# Quality Assurance Project Plan
# for
# Nine Mile Area Non-Point Source Monitoring Study: Water Quality Monitoring Study

## Spokane County, Contract Work 92946
## Contract/Project Number: P5027

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### Prepared for
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## Distribution List

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# 1.0 Background

## 1.1 Study Area and Surroundings

The Lower Spokane River drainage beginning below the confluence with Latah Creek and ending at the confluence with the Columbia River (Lake F.D. Roosevelt) defines Water Resource Inventory (WRIA) 54. The Spokane River bisects this drainage area with approximately the southernmost half dominated by agricultural land use and the northern half dominated by forest, rangeland and forest practice activity. The Spokane Indian Reservation occupies at least one-quarter of the land area near the lowermost portion of the WRIA 54 drainage.

WRIA 54 represