane River, built by the Washington Water Power Company in 1908 for power generation. The first significant irrigation reservoir was the 70-foot-high Conconully Dam and Reservoir, built by the U.S. Reclamation Service in 1910 for the Okanogan Project. In 1914, Seattle built the 215-foot-high Masonry Dam on the Cedar River to provide drinking water for the growing city. In addition to the water supply dams, the U.S. Army Corps of Engineers built several large flood-control dams in the 1940s, including the 350-foot-high Mud Mountain Dam on the White River.

In the ensuing years, dozens of major dam and storage reservoir projects were built for hydropower, irrigation, flood control and municipal supply. Today, there are more than 1,100 dams in Washington, including 80 dams greater than 50 feet in height. A map showing the locations of all dams in the state is shown in Figure 2. A breakdown of the purposes of the larger dams (greater than 50 feet high) is shown in Figure 3.

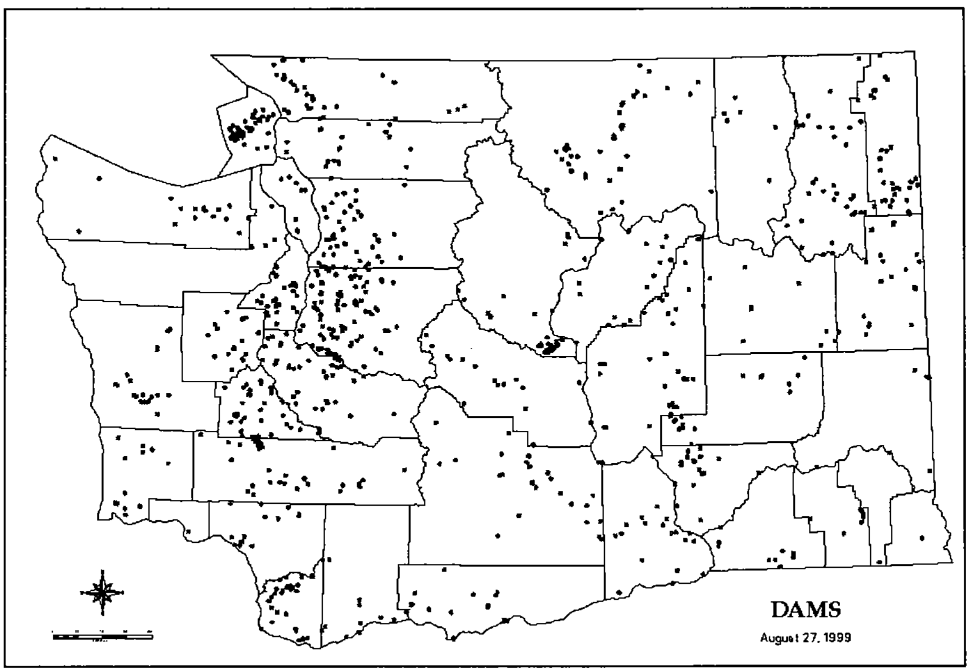
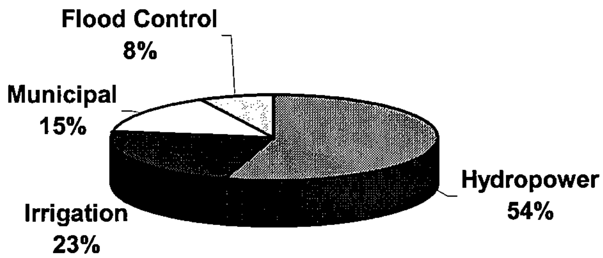


Figure 2: Location of Dams in Washington State

Figure 3.

Primary Purposes of Water Storage Dams Greater than 50 Feet High in Washington



Storage in Surface Reservoirs

Hydropower Reservoirs

The majority of large dams in Washington have been built for hydropower uses. A total of 44 large dams have been built, primarily on major rivers. The projects have been built by a variety of entities, including cities, public utility districts, and private utilities. While these dams store a large quantity of water, their primary purpose is non-consumptive generation of power, with some flood control provided as a secondary benefit. For the most part, these projects do not supply a significant quantity of water for consumptive uses, such as municipal supply or irrigation.

Examples of major dams and reservoirs that are primarily used for hydropower include:

- Ross, Diablo and Gorge dams on the Skagit River, owned by Seattle City Light
- Mossyrock and Mayfield dams on the Cowlitz River, owned by Tacoma Public Utilities
- Upper and Lower Baker dams on the Baker River, owned by Puget Sound Energy
- Nine Mile and Long Lake dams on the Spokane River, owned by Avista Corporation

Irrigation Reservoirs

While numerous irrigation reservoirs have been built in Washington by various individuals and agencies, the primary builder and owner of the largest projects is the U.S. Bureau of Reclamation (USBR). The USBR designed and constructed 12 large dams for storage reservoirs in Washington between 1910 and 1985. The largest of the state dams by far is Grand Coulee Dam, which stands 380 feet high and holds over 9.5 million acre-feet of water. Grand Coulee Dam is a multipurpose facility, used for hydropower, flood control and irrigation. The dam cost $1.85 billion in 1998 dollars to construct between 1935 and 1943 *(World Commission on Dams Case Studies: Grand Coulee Dam and Columbia Basin Project, USA, March 2000)*.

This dam is the cornerstone of the Columbia Basin Project, which uses a total of nine dams impounding five major and two minor reservoirs to distribute water to more than 550,000 acres of irrigated farmland in the Columbia Basin. The Columbia Basin dams were built between 1935 and 1962. The overall cost of the Columbia Basin Project (excluding Grand Coulee Dam) was $3.6 billion in 1998 dollars.

Municipal Water Supply Reservoirs

Numerous dams and reservoirs have been built for cities and towns since the early 1900s to meet their water supply and distribution system requirements. Most of the large dams with major reservoirs are located along the west slopes of the Cascade Mountains, serving the large cities in the Puget Sound area. These projects were designed to capture some of the winter and spring runoff from rainfall and snowmelt and hold it until needed in the dry summer and early fall months.

The largest projects include:
- Masonry/Chester Morse Reservoir dams and South Fork Tolt River Dam for the city of Seattle
- Casad Dam/Union River Reservoir for the city of Bremerton
- George Culmback Dam/Spada Lake for Snohomish County and the city of Everett

Many cities and counties also use smaller, off-stream reservoirs for storage and/or flow regulation, such as Seattle's Lake Youngs Reservoir, Everett's Lake Chaplain Reservoir, or the Skagit PUD No.1's Judy Reservoir project. The case study on Judy Reservoir is included in Appendix B. Many of these dams have been altered multiple times to increase storage to meet the needs of a growing population.

Flood Control Reservoirs

Most dams in Washington built to store water for flood control have been relatively small, stormwater-detention-type dams that serve small watersheds. However, the U.S. Army Corps of Engineers has built six large dams in the state solely for flood control. The first large flood control dam, Mill Creek Dam, was constructed in 1942 to reduce flooding in Walla Walla. This dam and reservoir is located off-channel in an adjoining drainage, and stores excess flows from Mill Creek via a diversion channel. The largest single-purpose flood-control dam in Washington is Mud Mountain Dam, a 350-foot-high structure constructed by the Corps in 1948 on the White River.

In addition to these single-purpose reservoirs, the Corps works with owners of hydropower and water supply dams throughout Washington to manage them in the winter to reduce the effects of large floods. The capability to store water for flood control is limited on these projects, because flood control operation (requiring that the reservoir be kept empty before the storm season) conflicts with the primary uses of the reservoir for water supply and/or hydropower.

Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) involves storing water via pumping or infiltration in an underground aquifer and recovering it through wells when needed. This technology has been around for some time and is extensively used in other states, including Oregon, but to date has seen limited use in Washington. One of the first significant ASR projects is the OASIS project in Federal Way, proposed by the Lakehaven Utility District. Planning for this project began in 1989 and would store up to 29,000 acre-feet of water. Another significant ASR project has been proposed by the city of Walla Walla, involving storing water in aquifers that have declined as a result of prior use.

Recent Reservoir Storage Projects

Although construction of new large dams and reservoirs slowed considerably in the latter part of the last century, there have been some notable projects constructed in Washington in the last 15 years. Table 2 provides listings and selected details on several of these projects.

Table 2: Recent Water Storage Projects Constructed in Washington

Project Name	County	River or Stream	Year Built	Dam Height (ft)	Storage (ac-ft)	Const. Cost	Purpose(s)
IRRIGATION							
French Canyon Reservoir	Yakima	N.F. Cowiche Creek	1985	56	670	$7.7 million*	Reregulation
Rosa Wasteway 6 Reregulation Reservoir	Yakima	Offstream	1988	18	65	$863,000	Reregulation
Rosa Wasteway 7 Reregulation Reservoir	Yakima		1991	15	15	$403,000	Reregulation
Wenatchee Heights Reservoir No. 2	Wenatchee	Stemilt Creek	1996	30	80	$241,000	Irrigation Supply
FLOOD CONTROL							
Zintel Canyon Dam	Benton	Zintel Canyon	1992	97	2300	$3.9 million	Flood Control
HYDROPOWER							
Cowlitz Falls Dam	Lewis	Cowlitz River	1993	120	10,000	??	Hydropower
MUNICIPAL SUPPLY							
Indian Creek Reservoir	Pacific	Bear River	1989	74	846	$2.3 million*	Municipal
Judy Reservoir Enlargement	Skagit	Offstream	2000	10 foot raise	1700 added	$9 million	Municipal
OASIS Underground Storage Pilot Project	King	Underground	1992	N/A	29,000 potential	$60-70 million ?	Municipal

* Year 2000 dollars

Policies Related to Storage

This section summarizes policies related to storage. Policies contained in government programs related to land management that may affect siting of new storage projects are also mentioned.

State Policies

Washington statutes contain several general policy statements related to water storage. The few key guiding principles related to storage are described below:

- Long-range development goals of the state include furnishing an adequate supply of water for domestic, industrial, agricultural purposes, municipal, fishery, recreational, and other beneficial uses. (RCW 43.83B.010; RCW 43.99E.010)

- It is in the public interest to encourage the impoundment of excess water in basins where there is water available on a seasonal basis that is in excess of the needs of streams or existing water-rights holders. Both storage and other alternatives should be encouraged. The goal is to strengthen the economy and improve the state's environment. (RCW 90.03.255)

- It is state policy to obtain maximum net benefits and support economically feasible and environmentally sound development of physical facilities for diversion and storage. (RCW 90.03.005)

- Storage that serves multiple purposes is preferred over single-purpose storage (RCW 90.54.020)

- In determining the cost-effectiveness of alternative water sources, full consideration should be given to benefits of storage. (RCW 90.54.180(4))

- Agencies are to help applicants seek a safe and reliable water source. Assistance can include creation of interties, storage, and conservation. (RCW 43.21A.064(5))

Detailed citations of state law related to storage, including agency authorities, planning, water rights, permits, and funding are provided in Appendix C.

Federal Policies

Some federal agencies have policies related to managing water, land and other natural resources that would be applicable to water storage projects. Some of these policies will affect any proposed storage project, while other policies will only affect storage projects proposed on federal lands.

The National Marine Fisheries Service (NMFS) has no formal, written policy concerning water storage. Storage projects are reviewed on a case-by-case basis. In general, the stated NMFS policy is to support activities if benefits for fish outweigh the disadvantages (personal communication, Mike Grady, 2000).

The U.S. Forest Service has a written Aquatic Conservation Strategy. The strategy was developed to restore and maintain the ecological health of watersheds and their related aquatic ecosystems. The strategy applies to federal lands managed by the Forest Service and Bureau of Land Management within the range of Pacific Ocean anadromous fish populations. The strategy does not directly address storage projects on federal lands, but its effect is to identify and prioritize certain land for the purpose of watershed restoration and to ensure that proposed activities on federal lands not interfere with the restoration objectives. A copy of the complete Strategy is in Appendix D.

While neither the U.S. Bureau of Reclamation nor the U.S. Army Corps of Engineers has any formal policies on water storage, both agencies have been responsible for planning, constructing and operating a number of the larger structures in the western U.S. These structures serve mostly irrigation, hydropower and flood-control purposes.

Tribal Policies

Some tribal governments have enacted water laws and adopted rules and programs related to managing water and land within their jurisdictions. Neither of the tribes involved with the Storage Task Force has written policies specifically related to storage. As independent governments, water and land-management policies will vary between different tribes.

Planning Considerations

State law provides several planning processes that directly relate to water storage.

Public water system plans

Public water systems are required to prepare water system plans for review and approval by the Washington Department of Health. All systems are required to prepare an initial plan. Larger systems and systems that are expanding need to prepare updates to these plans every six years.

Water system plans are required to include detailed evaluations of future water demand and to demonstrate adequate availability of water supplies to meet that demand. Water storage is routinely evaluated during development of these plans. Smaller storage units are a routine feature of many public water system plans. Some systems also rely heavily on their basin-level storage sites, and water system plans are often the origin of proposed new storage projects.

Watershed plans (2514)

In 1998, the state Legislature passed the Watershed Management Act to provide a framework for local citizens, interest groups and governmental organizations to collaboratively identify and solve water-related issues in each of the state's 62 Water Resource Inventory Areas (WRIAs). Two-thirds of the WRIAs in this state are currently involved in planning under the Act, and many of the watershed plans called for under the act will be prepared and adopted in the next few years.

One step in this planning process involves an assessment of the watershed, including a description of water supplies, uses and needs. The resulting watershed plan must include strategies for meeting future needs, both in-stream and out-of-stream. Water storage is expected to be a major feature of many of these watershed plans.

Land-use plans

Washington cities and towns have had land-use plans for years. Under the Growth Management Act (GMA), many local governments are required to plan for financing and delivering services needed to meet planned growth, including water supplies. Where growth is projected to occur in areas with limited existing water supplies, water storage can be an important tool for meeting the utility planning requirements.

Though GMA plans are not required in all parts of the state, local land-use plans of one form or another are prepared in all jurisdictions. Local land-use planning, whether done under GMA or outside GMA, could provide an opportunity to evaluate the need and potential for water storage.

Permits for Storage

Regulatory review and approval of water storage facilities usually involve multiple state and federal permits. A summary of some of the major permits and approvals that may be required for a storage project is provided below.

Environmental Review

Water storage projects that require local, state or federal approval require environmental review under the State Environmental Policy Act (SEPA) and/or the federal National Environmental Policy Act (NEPA). Environmental review is not a permit per se, but is intended to ensure that environmental values are considered during decision-making by government agencies. This review involves identifying and evaluating probable effects for all elements of the environment. Many water-storage projects will likely require the preparation of an environmental impact statement (EIS). When a project requires both a state and a federal EIS, the lead agencies can decide to prepare a single document to meet both state and federal requirements.

JARPA Permits

Numerous permits may be required for any water storage projects that involve working in or near state waters. These permits are typically applied for through the Joint Aquatic Resource Permits Application (JARPA). JARPA can be used to apply for the water-related permits shown in Table 3.

Fish and Wildlife Mitigation Policy

The Washington Department of Fish and Wildlife (DFW) has a formal policy related to mitigation that is applicable to proposed water storage projects. The policy is applied by DFW when issuing or commenting on environmental permits. The stated goal of the policy is to achieve no loss of habitat function and value. The hierarchy or continuum of preferred actions is (1) avoiding damage, (2) minimizing damage, (3) repairing damage, (4) reducing damage through long-term maintenance, (5) compensating damage by replacing resources and (6) taking corrective measures over the long-term. It lists the guiding principles for making decisions on appropriate mitigation activities, required elements of mitigation plans and appropriate legal documentation. A complete copy of the policy is in Appendix E.

Table 3: Typical Permits Covered under JARPA Related to Water Storage

Permit	Purpose	Trigger/Activity	Responsible Agency
Hydraulic Project Approval (HPA)	To provide protection for all fish life.	Work that uses, diverts, obstructs, or changes the natural flow or bed of state waters.	Department of Fish and Wildlife, Habitat Program
Water Quality Certification (401)	To ensure that federally permitted activities comply with the federal Clean Water Act, state water quality laws and any other state aquatic protection requirements.	Applying for a federal license or permit for any activity that could cause a discharge of dredge or fill material into water or wetlands, or excavation in water or wetlands.	Department of Ecology, Shorelands & Environmental Assistance Program
Coastal Zone Management Certification (CZM)	To assure compliance with state and Federal Clean Water Act, SEPA, Shoreline Management Act & Energy Facility Site Evaluation Criteria	Conducting projects authorized by the federal agencies and/or applying for certain federal permits or funding.	The federal permitting agency or Ecology Headquarters, Shorelands & Environmental Assistance Program
U.S. Army Corps of Engineers 404 Individual Permits: Discharge of Dredge and Fill Material	To restore and maintain the chemical, physical, and biological integrity of the nation's waters.	Placing a structure, excavating or discharging dredged or fill material in waters of the U.S., including wetlands.	U.S. Army Corps of Engineers
U.S. Army Corps of Engineers Section 10 of the Rivers & Harbors Act, Individual Permit: Work in Navigable Waters	Prohibits the obstruction or alteration of the navigable waters of the U.S. without a permit from the Corps of Engineers.	Placing structures and discharging material in navigable waters of the U.S., including wetlands.	U.S. Army Corps of Engineers
Shoreline Substantial Development Permit	To provide public involvement in the permit process and to foster appropriate uses and protection of the shorelines of the state.	Interfering with normal public use of the water/shorelines of the state, or developing or conducting an activity valued at $2,500 or more on the water or shoreline area.	Local Government (City or County)

State Water Rights/Reservoir Permits

Under Washington Water Code, there are three possible authorizations required for surface-water storage projects.

1. A water right permit or certificate is required to divert or withdraw water to an off-stream reservoir. On-stream reservoirs do not require this authority.

2. A reservoir permit or certificate is required to impound and store water if the reservoir is storing more than 10 acre-feet in volume or if it is 10 or more feet deep at its deepest point.

3. A third permit or certificate that may be necessary is a secondary permit(s) for using reservoir water outside the reservoir.

When practical, the authorizations to divert or withdraw public waters, to store water within a reservoir, and to use stored water outside the reservoir are combined into a single document.

For storing underground water, a water right permit is also required to divert or withdraw water to storage. Under legislation recently passed, the code now allows application for aquifer reservoir permits similar to applying for a surface reservoir permit. The legal need for secondary permit(s) to use reservoir water outside the reservoir is currently under discussion.

Other state laws allow for ground-water storage based upon creating a ground-water management area or sub-area by Ecology, the filing of declarations by a water user claiming to store and withdraw ground water, and confirmation by Ecology. There are several existing rights to store and withdraw ground water established under this process.

There is currently a long wait for processing new water-right applications, resulting in significant uncertainty as to the legal availability of water for storage projects.

Dam Safety Permit

A Dam Safety Construction Permit is required from the Department of Ecology's Dam Safety Office before constructing or modifying any dam or controlling works that can store 10 or more acre-feet of water. This requirement may apply to dams and storage lagoons for: flood control; domestic or irrigation water; domestic, industrial, or agricultural wastes; and mine tailings. Permit processing averages from six to eight weeks, but varies depending on the complexity of the project. Ecology also inspects the construction of all dams to reasonably secure safety of life and property.

Other State Permits

- Department of Natural Resources Forest Practices Permit – A forest practices approval is required of the owner/operator of land and timber before beginning any forest practice, such as harvesting, road construction, etc. Applications are generally processed in five to 30 days (RCW 76.09 and WAC 222).

- Department of Ecology Water Quality Modification – These permits are issued to address turbidity in water during construction, chemical applications in water, or other situations requiring a temporary modification of a water quality standard (RCW 90.48.445 and WAC Chapter 173.201A-110(2)).

Environmental Considerations

When many of the dams and reservoirs were built in Washington state, the environmental effects of these projects were a secondary consideration. Today, many important environmental issues can affect the feasibility and siting of new storage projects. The presence of environmental issues does not automatically preclude the possibility of building a storage project. Some projects may not be "environmentally feasible." For other projects, the presence of significant environmental issues means that additional planning and mitigation will likely be needed, with a concomitant increase in cost and time. Still other water storage projects provide a good opportunity to enhance or restore fish and wildlife habitats.

Environmental considerations for water storage projects will vary by the type of storage (e.g., surface reservoir or aquifer storage) and by the resources that exist at the proposed storage site. Endangered species and the environmental role of flooding are two significant issues that will surface on many storage projects.

Endangered species

The declining status of many salmon species in Washington has resulted in their listing as either endangered or threatened under the federal Endangered Species Act (ESA). The ESA listing could have a significant effect on the state's ability to construct new storage, as well as managing existing storage. There are three major ways in which the ESA may affect existing or new water storage projects.

- First, where a proposed federal action might affect a listed species, the federal agency is required to consult with either the National Marine Fisheries Service (for anadromous fish) or the U.S. Fish and Wildlife Service (for wildlife and non-marine fish) to determine if the action will jeopardize the species. If it does, the action is either prohibited or modified so that jeopardy does not occur.

- Second, to provide protection from ESA sanctions, private landowners, public agencies and others have developed habitat conservation plans (HCPs) that reduce harm to certain listed species while ensuring their long-term protection.

- Third, where actual harm has occurred to a listed species, litigation can be initiated by the federal government or a citizen to enforce the protection requirements of the ESA. For example, an irrigation district in southwest Oregon was forced to remove an irrigation dam to protect a listed fish species.

Endangered species can be a significant challenge for new storage projects. However, if properly designed, storage projects can also provide direct benefits to endangered species.

Environmental Role of Floods

While high flows and flooding can result in significant damage to the human built environment, natural flooding events have shaped many of the features of our watersheds, and they continue to play an important role in sustaining the natural ecosystem functions. A river ecosystem encompasses the river itself, the riparian areas adjacent to it and the substrate below the water. All three are important in providing for healthy fish stocks.

Water temperature, flow in the river and under ground, timing of flow, nutrients, and physical features of the stream channel can affect the ability of the stream to support aquatic life. These features, in turn, are affected and shaped by flooding events. When these events are eliminated, the physical features of the stream can be altered over time and the natural capacity of the stream can be diminished.

Recent advances in the science of river systems have underscored the importance of the natural flow regimen of a river as the template that formed the diversity and abundance of aquatic species. A body of science known as Normative River Concept emphasizes the ecosystem functions of the variability of the natural hydrograph, including the benefits of high spring flows and river floodplain interactions, as well as stable, ample base flows.

Water storage projects that reduce or eliminate natural flooding events in a river system will likely need to address the potential implications to natural functions in the watershed. Analysis and evaluation of these storage projects will likely involve demand curves for each purpose of water needed from the project, including fish.

Operational Considerations

How a water storage project is operated can affect the benefits and consequences of the project.

Using reservoirs for multiple purposes can help spread the benefits (and costs). However, different purposes may need the storage capacity at times that conflict with each other. For example, flood control operation tends to conflict directly with water supply operations, as flood control reservoirs need to be lowered at the time when water supply uses would dictate filling.

Many large hydropower projects have allowed other smaller uses of their water storage reservoirs, under a so-called "good neighbor" policy. However, if these consumptive uses significantly affect power production, the senior and primary uses of the reservoir could assert their right to the water.

Constructing new dams or raising existing dams has public safety implications to downstream residents and property. Raising existing dams will require increased efforts to ensure the safety of these dams. Also, land-use management should be considered below these dams to avoid increasing the risk posed by the dam.

Land-use management is also a consideration for aquifer storage sites. Protecting aquifer storage sites may require actively managing land uses at the storage site to prevent contamination of the stored underground water.

Many reservoirs have a pool of water below the lowest release point on the dam that is typically not used, known as "dead storage." "Dead storage" is used in some existing reservoirs and could be used in other projects. However, the effects to carryover storage, to other uses of the reservoir, and to habitat may make it unfeasible except for emergencies.

Financing of Water Storage

Funding for water storage has come from several places and varies depending on the purpose of storage. In general, federal dollars have paid for the majority of flood control, irrigation and hydropower storage projects in Washington state. State funding, local government or special purpose districts, and water users have funded the remainder.

For hydropower and irrigation uses, funding for storage projects has mostly come from the public. Federal funds from the U.S. Bureau of Reclamation have paid to construct and operate 58 hydropower plants and 348 reservoirs in 17 western states. The Columbia Basin and Yakima projects, the largest water storage projects in the state, were largely built with these funds. The Yakima enhancement program -- in which the U.S. Bureau of Reclamation , irrigation districts, and Ecology are working together to conserve water, rehabilitate and improve district distribution facilities -- is also primarily funded through federal dollars. Funding from the Corps of Engineers paid for other dams, such as Mud Mountain, Howard Hanson, Wynoochee and several dams on the Columbia and Snake Rivers.

State money has also been used to construct some storage projects in Washington. Referendum 27 was a bond issue in 1972 and provided $25 million dollars for agricultural water supply facilities. All funds were spent. Referendum 38, passed in 1980, provided $50 million for agricultural supply/storage/conservation projects. Rules for Referendum 38 were adopted in 1990 with two phases. Irrigation districts could elect to prepare water conservation plans and then receive state funding for a portion of the capital cost. The Drought Preparedness Account from 1989 provided approximately $12-15 million in loans or grants for short-turn-around drought projects. Funds are available only to public bodies such as irrigation districts and Indian tribes.

Local match funding for the public funds has typically come from the irrigation districts.

For municipal projects, Referendum 38 provided $75 million for public water supplies. However, rate revenue and bonds have been used more recently for storage projects. Storage for fish and wildlife has usually been funded as an add-on to storage projects funded for other purposes.

There is currently no single, clear answer on how new storage projects can be funded. State infrastructure studies have shown the need for water supply projects, but existing sources of public funding are currently oversubscribed. Many storage projects will cost more than a single utility could afford. As a result, coalitions of interests may need to be formed to put together the necessary funding.

Typical Costs

It is difficult to provide precise cost information for "typical" storage projects, because the costs can vary significantly depending on the location, siting, engineering requirements, environmental effects and mitigation, difficulty of construction, and purpose(s) of the project.

However, data on recent projects show that the costs can vary from around $200 per acre-foot of storage for raising existing dams to more than $10,000 per acre-foot for new re-regulation projects with small storage capacity. In general, the cost per acre-foot tends to be higher for small reservoirs and much lower for large reservoirs. Also, projects to construct new dams tend to cost more than raising existing dams. Tables 4 and 5 provide some comparative cost data for selected projects in Washington and other states.

Table 4: Construction Costs for Selected New Reservoirs in Washington and Other States

Project Name	On/Off Channel	Total Cost	Dam Height	Storage	Cost/AF	Purpose/Use
In State						
Zintel Canyon Dam	On	$3.9 million	97 ft.	2300 acre-feet	$1,695	Flood Control
Wenatchee Heights #2 Reservoir	Off	$241,600	30 ft	80 acre-feet	$3,020	Irrigation
Rosa Wasteway 6 Reregulation Res.	Off	$863,000	18 ft	65 acre-feet	$13,280	Irrigation Reregulation
Pine Hollow Reservoir	Off (Proposed)	$50.5 million	185 ft.	24,000 acre-feet	$2,145	Irrigation, Fish
Other States						
Ritschard Reservoir (Colorado)	On	$32 million	122 ft.	66,000 acre-feet	$485	Irrigation, Municipal
Westminister Lake (Colorado)	Off	$3.7 million	31 feet	955 acre-feet	$3,860	Municipal
Eastside Reservoir (California)	Off	$2.1 billion	280 feet	800,000 acre-feet	$2,625	Municipal, Irrigation

Table 5: Construction Costs for Selected Dam & Reservoir Enlargements in Washington

Project Name	On/Off Channel	Total Cost	Dam Raise	Storage Increase	Cost/AF Increase	Purpose/Use
Patterson Lake Dam	Off	$100,000	3 feet	500 acre-feet	$200	Irrigation, Recreation
Keechelus Dam *(Cost to rebuild dam and retain storage instead of permanent drawdown)*	On	$31.9 million	N/A	110,000 acre-feet	$290	Irrigation
Cle Elum Dam (Proposed)	On	$16.7 million	3 feet	14,600 acre-feet	$1,140	In-Stream Flow
Wenas Dam (1982)	On	$3.5 million (Yr. 2000 dollars)	35 ft	2,200 acre-feet	$1,590	Irrigation
Judy Reservoir (Under Construction)	Off	$9 million	10 ft.	1,700 acre-feet	$5,294	Municipal

Construction Costs for Aquifer Storage and Recovery Projects

The cost of Aquifer Storage and Recovery (ASR) projects is variable and site specific. A systematic assessment of costs for ASR systems has not been published, and the estimates presented 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.

Alternatives to Storing Water

Water storage is one of several water management tools that can provide additional water to meet identified needs. Since the availability and needs for water vary, the use of storage and other tools will differ across the state. Evaluating these tools and decisions on how current and future water needs will be met are best made using a basin-by-basin approach.

Water conservation programs and reclaimed water can provide additional water in many areas. Conservation programs can free up water currently in use and provide new supplies for a relatively small cost. The opportunities for conservation and the costs will depend on how water is currently used in a given area. Reclaimed water is municipal wastewater effluent that is treated to allow use for irrigation or other non-potable purposes. There are significant volumes of waste water that could be reclaimed and put to use, though the costs of treatment and distribution are a significant issue.

In addition to new storage, conservation and re-use, preserving existing natural storage is an important feature for efficient water management. One of the biggest sources of storage is natural groundwater storage, which helps maintain the base flow in streams in the low-flow summer months. Precipitation falling on impervious surfaces such as roads and roofs runs off quickly, resulting in higher winter flows and less infiltration, which reduce natural storage.

Stormwater storage facilities can retain the runoff from urban areas and release it more slowly, which can prevent flooding and erosion. They can also be designed to infiltrate the runoff back into the ground. Small-scale infiltration features can be built into new urban areas, such as leaving more natural vegetation, small-scale infiltration basins, etc. Enhancing snow retention in agricultural areas may also help infiltration.

All these measures could help improve the natural storage in underground water, which will, in turn help, maintain ground-water levels and stream flows during crucial periods of need.

Conclusions

Importance of Water

1. Water is a vital resource for Washington State. Dependable water supplies of sufficient quantity and quality are essential to the economic and environmental health of the state.

Role of Storage

2. Storage can be an important and useful water supply and environmental management tool. Water storage can:
   - Address the needs of all water users.
   - Provide supplies for economic development and population growth.
   - Be used to restore fisheries and help preserve the biological integrity of our watersheds.
   - Enhance recreational activities and provide protection from destructive floods.

3. Members of the Waster Storage Task Force have differing opinions on the relative importance of storage in meeting future water supply needs:
   - Some members believe it is the only tool that will allow the state to meet its future water supply needs in much of the state. These members note that storage is the only method that will produce large enough quantities to meet the identified needs. They also note that storage to produce new supplies will avoid the need to fight over water rights and ownership of existing supplies.
   - Other members believe it will be an important tool in some basins and not in others, and must be used in conjunction with other water supply and demand management options (e.g., conservation, water transfers, and water reuse). These members note that storage options can be very expensive and controversial, and that future needs may be met by water conservation, re-use and marketing of existing supplies in some areas of the state.

Planning For Storage

4. There are many areas in Washington that have abundant, and some times excessive, water during the wet season that could benefit from further evaluation of storage as a tool to meet current and future water needs.

5. The watershed planning process is a significant and timely opportunity for evaluating water storage as a management strategy to meet water needs.

6. Storage projects which are part of an overall plan or agreement among the federal, state, local and tribal governments regarding water management in a basin, and storage projects that serve multiple purposes are most likely to be successfully sited and funded.

7. Different uses of storage may compete with each other by requiring that water be stored or released at different times of year. Optimizing use of storage for one purpose (releasing water from a reservoir to make room for flood control) can hamper the ability to secure other

storage purposes (saving water in a reservoir for later production of hydropower).

8. Planning for new storage projects should consider how to balance the full range of potential uses for the stored water.

Evaluating Storage Projects

9. Because of the complex economic, technical and environmental issues surrounding storage projects, the feasibility of each project must be determined on a case-by-case basis.

10. The potential benefits and impacts of any particular storage project can only be determined by assessment of that particular project and its watershed.

Environmental Considerations

11. If a storage project is to be designed to benefit fish, not just to minimize harm to fish, the design and operation of the project must take into account the variations in timing and flow that support important habitat and crucial ecological functions.

12. Aquifer storage and recovery (ASR) projects, when properly sited and operated, could result in less harm than surface alternatives.

Funding

13. Funding is essential for developing storage projects. Construction costs can vary significantly, with recent project costs ranging from around $100 to more than $10,000 per acre-foot of stored water. New, large storage projects can cost millions of dollars. Planning, design and permitting can also be a significant portion of the total costs. While some public funding is available for select storage uses, the existing public funding programs are severely over-subscribed and would not cover the full cost of a storage project.

14. Funding will need to come from a variety of sources, including a new source of public funds.

Land Use

15. On-site and local practices to manage storm water (e.g., reducing impervious area and providing infiltration basins) will reduce flooding, improve water quality and benefit the water quantity of a basin by preserving the "natural storage" capacity of the land. Storm water that is recharged to the ground will help sustain aquifers and dependent streams during low-flow periods.

Recommendations

Water supply as a state priority

1. Providing adequate water at the right time for diverse needs of the state including people, fish, and agriculture should be a high priority.

Role of the State

2. State agency responsibilities for water storage should be coordinated by Ecology. This would include: providing technical assistance; ensuring effective participation by state agencies; assisting in bringing state, local, tribal, and federal agencies together; and encouraging timely, regulatory review by state agencies. Ecology's coordinating role applies to major projects and planning, not individual projects such as the approval of domestic water storage tanks or other items typically reviewed by Department of Health in water system plans.

Permits and Laws

3. Without compromising environmental review and public involvement, the state should identify and implement efficiencies, to streamline the permitting process of siting and constructing additional water storage projects, reducing the amount of time and overall cost of these projects.

4. The legislature should evaluate existing state laws related to storage to determine if there are gaps or conflicts that need to be addressed.

Planning for Storage

5. Planning for new water storage projects should consider the full range of storage alternatives, including off-channel storage, underground storage, the enlargement or enhancement of existing storage, and on-channel storage; and of both large and small scale (e.g., small stormwater facilities) options.

6. Planning and design for storage should be considered in the context of how water works within an entire basin or watershed. This includes consideration of the natural variability of stream flow and its interaction with the floodplains and associated ground waters, as well as scientific analysis of the water needs of all life stages of the species of interest present in the basin. Planning for storage should also address how storage will integrate with the water supply and delivery system(s) within an entire basin.

7. Water storage infrastructure needs should be inventoried and assessed through watershed planning processes. The inventory should include all public and private water systems. The inventory should ensure that small drinking water systems and fire safety needs are addressed.

8. Consistent with the Watershed Management Act, and other laws, the state should help local watershed planning groups, local governments, utilities, and other stakeholder groups define:
   - The current and future water supply and demand in their watersheds, including in-stream and off-stream needs;
   - The type of storage projects for that watershed; and
   - Potential storage site locations.

9. The Watershed Management Act manual should be updated to add a section on storage. Topics to include are:
   - Different types of storage;
   - Case studies of successful and unsuccessful projects, including aquifer storage and recovery;
   - Recommended procedures for evaluating storage projects; and
   - Recent advances in the science of how a river system supports the diversity of aquatic species, including the latest information on addressing the types of flows that are necessary to provide for key ecological functions of the river system.

10. Groups planning for water storage should be encouraged to include climate fluctuations as it impacts the availability of water as part of the planning processes.

11. The state Dam Safety Office should advise local governments of the status of dams within their jurisdiction so informed local land use decisions can be made.

12. Ecology should work with federal agencies to develop clearer policies and procedures for use of federal lands for water storage projects.

Funding

13. The state needs to pursue creative methods to facilitate the financing of water storage projects, including consideration of: (1) direct appropriation of federal funds; (2) use of salmon recovery funds (federal and state) to help pay for the fish flows and fish features of storage projects; (3) use of state bonding capacity. In addition, some members of the task force suggested consideration of the use of power revenue resulting from changes in flow augmentation programs on the Columbia River mainstem.

14. The legislature should consider establishing funding sources for the design and construction of water storage projects, in consideration of the following:
   - Priority for funding should be provided to projects identified in adopted watershed plans or to projects that are part of an approved HCP or other intergovernmental agreement.
   - The funding should promote a cost-share contribution from those who would directly benefit from the storage.
   - The funding should, at a minimum, cover the costs of storage benefits that would accrue to fish recovery and enhancement and to other general public purposes.
   - Prioritize projects that address multiple needs for water supply and/or flood control.
   - The funding should emphasize small or medium-scaled projects using off-channel or underground storage, or projects that enlarge existing storage sites.

15. When considering infrastructure needs, the legislature should consider water storage projects.

Types Of Storage

16. State and local governments should improve utilization of natural aquifer recharge where practical, by prioritizing measures that control increased runoff.

Role of Storage

17. All task force members agree that properly designed and sited storage is one of several tools available to meet the water supply needs of the state. However, the members have differing recommendations on whether or not storage should be considered in conjunction with other water management tools.
    - Some members recommend that water storage projects be pursued as the primary water management tool in most of the state. These members say that storage is the only method that will generate the quantities required to meet the water supply needs.
    - Other members recommend that water storage be developed in conjunction with water conservation, water reuse, water transfers and water acquisition. These members say that these other water management techniques can extend the life of existing storage facilities and reduce the size and cost of new storage facilities.

Fish Passage

18. Fish passage should be addressed consistent with current laws when developing new water storage dams or when making major modifications to existing water storage dams. When assessing basin needs for storage infrastructure, watershed planning groups should evaluate the need for providing fish passage through existing or future storage projects, including evaluating the water supply needed to operate the fish passage facilities and funding to build the passage structures.

19. All task force members agree that major modifications to existing storage dams will involve an evaluation of the needs and opportunities to provide for fish passage. However, members have differing recommendations on whether passage should be restored on all existing storage dams when they undergo major modifications.
    - Some members recommend that restoring fish passage to existing dams should be pursued where it is economically feasible to build the passage, where the fish benefits will warrant this additional investment for a modification project, and where there are available water supplies to operate the passage facilities.
    - Other members recommend that fish passage on existing dams should, in most cases, be restored as a basic requirement for major modification projects.

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

2001 Report to the Legislature

Artificial Storage and Recovery of Ground Water

Progress Report

December 2001

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APPENDIX B

WAC 173-157

and

AQUIFER STORAGE AND RECOVERY REPORT TO LEGISLATURE (2001)

Chapter 173-157 WAC
UNDERGROUND ARTIFICIAL STORAGE AND RECOVERY

Last Update: 1/15/03

WAC SECTIONS

PART I INTRODUCTION

WAC 173-157-010 What is the purpose of this rule? The purpose of this rule is to establish the standards for review of applications for underground artificial storage and recovery projects and, when necessary, to identify options for mitigation of potential adverse impacts to ground water quality or the environment. The rule also outlines the process the department of ecology will use to evaluate applications and issue permits to artificially store water in underground geological formations and subsequently recover it for beneficial use.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-010, filed 1/15/03, effective 2/15/03.]

WAC 173-157-020 What is the authority for this rule? In 2000, the Washington state legislature passed Engrossed Second Substitute House Bill 2867 (E2SHB 2867), which amended chapters 90.03 and 90.44 RCW. This bill expanded the definition of "reservoir" in RCW 90.03.370 to include "any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project." Projects of this type are more commonly known as "aquifer storage and recovery" or "ASR" projects. The legislation directed the department to adopt rules establishing the "standards for review and standards for mitigation of adverse impacts for an underground artificial storage and recovery project." The department of ecology promulgates this rule under the authorities provided in chapter 34.05 RCW and RCW 90.03.370.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-020, filed 1/15/03, effective 2/15/03.]

WAC 173-157-030 To whom does this rule apply? This rule applies to any firm, association, water users' association, corporation, irrigation district, municipal corporation, or anyone else that intends to obtain a reservoir permit to develop an underground artificial storage and recovery project pursuant to RCW 90.03.370. This chapter does not apply to projects utilizing irrigation return flow, or to operational and seepage losses that occur during the irrigation of land, or to water that is artificially stored due to the construction, operation, or maintenance of an irrigation district project, or to projects involving water reclaimed in accordance with chapter 90.46 RCW.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-030, filed 1/15/03, effective 2/15/03.]

WAC 173-157-040 What are the meanings of words and phrases used in this rule? "Aquifer storage and recovery project," "ASR project," or **"underground artificial storage and recovery project"** means those projects where the intent is to artificially store water in an underground geological formation through injection, surface spreading and infiltration, or other department-approved method, and to make subsequent use of the stored water.

"Artificial recharge" means either controlled subsurface addition of water directly to the aquifer or controlled application of water to the ground surface for the purpose of replenishing the aquifer.

"Beneficial use" includes, among others, uses for domestic, stock watering, industrial, commercial, agricultural, irrigation, hydroelectric power production, mining, fish and wildlife maintenance and enhancement, recreational, thermal power production, municipal, and preservation of environmental and aesthetic values.

"Confined aquifer" means an aquifer where the permeability of the beds above and below the aquifer is significantly lower than the aquifer itself.

"Department" means the Washington department of ecology.

"DOH" means the Washington department of health.

"Hydraulic continuity" means the existence of some degree of interconnection between two or more sources of water, either surface water and ground water or two ground water sources.

"Hydrogeology" means the study of the geologic aspects of subsurface waters.

"Normative flow" means a flow that resembles the natural flow sufficiently enough to sustain all life stages of several species native to the state of Washington, including salmonid populations.

"Permeability" means the ability for a fluid to be transmitted in porous rock, sediment, or soil.

"Piezometric elevation" means the static level to which the water from a given aquifer will rise under its full head.

"RCW" means the Revised Code of Washington.

"Receiving aquifer" or **"reservoir"** means any portion of a naturally occurring underground geological formation in which the source water will be collected and stored for a future beneficial use as part of an ASR project.

"Reservoir permit" means a permit to artificially store water in underground geological formations and subsequently recover it for beneficial use.

"SEPA" means the State Environmental Policy Act, chapter 43.21C RCW.

"Secondary permit" means a permit for the appropriation of ground water which was artificially stored in underground geological formations for subsequent beneficial use.

"Source water" means water that will be stored in a receiving aquifer.

"Stored water" means water that has been stored in a receiving aquifer pursuant to a reservoir permit issued in accordance with the provisions of this chapter.

"Transmissivity" is a measure of the rate which water passes through the geologic material within an aquifer.

"UIC" means the Underground Injection Control program, which was created by the U.S. Environmental Protection Agency pursuant to federal legislation (the Safe Drinking Water Act) and is administered by the department's water quality program.

"Vadose zone" means within the zone of aeration, i.e., water vapor above the saturation zone within an aquifer.

"WAC" means Washington Administrative Code.

"WDFW" means the Washington department of fish and wildlife.

"You" and **"I"** means any firm, association, water users' association, corporation, irrigation district, municipal corporation, or anyone else that intends to obtain a reservoir permit to develop an underground artificial storage and recovery project pursuant to RCW 90.03.370.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-040, filed 1/15/03, effective 2/15/03.]

WAC 173-157-050 What authorization is required for an ASR project? The following permits or authorizations are required:

(1) **Water rights to source waters.**

(a) Any source water you use as part of a project by diverting from a state watercourse or withdrawing state ground waters, must be obtained under a valid water right permit, certificate, or registered water right claim.

(b) The underlying water right specifies authorized uses. Any proposal to use stored water for different uses will require issuance of a secondary permit.

(2) **Reservoir permit.** When proposing to collect and store water in a naturally occurring underground geological formation for subsequent use as part of an ASR project, you must apply for a reservoir permit in accordance with the provisions of RCW 90.03.370 (2)(a).

(3) **Secondary permit.** You must apply for a secondary permit in accordance with the provisions of RCW 90.03.370 if you propose to apply the water stored in a reservoir to a beneficial use, except that you are not required to apply for a secondary permit if you already have a water right for the source water that authorizes the proposed beneficial use.

(4) **UIC registration.** All UIC wells to be utilized as part of an ASR project must be registered with the department in accordance with the provisions of chapter 90.48 RCW. Additionally, the construction and technical aspects of the injection wells must abide by UIC regulations as stated in chapter 173-160 WAC.

(5) **NPDES permit.** Discharges to surface water must meet water quality standards set forth in chapter 173-201A WAC to protect aquatic life.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-050, filed 1/15/03, effective 2/15/03.]

PART II APPLICATION PROCESS

WAC 173-157-100 What should I know before I apply? (1) You must assess potential impacts to the hydrogeologic system and the environment prior to submitting your application. If your application does not describe the general setting and conditions with sufficient information for the department to assess the application, the department may require you to perform a detailed feasibility study. This feasibility study should reduce uncertainty of the impacts, and better quantify the available storage capacity of the aquifer.

(2) To further reduce uncertainty, you must design a pilot phase for the project, to be used to collect data that will be used to validate the conceptual model, monitor efficacy, and adjust the monitoring, operation, and mitigation plans based upon results. The duration of this phase will be determined by the complexity of the project and stated within the reservoir permit.

(3) You may schedule a preapplication meeting with the department to discuss the project plan and likely requirements for monitoring and mitigation.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-100, filed 1/15/03, effective 2/15/03.]

WAC 173-157-110 What types of information will I need to provide as part of my application? Your application for an ASR project must contain, at a minimum:

(1) A description (conceptual model) of the hydrogeologic system (see WAC 173-157-120) prepared by a hydrogeologist licensed in the state of Washington.

(2) A project operation plan (see WAC 173-157-130) with a description of the pilot and operational phases of the ASR project prepared by an engineer or geologist licensed in the state of Washington.

(3) A description of the legal framework (see WAC 173-157-140) for the proposed project.

(4) An environmental assessment and analysis (see WAC 173-157-150) of any potential adverse conditions or potential impacts to the surrounding ecosystem(s) that might result from the project, along with a plan to mitigate such conditions or impacts.

The environmental assessment will establish whether a determination of nonsignificance or an environmental impact statement is required per SEPA regulations.

(5) A project mitigation plan (see WAC 173-157-160), if required.

(6) A project monitoring plan (see WAC 173-157-170).

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-110, filed 1/15/03, effective 2/15/03.]

WAC 173-157-120 What must I include in the hydrogeologic system description? Your hydrogeologic system description must include a conceptual hydrogeologic model that describes:

(1) The aquifer targeted for storage, to include at a minimum estimates for:

(a) Lateral and vertical extent;

(b) Whether the aquifer is confined or unconfined;

(c) Permeability;

(d) Total storage volume available;

(e) Effective hydraulic conductivity;

(f) Transmissivity; and

(g) Potential for physio-chemical changes in the aquifer or vadose zone as a consequence of recharge.

(2) The estimated flow direction(s) and rate of movement.

(3) The anticipated changes to the ground water system due to the proposed ASR project.

(4) The estimated area that could be affected by the project.

(5) The general geology in the vicinity of the proposed project, including stratigraphy and structure.

(6) The locations of existing documented natural hazards that could be affected or exacerbated by the project, such as landslide-prone areas or areas of subsidence along with a plan to mitigate such conditions or impacts.

(7) The locations of surface waters such as springs, creeks, streams or rivers that could be affected by the ASR project.

(8) The locations of all wells or other sources of ground water of record within the area affected by the project.

(9) The chemical and physical composition of the source water(s) and their compatibility with the naturally occurring waters of the receiving aquifer.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-120, filed 1/15/03, effective 2/15/03.]

WAC 173-157-130 What must I include in the project operation plan? Your project operation plan should include, at a minimum, the following information:

(1) The quantity and times of year source water is available for recharge.

(2) The proposed rate of injection and withdrawal of water.

(3) The length of time the water is proposed to be stored.

(4) The location, number, and capacity of proposed recharge wells or infiltration basins, and recovery facilities.

(5) Any variability in quality and reliability of the source water.

(6) A description of any water treatment method(s) you will use at the time of injection and recovery to ensure compliance with the water quality standards set forth in chapter 173-200 WAC, as well as the department's antidegradation policy.

(7) Any plans to discharge ASR water to a surface body should include information on the quantity, timing, duration, and water quality parameters such as chlorine, pH and dissolved oxygen of the ASR discharge water.

(8) Any operation and maintenance plans to discharge ground water and suspended sediment from the ASR well shall provide information on the quantity, duration, quality, and means of discharge.

(9) Destination(s) and permitting for water used for operation and maintenance (e.g., flushing water).

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-130, filed 1/15/03, effective 2/15/03.]

WAC 173-157-140 What must I include in the description of the legal framework? Your description of the legal framework should include, at a minimum:

(1) Documentation of the water rights for the source waters intended to be stored for the proposed ASR project.

(2) A list of other water rights within the ASR project area.

(3) Instream flows established by the department or stream closures in the vicinity of the point of diversion/withdrawal of the source water and/or within the ASR project area.

(4) Ownership and control of any facilities to be used for the proposed project.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-140, filed 1/15/03, effective 2/15/03.]

WAC 173-157-150 What must I include in the environmental assessment and analysis? Your environmental assessment and analysis must, at a minimum, describe:

(1) The environment within the ASR project area, including:

(a) Proximity to contaminated areas;

(b) Present and prior land use(s) within the ASR project area;

(c) Location(s) of historical or existing wetland habitat(s);

(d) Location(s) of historical or existing flood plain(s);

(e) Location(s) of historical or existing surface water body or spring, including documented:

(i) Base flows;

(ii) Seven-day low flows;

(iii) Maximum flows.

(2) Adverse impacts to the surrounding environment by the ASR project, including, but not limited to:

(a) Slope stability;

(b) Wetland habitat;

(c) Flood plain;

(d) Ground deformation;

(e) Surface water body or spring.

(3) If an environmental assessment has already been performed for the purposes of this specific ASR project, the application may simply refer to that documentation and need not repeat that analysis.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-150, filed 1/15/03, effective 2/15/03.]

WAC 173-157-160 What must I include in the project mitigation plan? Your project mitigation plan, if necessary, must be reviewed and approved or prepared by an appropriately experienced engineer licensed in the state of Washington. The mitigation plan shall prescribe actions to be taken to prevent adverse impacts to the environment and methods for evaluation of the effectiveness of these actions.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-160, filed 1/15/03, effective 2/15/03.]

WAC 173-157-170 What must I include in the project monitoring plan? Your project monitoring plan, which will be utilized to evaluate and verify the assumptions in the conceptual model, during the pilot and operational phases, must include the following:

(1) Proposed time intervals for sampling and subsequent reporting.

(2) Descriptions of measurement methodology, threshold values, and evaluation techniques for the following criteria:

(a) The quality of the source and receiving waters. This information must be provided for the period or periods of the year when the water will be stored. Testing must be done by a laboratory certified by either the department or DOH.

(b) The actual quantity of water injected.

(c) Changes in ground water piezometric elevations in the receiving aquifer.

(d) The percentage of the initial amount of stored water that is recoverable after varying lengths of storage time to validate the estimates of the amount of stored water that is actually recovered.

(e) Data necessary to evaluate the effectiveness of required mitigation.

(f) Other data you or the department determine necessary for monitoring the ASR project and adverse impacts.

You must provide a report of the monitoring data, at least annually, to the department. Based on the complexity of the project, the department may require you to comply with a more frequent reporting schedule. The required reporting frequency will be specified in the reservoir permit.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-170, filed 1/15/03, effective 2/15/03.]

WAC 173-157-180 Where do I submit my application for a reservoir and/or secondary permit? You must submit your application to the ecology water resources regional office that serves the area where your project would be located. Please refer to the department's website for telephone numbers.

(1) The Northwest regional office serves Whatcom, Island, Kitsap, San Juan, Skagit, Snohomish, and King counties.

(2) The Southwest regional office serves Clallam, Jefferson, Grays Harbor, Mason, Thurston, Pierce, Pacific, Lewis, Wahkiakum, Cowlitz, Clark, and Skamania counties.

(3) The Central regional office serves Okanogan, Chelan, Douglas, Kittitas, Yakima, Klickitat, and Benton counties.

(4) The Eastern regional office serves Ferry, Stevens, Pend Oreille, Lincoln, Spokane, Grant, Adams, Whitman, Franklin, Walla Walla, Columbia, Garfield, and Asotin counties.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-180, filed 1/15/03, effective 2/15/03.]

PART III APPLICATION REVIEW PROCESS

WAC 173-157-200 How will the department issue reservoir permits and/or secondary permits for ASR projects? (1) The department will process applications for permits for ASR projects in accordance with the provisions of RCW 90.03.250 through 90.03.320, RCW 90.03.370, chapter 173-152 WAC and this chapter. The department shall expedite processing applications for those projects that:

(a) Will not require a new water right for diversion or withdrawal of the water to be stored;

(b) Are adding or changing one or more purposes of use for the stored water;

(c) Are adding to the storage capacity of an existing reservoir; or

(d) Are applying for the secondary permit to secure use of water stored in an existing reservoir.

(2) The department shall give strong consideration to the overriding public interest in its evaluation of compliance with ground water quality protection standards.

(3) Any application considered under this chapter that may impact surface waters will be subject to review by the department, WDFW, DOH, and the appropriate Indian tribe(s), specifically to ensure that the following do not occur during ASR project injections or withdrawals:

(a) Alteration of the normative hydrograph which may result in adverse impacts to fish;

(b) Detrimental changes in temperature, nutrient, heavy metals, hydrocarbon, or other deleterious material levels during critical spawning and rearing periods;

(c) Disruption of natural downwelling or upwelling within stream during critical spawning and rearing periods; or

(d) Saturation of stream bank which could lead to erosion, bank failure, and excess sedimentation entering the stream which can alter stream chemistry, flow, and bed morphology.

Each ASR project application will be subject to public notice and comment per RCW 90.03.280. The department will consider any comments by the reviewers in evaluating the application.

(4) The department may issue a conditioned permit to prevent any long-term changes to the aquifer, or other adverse impacts to the environment. The conditioning will provide for a pilot phase of the project, to be used to collect data, monitor efficacy, evaluate the effectiveness of any mitigation plan approved under WAC 173-157-150, and adjust the ASR project or mitigation plan based upon pilot phase results.

(5) Permits will contain a schedule for:

(a) Development and completion of the project;

(b) Monitoring and reporting during the pilot and operational phases of the project.

(6) The department can, upon a showing of good cause, issue extensions for the permit in accordance with the provisions of RCW 90.03.320.

(7) Once sufficient information is developed and provided to the department to verify that the project is viable and the requirements of RCW 90.03.330 have been met, the department will issue proper documentation for the reservoir and secondary permit, if any, with the priority date or dates based on the underlying source water right.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-200, filed 1/15/03, effective 2/15/03.]

WAC 173-157-210 Can I appeal a decision made by the department on my application? Yes, all final written decisions of the department made on applications pursuant to this chapter are subject to review by the pollution control hearings board in accordance with the provisions of chapter 43.21B RCW if you comply with the requirements for appeal established by statute and rule.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-210, filed 1/15/03, effective 2/15/03.]

WAC 173-157-220 Can this regulation be reviewed or updated? Yes, the department may initiate a review of the rules established in this chapter whenever new information, changing conditions, statutory modifications, or other factors make it necessary or desirable to consider revisions.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-220, filed 1/15/03, effective 2/15/03.]

WAC 173-157-230 Where can I obtain copies of ecology statutes and regulations? Copies of statutes and regulations cited in this chapter may be obtained from the public records office at the department's headquarters office. You may also obtain copies by downloading documents from the department's internet site at http://www.ecy.wa.gov or copies of rules of the pollution control hearings board from the pollution control hearings board's internet site at http://www.eho.wa.gov.

[Statutory Authority: RCW 90.03.370 (2)(b) and 90.44.460. 03-03-081 (Order 02-06), § 173-157-230, filed 1/15/03, effective 2/15/03.]

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

2001 Report to the Legislature Artificial Storage and Recovery of Ground Water

Progress Report

by
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Olympia, Washington 98504-7775

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INTRODUCTION

During its 2000 session, the Washington State Legislature extended the Department of Ecology's authority to issue reservoir permits under the state surface water code to cover projects designed to store water in underground geological formations for future recovery and use. Previously, Ecology only had authority to issue permits for typical surface water reservoirs.

The measure, Engrossed Second Substitute House Bill 2867, E2SHB-2867 (see **Appendix A** for full bill text), defines these types of water storage projects as "artificial storage and recovery", or "aquifer storage and recovery" (ASR) projects as they are commonly called. Under E2SHB-2867, Ecology is required to provide a report to the Legislature by December 31, 2001, outlining its standards for review and mitigation and the status of any applications that have been filed for such projects. This report is submitted in fulfillment of that statutory requirement.

BACKGROUND

Aquifer storage and recovery projects have been legally possible in the state of Washington since the first days of the state ground water code, Ch. 90.44 RCW, which was enacted in 1945. Early ASR projects came about more by accident than by design, particularly when irrigation districts realized that they were, in effect, recharging water table aquifers through canal leakage. The districts recognized the value of the stored water and sought ways to access that water.

Groundwater management sub-areas

The process developed, and outlined in RCW 90.44.130, allows Ecology to control withdrawals of ground water through the creation of ground water management sub-areas. Ground water management sub-areas, designed for distinct bodies of ground water, can be created either by the agency directly or by petition from local entities.

Prior to the formal designation of a sub-area, Ecology is required to publish notice of its intention and make findings of fact on the designation and any objections.

Within 90 days after a ground water management sub-area is designated, anyone claiming ownership of artificially-stored ground waters must file a declaration, including providing evidence that no water withdrawn is public ground water. If necessary, a claimant may apply for an extension after 90 days. Claimants to artificially-stored ground water subsequent to designation can file similar declarations within three years and, if necessary, apply for extensions of up to two years. Those withdrawing artificially-stored ground water must file similar declarations within 90 days following the earliest withdrawal.

Because the process for declaring ground water management sub-areas was relatively cumbersome and not well suited to meet their needs, ASR proponents approached the 2000 Legislature to propose an alternative process. The new process was created by E2SHB-2867.

The New Process

The process created by the new ASR legislation expands the definition of "reservoir" to include "any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project." A person wishing to use any water stored in a reservoir must file an application for a secondary permit and provide evidence that an agreement exists with the owners of the reservoir to secure enough water for the secondary permit. Ecology can now issue permits for the storage of water in "natural underground formations" by means of injection, surface spreading and infiltration, or other Ecology-approved methods, as part of an ASR project.

A proposed ASR project would have to meet standards for review and mitigation established by Ecology rule. Those elements to be addressed include:

- Aquifer vulnerability and hydraulic continuity.
- Potential impairment of existing water rights.
- Geotechnical impacts and aquifer boundaries and characteristics.
- Chemical compatibility of surface and ground waters.
- Recharge and recovery treatment requirements.
- System operation.
- Water rights and ownership of water stored for recovery.
- Environmental impacts.

Analysis of each proposed ASR project and geological formation must be conducted through studies initiated by the applicant. The studies will then be reviewed by Ecology. Certain types of projects are exempted from the new law, including operational and seepage losses from irrigation projects, irrigation return flows, water artificially stored as part of irrigation district projects, reclaimed water, or artificially stored water that may be claimed when a groundwater sub-area is established. Existing law governing the issuance of permits to appropriate or withdraw waters remains unchanged.

IMPLEMENTATION OF THE LEGISLATION

Shortly after the legislation took effect, Ecology convened a technical advisory group to determine how best to implement the new legislation. The group included membership from a broad spectrum of interests such as water utilities, local governments, consultants, academics, and state, local, and tribal agencies.

Between July 2000 and January 2001, the advisory group held six meetings. Topics included:

- Background information on the history of artificial storage of ground water in Washington.
- General Washington water law.
- The water-right permitting process.
- Specific legal issues pertaining to ASR projects.

Committee members working on various ASR projects also presented information about their particular projects, which range in size from small projects intended to serve the needs of a single business to large ones that could potentially constitute a major source of water for one or more regional water suppliers.

The advisory committee had completed a draft of the regulation, which was being circulated for review and comment in January 2001, just as Washington entered the state's second-worst drought in recorded history. Therefore, work on the rule was suspended so Ecology staff could work on drought-related issues. The 2001 drought declaration expired on December 31, 2001, so Ecology is resuming work on the ASR regulation.

Framework

In considering the standards to be met by ASR projects, the advisory group agreed that four different aspects should be analyzed prior to permitting:

- **Hydrogeologic** — how water will be stored underground in a reservoir and be available for later recovery and how that operation would affect the area where the recharge and storage will be developed.
- **Operational** — how the project will be operated and over what time cycle.
- **Environmental** — potential effects a proposed project might have on environmental conditions in the vicinity.
- **Legal** — how other water right holders and water users might be affected by a specific project.

The **hydrogeologic analysis** is the primary analysis to be conducted in conjunction with a proposed ASR project. It would, at least initially, include the development of a conceptual hydrogeologic model that identifies the general geological and hydrogeological conditions in the area where the project is proposed. This would include identifying such features as the geologic materials and their thicknesses, structural information such as faults, fractures, or synclines, and other relevant information that would help to describe the general geologic setting in the vicinity of the project. General ground water information should be part of this analysis as well, including such elements as the water bearing units and their hydraulic properties, the general ground water flow system, and any ground water boundaries. The size of a proposed ASR project will have a bearing on the level of detail needed and the amount of investigation required to ascertain its feasibility. Larger and more complex projects may well require considerably more study, including the development of sophisticated computer models as part of the analysis.

The **operational analysis** would describe how the project, once completed, would function. This analysis would include the major elements of the project operation such as the means of recharge (e.g. injection well or spreading basin), the location, number, and capacity of proposed recharge facilities, the source water quality and the means of treatment and disinfection of the source and recovered waters, the timing of both the recharge operations and the use of the stored water, and the rates of recharge and recovery.

The **environmental analysis** would describe probable and potential environmental effects that might result from the ASR project. Possible effects identified in the conceptual model would be considered and assessed, including changes to local water bodies such as wetlands and springs, changes to water levels and water quality in nearby wells, changes in slope stability, and possible subsidence or ground heave. Some of this analysis could be conducted through compliance with the State Environmental Policy Act (SEPA) as part of completing an environmental checklist or preparing an environmental impact statement. The size of the project will have a bearing on the level of review necessary under SEPA.

The **legal analysis** would identify and assess the significance of any potential legal issues associated with a proposed project. This would include identification of any wells completed in the aquifer and water rights connected with them. It would also address any changes necessary to the ASR proponent's water rights to cover the project, including changes to water rights for the source waters, and any legal issues associated with the proposed recharge area, in terms of land use activities, land ownership, and possible adverse environmental effects.

Monitoring plan

A key component of the framework outlined above is the implementation of an appropriately-designed and scaled monitoring plan. A well-designed plan should identify any elements that need additional analysis. The design of a monitoring plan needs to be carefully tailored for each specific project to ensure the appropriate factors are evaluated. The monitoring plan should also provide an early-warning mechanism to detect adverse impacts to the physical, chemical, or biological environments that were not predicted by the conceptual model. The advisory group even discussed making the results of the monitoring plan available to the public as a way to demonstrate compliance with the applicable regulations and reduce concerns about project effects.

Phased approach

Central to the framework identified above is the notion of a phased approach to the necessary investigations, moving from the general to the specific as needed. As shown in **Appendix B**, the scale and scope of potential ASR projects varies greatly. While some are sufficiently large and complex enough to warrant thorough investigation from the start, similar expectations for a smaller project might render it infeasible. Therefore, advisory group members agreed that some form of phased approach made the most sense for all projects. A proponent of a project could conduct preliminary studies and, based on the results of those studies, work with Ecology to determine the need for more detailed investigations. This would also allow the proponent to then make an informed decision about the likely viability of the project.

A phased approach will also help identify possible problems before they pose a threat to the project, other parties, or the environment. Even the most sophisticated analytical techniques can still fail to identify or predict potential problems. The phased approach methodically expands the need for investigations if any problems are found. Finally, because the largest proposed ASR projects will take a long time to complete, this approach will allow necessary investigations to be conducted over time, rather than placing an unmanageable burden on proponents at the start.

ISSUES IDENTIFIED

Changes of purpose of use

Most ASR projects already are operating under one or more water rights, so new water rights are usually not an issue. However, the question arose about whether storage needed to be added as a new purpose of use for the source waters if it was not part of the original water right. This could have posed a serious difficulty since it would have required changes to existing rights. If those rights were inchoate surface water rights, as was the case with some of the proposed projects, adding storage as a purpose of use would not be allowed under current state law (RCW 90.03.380).

The Attorney General's office subsequently advised Ecology that, in itself, storage is not a purpose of use of water. Rather it is merely a means to provide water for the true purposes of use identified in the secondary permit. Therefore, in applying for a reservoir permit under RCW 90.03.370, there would be no need to change the purpose of use of the water to add storage.

Preliminary vs. temporary permits

ASR projects usually require a significant amount of testing to determine their feasibility. Generally, this can be accomplished over a relatively short period of time for smaller projects but larger projects may require years before the full operational capacity of the project can be completely evaluated. Ecology normally authorizes the necessary drilling and testing that needs to take place to determine the feasibility of a new water project through the issuance of a preliminary permit. A preliminary permit requires the applicant to make "such surveys, investigations, studies, and progress reports as the department deems necessary."

The difficulty arises because a preliminary permit is normally issued for a period of three years or less, and can only be extended to a maximum of five years and then only with the approval of the governor. Failure to comply with the conditions of the preliminary permit and the application upon which it is based results in the automatic cancellation of the application. Given the longer time frames necessary to evaluate the viability of some ASR projects, the relatively short duration of a preliminary permit really is an inappropriate and inadequate tool for authorizing the initial investigations.

Presently, the interim solution is to allow initial testing and evaluation of proposed projects to be undertaken under temporary permits, as was done for the city of Seattle's Highline well field. However, the use of temporary permits is only appropriate for projects where the water rights to the source waters are secured and available.

Single line for new applications and reservoir permits

Applications for ASR projects, which require reservoir and secondary permits, must go into the same line as applications for new water right permits. This is probably a vestige of the early days of the water code, when new rights were needed for virtually all new water projects, including storage projects. Applications for new permits must be investigated to answer questions about use and availability of water and effects on other rights and the public interest, often a time-consuming process. In most cases, ASR projects have already secured the necessary water rights for their source waters and simply need to have the storage and recovery elements of the projects evaluated through the permitting process. Some projects could be moved forward in the permitting line if they met the criteria identified in Ch. 173-152 WAC, the *Hillis* rule, but many projects will not meet those criteria. The obvious solution would be the creation of a third line for such ASR projects.

Introduction of disinfection byproducts

Most of the ASR projects proposed thus far are for public water systems and would use treated drinking water as their source waters. However, some of the byproducts of disinfection exceed the state ground water quality standards, Ch. 173-200 WAC. Chlorine, which is the standard method of drinking water disinfection, can react with organic materials that occur in ground water to produce carcinogenic chemicals. While any long-term health and environmental effects from the introduction of those byproducts are extremely unlikely, their removal would be quite costly. Nonetheless, their introduction into the ground water system runs contrary to the antidegradation policy of the ground water quality standards.

Some of the options that were considered to address this problem included the use of alternative points of compliance for determining compliance with ground water standards, possible alteration of the standards to allow any disinfection byproducts to only meet Maximum Contaminant Levels, or the application of the "overriding consideration of the public interest" and "all known, available, and reasonable methods of prevention, control, and treatment" provisions of the water quality standards. The technical advisory group has yet to agree on the most appropriate option to pursue. Fortunately, public water systems are beginning to make the transition to different methods of disinfection, so the problem will gradually cease to exist.

The natural discharge of stored waters

Some advisory group members expressed interest in using ASR projects to augment late-season streamflows by allowing stored water to naturally discharge to a stream, rather than actually withdrawing the water for that purpose. Currently, none of the projects under consideration in Washington would be for this purpose.

Projects of this type are normally referred to as "artificial recharge" projects and are specifically authorized in several western states. However, Washington law presently makes no provisions for such projects. Advisory group members differed regarding whether such projects would, or should, be possible under the new statute. At this point, the issue is undecided, although the prevalent view is that if the Legislature would like to endorse such projects, some change to the statute should probably be considered.

Priority dates

State-issued water rights are assigned a priority date when the application is filed. Applications for ASR permits can only be filed after the effective date of E2SHB-2867. Thus, permits for ASR projects would be junior to most other water rights. In some instances, ASR projects would be junior to established instream flows. There is concern that an ASR project subject to an established instream flow could not operate when flows were not being met. This could, conceivably, prevent the use of the project at a time when it would be most valuable. This potential exists despite the strong chance that the rights for the source waters for ASR projects may be senior to those established instream flows. Advisory group members were uncertain about the likelihood of subjecting ASR projects to instream flows, but the issue remains unresolved.

CONCLUSIONS

ASR has been demonstrated to be a successful way of augmenting water supplies in areas where it is technically and economically feasible. As such, ASR can help address future water supply needs in Washington. ASR projects can vary significantly in terms of size and purpose. The key to making ASR successful in Washington is to provide a program for authorizing ASR projects that provides the necessary flexibility to accommodate the different types of projects while simultaneously assuring the health and safety of the public and the state's environment are adequately protected.

As the technical advisory group discovered, there are several legal and technical obstacles that need to be resolved before the potential of ASR projects will fully be realized in Washington State. Nonetheless, work on possible ASR projects needs to continue, particularly as Washington confronts the dilemma of how to accommodate the future water needs of its population and industry.

FOR MORE INFORMATION

If you have questions or would like further information about aquifer storage and recovery in Washington, please contact Doug McChesney at (360) 407-6647 (e-mail: mcc461@ecy.wa.gov).

APPENDIX A

ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867

CERTIFICATION OF ENROLLMENT

ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867

Chapter 98, Laws of 2000

56th Legislature
2000 Regular Session

UNDERGROUND WATER STORAGE

EFFECTIVE DATE: 6/8/00

Passed by the House March 6, 2000
Yeas 98 Nays 0

CLYDE BALLARD
Speaker of the House of Representatives

~~FRANK CHOPP~~
Speaker of the House of Representatives

Passed by the Senate March 1, 2000
Yeas 46 Nays 0

BRAD OWEN
President of the Senate

Approved March 24, 2000

GARY LOCKE
Governor of the State of Washington

CERTIFICATE

We, Timothy A. Martin and Cynthia Zehnder, Co-Chief Clerks of the House of Representatives of the State of Washington, do hereby certify that the attached is **ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867** as passed by the House of Representatives and the Senate on the dates hereon set forth.

CYNTHIA ZEHNDER
Chief Clerk

~~TIMOTHY A. MARTIN~~
Chief Clerk

FILED

March 24, 2000 - 2:49 p.m.

Secretary of State
State of Washington

ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867

Passed Legislature - 2000 Regular Session

AS AMENDED BY THE SENATE

State of Washington **56th Legislature** **2000 Regular Session**

By House Committee on Agriculture & Ecology (originally sponsored by Representatives Linville, G. Chandler, Miloscia, Mitchell, Koster and Cooper)

Read first time 02/07/2000. Referred to Committee on .

AN ACT Relating to underground water storage; amending RCW 90.44.035 and 90.03.370; and adding a new section to chapter 90.44 RCW.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF WASHINGTON:

NEW SECTION. **Sec. 1.** A new section is added to chapter 90.44 RCW to read as follows:

The legislature recognizes the importance of sound water management. In an effort to promote new and innovative methods of water storage, the legislature authorizes the department of ecology to issue reservoir permits that enable an entity to artificially store and recover water in any underground geological formation, which qualifies as a reservoir under RCW 90.03.370.

Sec. 2. RCW 90.44.035 and 1987 c 109 s 107 are each amended to read as follows:

For purposes of this chapter:

(1) "Department" means the department of ecology;

(2) "Director" means the director of ecology;

(3) "Ground waters" means all waters that exist beneath the land surface or beneath the bed of any stream, lake or reservoir, or other body of surface water within the boundaries of this state, whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves. There is a recognized distinction between natural ground water and artificially stored ground water;

(4) "Natural ground water" means water that exists in underground storage owing wholly to natural processes; ((~~and~~))

(5) "Artificially stored ground water" means water that is made available in underground storage artificially, either intentionally, or incidentally to irrigation and that otherwise would have been dissipated by natural ((~~waste~~)) processes; and

(6) "Underground artificial storage and recovery project" means any project in which it is intended to artificially store water in the ground through injection, surface spreading and infiltration, or other department-approved method, and to make subsequent use of the stored water. However, (a) this subsection does not apply to irrigation return flow, or to operational and seepage losses that occur during the irrigation of land, or to water that is artificially stored due to the construction, operation, or maintenance of an irrigation district project, or to projects involving water reclaimed in accordance with chapter 90.46 RCW; and (b) RCW 90.44.130 applies to those instances of claimed artificial recharge occurring due to the construction, operation, or maintenance of an irrigation district project or operational and seepage losses that occur during the irrigation of land, as well as other forms of claimed artificial recharge already existing at the time a ground water subarea is established.

Sec. 3. RCW 90.03.370 and 1987 c 109 s 93 are each amended to read as follows:

(1) All applications for reservoir permits shall be subject to the provisions of RCW 90.03.250 through 90.03.320. But the party or parties proposing to apply to a beneficial use the water stored in any such reservoir shall also file an application for a permit, to be known as the secondary permit, which shall be in compliance with the provisions of RCW 90.03.250 through 90.03.320. Such secondary application shall refer to such reservoir as its source of water

supply and shall show documentary evidence that an agreement has been entered into with the owners of the reservoir for a permanent and sufficient interest in said reservoir to impound enough water for the purposes set forth in said application. When the beneficial use has been completed and perfected under the secondary permit, the department shall take the proof of the water users under such permit and the final certificate of appropriation shall refer to both the ditch and works described in the secondary permit and the reservoir described in the primary permit.

(2)(a) For the purposes of this section, "reservoir" includes, in addition to any surface reservoir, any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project. To qualify for issuance of a reservoir permit an underground geological formation must meet standards for review and mitigation of adverse impacts identified, for the following issues:

(i) Aquifer vulnerability and hydraulic continuity;

(ii) Potential impairment of existing water rights;

(iii) Geotechnical impacts and aquifer boundaries and characteristics;

(iv) Chemical compatibility of surface waters and ground water;

(v) Recharge and recovery treatment requirements;

(vi) System operation;

(vii) Water rights and ownership of water stored for recovery; and

(viii) Environmental impacts.

(b) Standards for review and standards for mitigation of adverse impacts for an underground artificial storage and recovery project shall be established by the department by rule. Notwithstanding the provisions of RCW 90.03.250 through 90.03.320, analysis of each underground artificial storage and recovery project and each underground geological formation for which an applicant seeks the status of a reservoir shall be through applicant-initiated studies reviewed by the department.

(3) For the purposes of this section, "underground artificial storage and recovery project" means any project in which it is intended to artificially store water in the ground through injection, surface spreading and infiltration, or other department-approved method, and to make subsequent use of the stored water. However, (a)

this subsection does not apply to irrigation return flow, or to operational and seepage losses that occur during the irrigation of land, or to water that is artificially stored due to the construction, operation, or maintenance of an irrigation district project, or to projects involving water reclaimed in accordance with chapter 90.46 RCW; and (b) RCW 90.44.130 applies to those instances of claimed artificial recharge occurring due to the construction, operation, or maintenance of an irrigation district project or operational and seepage losses that occur during the irrigation of land, as well as other forms of claimed artificial recharge already existing at the time a ground water subarea is established.

(4) Nothing in this act changes the requirements of existing law governing issuance of permits to appropriate or withdraw the waters of the state.

(5) The department shall report to the legislature by December 31, 2001, on the standards for review and standards for mitigation developed under subsection (3) of this section and on the status of any applications that have been filed with the department for underground artificial storage and recovery projects by that date.

Passed the House March 6, 2000.
Passed the Senate March 1, 2000.
Approved by the Governor March 24, 2000.
Filed in Office of Secretary of State March 24, 2000.

Appendix B
Summary of major ASR projects in Washington

Compiled from submitted material by Doug McChesney.

Appendix B: Summary of major ASR projects in Washington

Cities of Kennewick and Richland

Together, the cities of Kennewick and Richland are evaluating the feasibility of ASR as part of an overall water resources plan to meet future water supply needs. Part of the plan would use Richland's existing Willowbrook well, which has mostly been used as an emergency backup when the city's primary water sources have experienced elevated temperatures.

Groundwater from the Willowbrook well contains hydrogen sulfide and methane that cause taste and odor problems. Due to these water quality conditions, Kennewick and Richland would like to determine whether ASR can improve well water quality and allow the cities to use the well more often without customer complaints.

Under the ASR proposal, Columbia River water from the cities' treatment plants would be recharged into the Wanapum Basalt aquifer using the Willowbrook well. The length of the storage period as well as the percentage of recharged water recovered would vary, depending on the hydraulic properties of the aquifer, the physical and chemical changes to the water during storage, and the length of demand.

The overall objective would be to design a reliable system to maximize the recovery of recharge water while providing consistent water quality to the municipalities' customers. Development of the Richland ASR appears to be feasible, based on an evaluation of new and existing information, provided the Willowbrook well:

- Is completed in a moderately transmissive portion of a basalt aquifer that cannot impact surface water.
- Meets state well construction standards and is equipped with a pump that can be easily modified for ASR operations.
- Is connected with the city of Richland distribution system so recharge water can be easily conveyed to the well.
- Does not seriously affect the few major users of groundwater from the basalt aquifer in the vicinity of the well.

However, there are also some factors that need to be addressed before the Richland ASR can move forward. These include:

- Groundwater temperatures need to be reduced sufficiently.
- Detectable levels of methane and hydrogen sulfide need to be low enough.
- The presence of disinfection by-products in the recharge water, sometimes at levels higher than current state water quality (anti-degradation) standards, needs to be addressed.

Permitting status — The feasibility study was just completed and the cities have yet to submit any applications for reservoir and secondary permits.

Lakehaven Utility District

The Lakehaven Utility District, located in Federal Way, has one operational ASR well that has been used as a pilot since 1991. The district is planning additional ASR wells as part of their Optimization of Aquifer Storage for Increase Supply (OASIS) project. The Federal Way area, like nearly all Western Washington, receives most of its precipitation between October and April when water demand is relatively low. The OASIS project is intended to operate seasonally, storing excess winter water from either ground or surface water sources and making it available between May and September when customer demand is at its peak and regional precipitation at its lowest.

Currently, the district's source water comes from the Redondo-Milton Channel aquifer which lies above the Mirror Lake storage aquifer. The shallower aquifer provides natural recharge to the storage aquifer and is more susceptible to variations in seasonal precipitation. During wet years, excess water from the channel aquifer recharges the storage aquifer. In drier years, the channel aquifer is supplemented with water from the Mirror Lake aquifer.

In the future, excess winter surface water will be available as recharge to the storage aquifer, allowing the storage aquifer to supplement high and higher summer demands both locally and regionally. The source of the winter recharge water would come primarily from the Green and Cedar rivers.

The Mirror Lake aquifer has an estimated usable storage volume of 29,000 acre-feet. It consists primarily of coarse sand and gravels with aquitards above and below the aquifer. Wells have been screened from approximately 100 feet above sea level to about 200 below sea level with an average screen length of around 60 feet. The raw water quality meets both primary and secondary drinking-water standards.

There are currently three wells in the storage aquifer. Two wells provide recovery while the third is a duel-purpose recharge and production well. In the future, as many as 27 wells are contemplated. Past operational tests, using groundwater as the source water, have not included pre- or post-treatment. However, if surface water is used, it is expected that pre- and post-treatment will be required.

Permitting status — No action has yet been taken on the district's application. Lakehaven Utility District applied to Ecology for reservoir and secondary permits shortly after E2SHB-2867 became law, primarily to secure a place in the permitting line. The district continues testing for the project.

Small-scale ASR in Redmond

An electronics firm in the city of Redmond is constructing a data facility designed to withstand and remain in operation after a major earthquake. As part of its requirements, the facility will need a reliable source of emergency cooling water at a maximum sustained rate of 175 gallons per minute until its normal connection with the city of Redmond can be re-established. The maximum design stored volume for a 50-day supply is approximately 10 million gallons.

The firm is evaluating the feasibility of using a small-scale ASR system to provide a reliable supply of emergency cooling water for the facility. ASR is being considered for the following reasons:

- Well technology has been shown to be reliable in large-magnitude earthquakes, particularly if a facility's power and piping are designed for the event.
- The likelihood of obtaining a new groundwater right in the known aquifers is low due to the over-appropriation and potential surface water-ground water interconnection issues in the area.
- The availability of an existing water right for purchase is uncertain and appears to be unlikely.

Even though ASR is envisioned as primarily for emergency supply, an annual operational cycle is proposed for the system to provide the following benefits:

- Annual exercise of the system to ensure operational reliability.
- Use of the ASR system for facility cooling water during peak usage times in the summer to provide relief to the regional water supply.
- Replenishment of the stored water "bubble" after migration during storage periods.

The key feasibility factors to be addressed in 2002 include obtaining a commitment on the part of water purveyors to provide source water for the facility and for ASR injection, determining the permitting requirements for the project, and drilling a test well to verify the presence of a separate deeper aquifer that can accommodate the desired ASR system.

Permitting status — As the summary indicates, this project is still in its early stages of development. Project proponents have not submitted any applications to Ecology at this time.

Seattle Public Utilities

During the 1980s, the Seattle Water Department, now called Seattle Public Utilities, developed and put the Highline well field in service. The well field consists of three production wells capable of delivering a total of 10 million gallons per day. The well field has two basic uses:

- A peaking source that could be started in July and run for up to four months.
- An emergency supply.

In the early 1990s, Seattle Public Utilities received a grant from the U.S. Bureau of Reclamation to study artificial recharge as a means to enhance its Highline well field productivity. Artificial recharge of the aquifer with treated drinking water from the utility's Cedar River source was found to be feasible.

Two production wells are configured so water can be dropped by gravity down the space between the well casing and the pump column and out through the well screen into the aquifer. The ASR study found that artificial recharge in the Highline well field will not increase production capacity significantly above the current 10 million gallons per day. However, its use following heavy pumping of the well field will hasten the return of the aquifer to pre-pumping conditions. Seattle utility operators currently favor the use of its Cedar and South Fork Tolt surface water sources, so the Highline well field has been used only sparingly in recent years and augmentation of the natural recharge to the aquifer has not been needed. Even so, it is considered a viable technique that should be "on call" for future well field operations.

Permitting status: Seattle has operated its Highline well field ASR project for several years under a series of temporary permits issued by Ecology. In 2001, Ecology sought to update the permitting status of the project but was advised by counsel to ensure that Seattle complied with the terms and conditions of the new legislation before proceeding.

City of Walla Walla

The city of Walla Walla's ASR program, implemented in 1999, is the lynchpin for the city's long-term water supply planning efforts. The program has shown that recharged water can replenish portions of the region's deep basalt aquifers. In addition to seeing aquifer water levels rise, the program has also sparked a dialogue with other deep basalt water-right holders in the area regarding regional planning for groundwater use.

Walla Walla's ASR program may also prove a key tool in the city's fire fighting arsenal. Recently, the U.S. Forest Service notified the city that the 36-square mile Mill Creek Watershed is at risk for a catastrophic fire because of the buildup of combustible materials. Should a catastrophic fire erupt in the watershed, turbidity levels in Mill Creek would rise above state and federal standards. Since the city is served by an unfiltered water supply, Walla Walla would no longer be able to divert Mill Creek water for a substantial period of time. An aggressive ASR program would provide the resources and ability to counter the loss of surface water supplies with stored ASR reserves.

Currently Walla Walla's single ASR well has the capability of recharging 150-200 million gallons per year. In 2002, the city hopes to bring another ASR well on line. If the rules are finalized by that time and no new water right is required, the city would like to drill a new well which would replace the need for a large, expensive above-grade storage tank needed to supplement low pressures during the summer.

An expanded ASR program in Walla Walla will also likely have another benefit for the community and the environment. During the 2001 drought, the city was approached by the National Marine Fisheries Service to participate in an experiment to increase survivability of Endangered Species Act-listed steelhead in Mill Creek. The city voluntarily returned a portion of its appropriated surface water flow to Mill Creek and offset this loss by pumping back the balance into the distribution system using its ASR water.

Permitting status: Walla Walla has conducted the pilot test of its ASR project under a water right issued by the state of Oregon. The city intends to eventually operate its ASR project under an inchoate Washington water right permit. However, because the actual diversion of water under that permit would take place within the state of Oregon, some legal issues need to be resolved before that water right permit can be used. To date, Walla Walla has not submitted any applications for reservoir or secondary permits to Ecology.

City of Yakima

The city of Yakima commissioned a pilot test to determine the feasibility of an ASR project in the Ahtanum-Moxee sub-basin in the central part of the Yakima Basin. A pilot test conducted during the fall and winter of 2000-01 indicates that a full-scale ASR program would be both hydrogeologically and operationally feasible.

The primary source of the ASR water is the city's Naches River Rowe Hill Water Treatment Plant. The recharge well was the city's Kissel well, which is screened between 876 and 1,163 feet below ground surface, in the Lower and Middle Members of the Upper Ellensburg Formation.

Recharge to the Kissel well was conducted for 25 days at a rate of approximately 1,200 gallons per minute. A total of 45.2 million gallons was recharged. After a storage period of 55 days, recovery was conducted at a constant pumping rate of approximately 2,000 gallons per minute for 30 days. A total of 89.7 million gallons was withdrawn as part of the test, the additional amount withdrawn to ensure that there were no residual disinfection by-products. Additional water was removed during post-pilot test step tests. Water for the pilot test was delivered through the existing municipal water supply system of the city of Yakima. The distribution system operated without disruption of public service.

Recharge activities resulted in an estimated sustained rise of about six feet in the water levels of the Ellensburg Formation at the Kissel well for the two-month storage period.

Water quality monitoring indicated compliance with state drinking water standards. Although disinfection by-product concentrations did increase temporarily during storage before decreasing, they remained well below drinking water standards at all times. Based on the results of tracer analyses, it is estimated that approximately 70 percent of the water recharged to the aquifer was recovered. The remainder of the water presumably remained in the aquifer and contributed to the net storage of the hydrologic system.

A full-scale ASR program using the city of Yakima's available infrastructure is also operationally feasible. However, to increase the capacity of the groundwater supply system, additional wells would have to be installed. The permitting of these withdrawals should be easier if they are operated as part of an ASR program. Key regulatory components include:

- How ASR operations using chlorinated potable water containing disinfection by-products will be addressed under water quality standards for groundwater.
- The means of quantifying the permitted amount of water that may be recovered following recharge.

Permitting status — While Yakima and its consultant have engaged in discussions with Ecology, the city has yet to submit applications for reservoir and secondary permits. Ecology did issue the city temporary permits to conduct the pilot test.

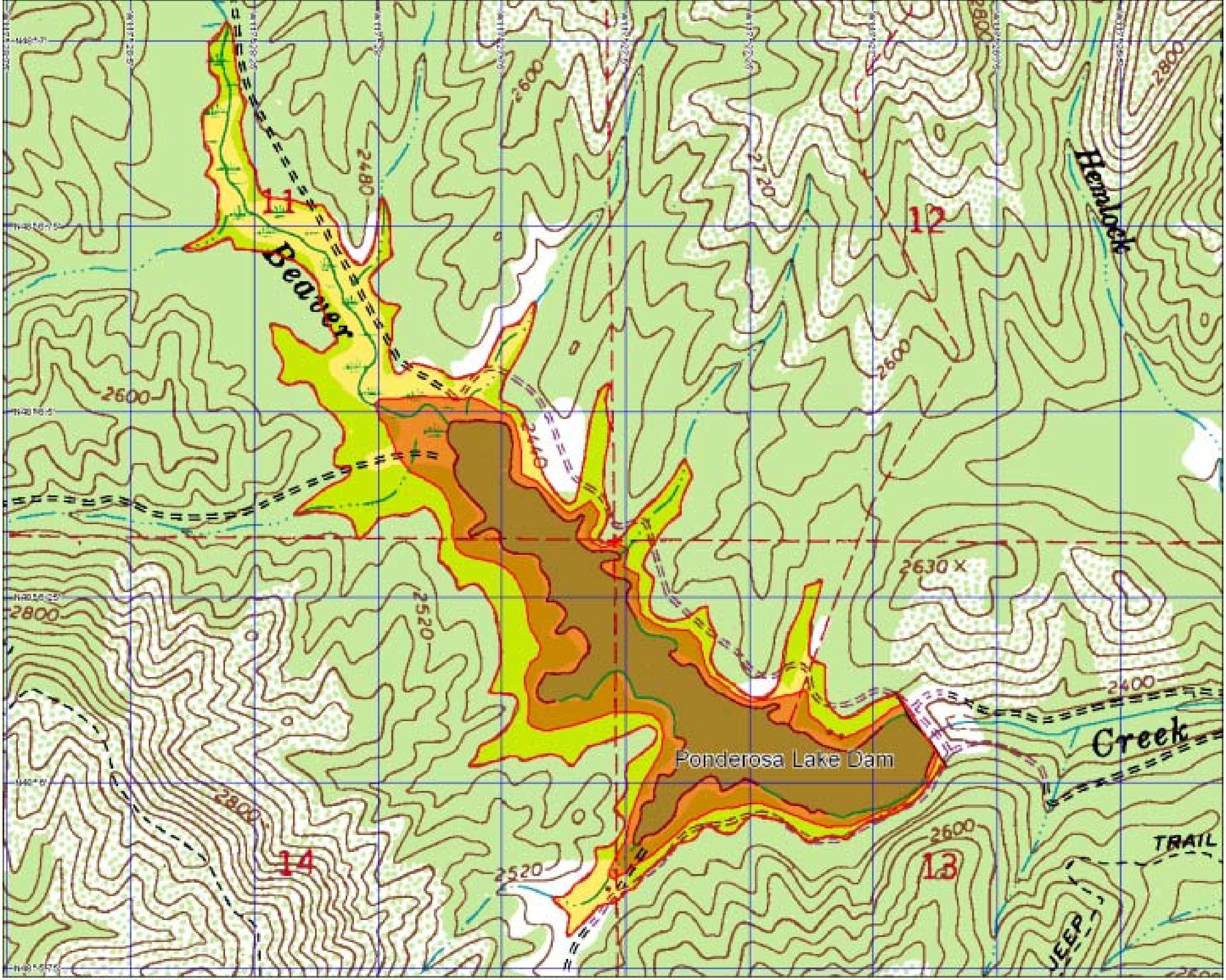
APPENDIX C

Potential Surface Storage in Existing Lakes and Reservoirs

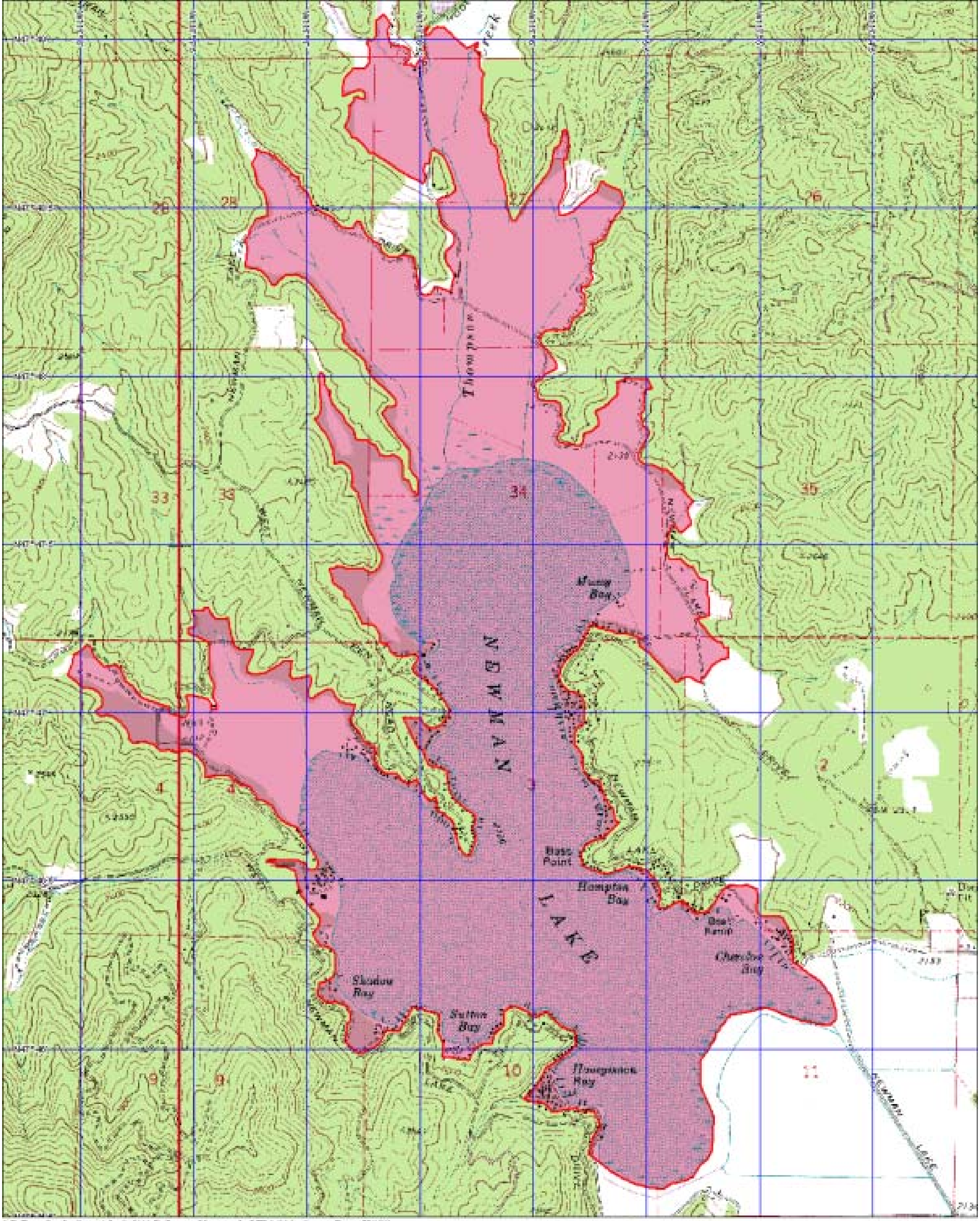
Table of Contents

Legend

Orange	Area flooded by 20-foot dam raise.
Green/Yellow	Area flooded by 40-foot dam raise (forested/open land).
Magenta	Flooded area: Distinction between 20-foot and 40-foot dam raise not made due to available topographic resolution.

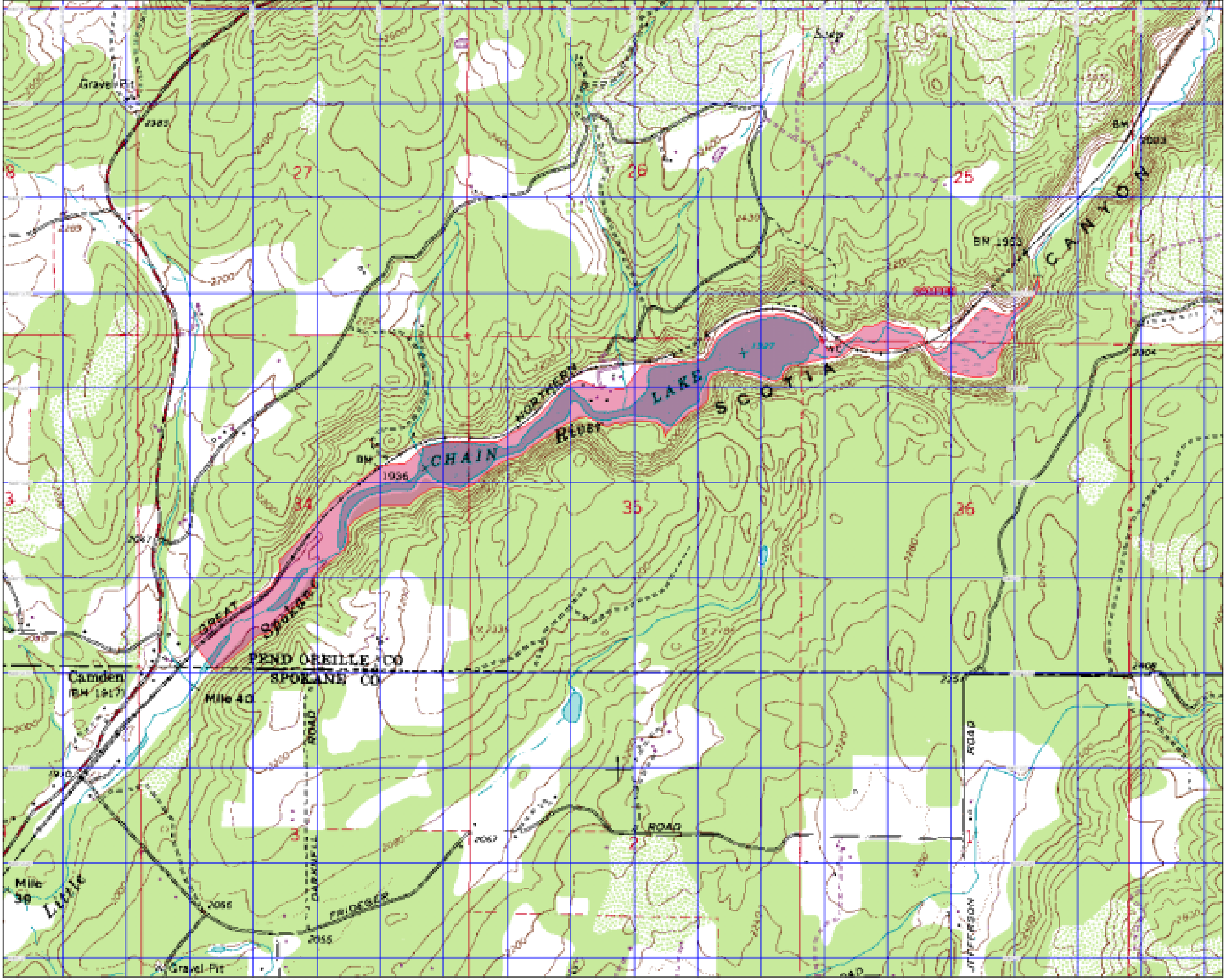


3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS
350 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84



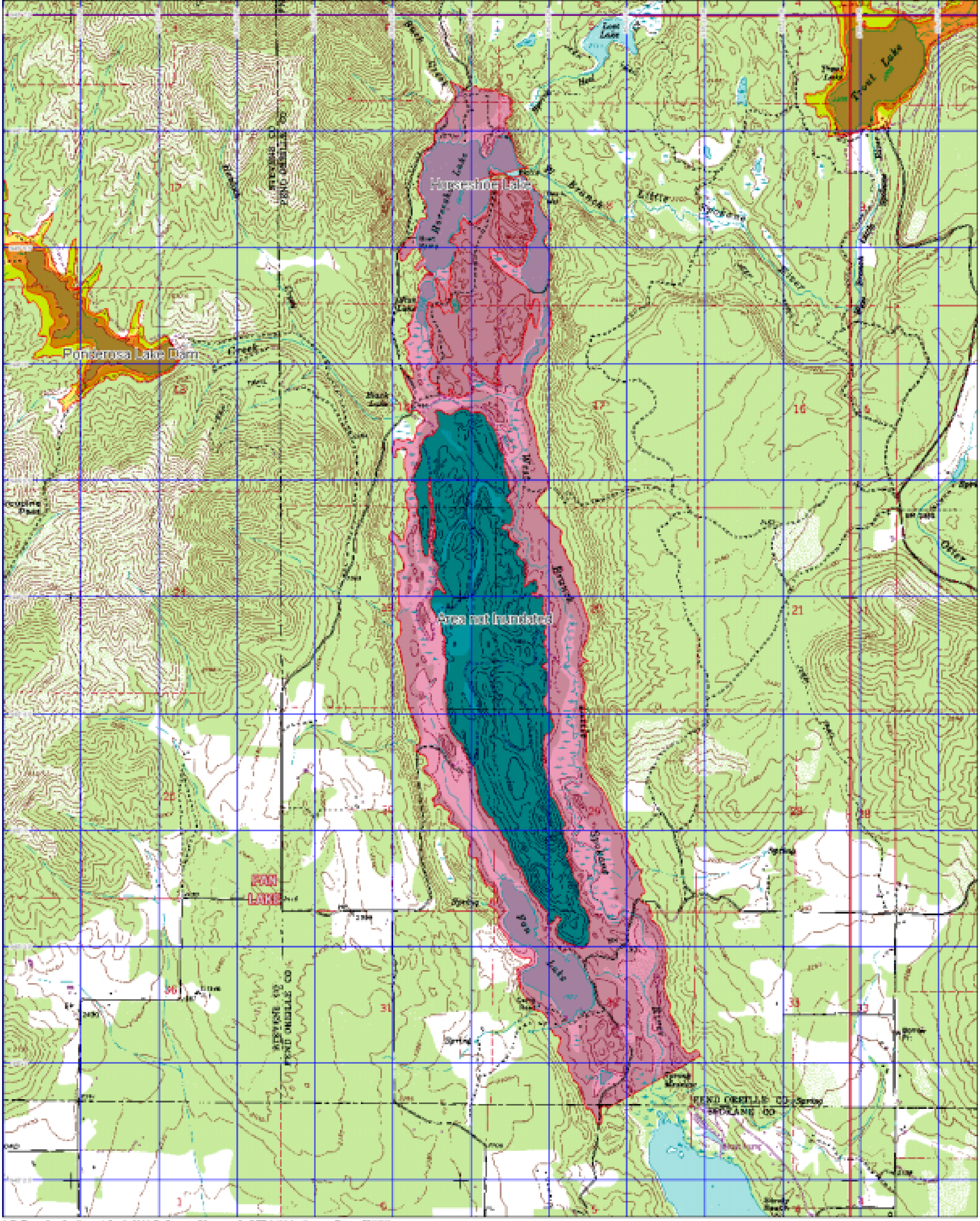
3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

800 ft Scale: 1 : 28,125 Detail: 13-0 Datum: WGS84



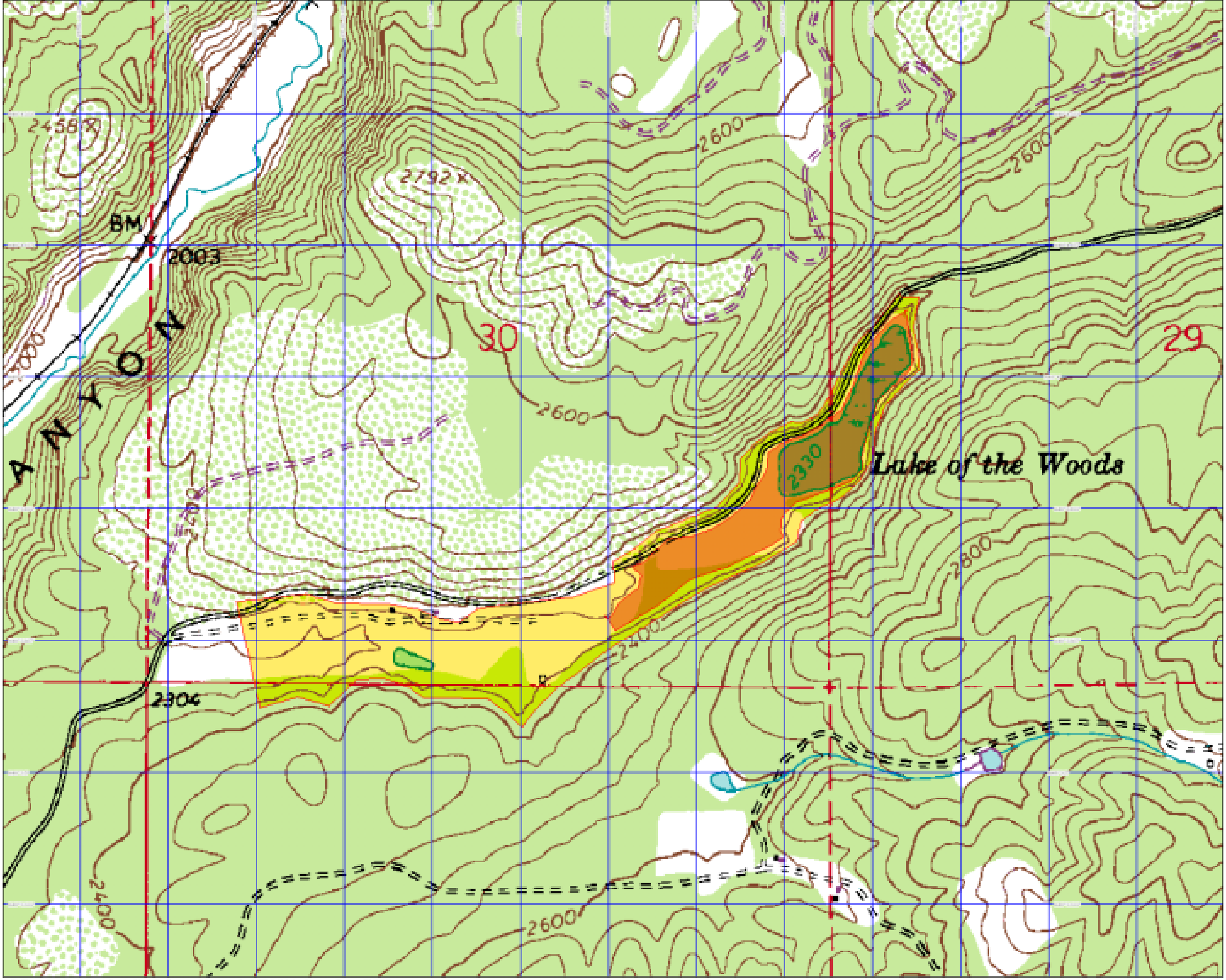
3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

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



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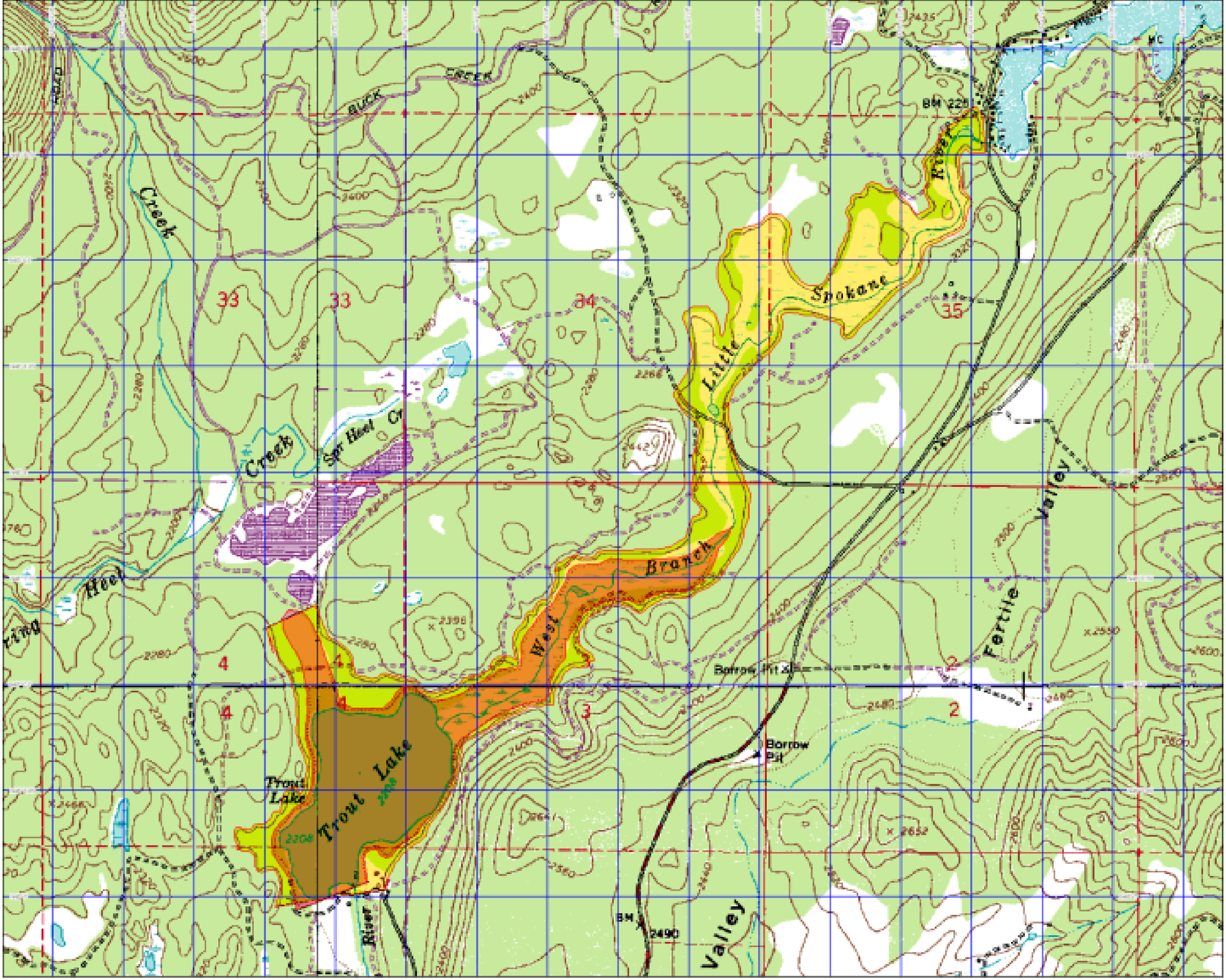

3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

650 ft Scale: 1 : 22,400 Detail: 14-0 Datum: WGS84

APPENDIX D

SELECTED GRAVEL PIT PLANS

(to be provided at the mid-project workshop)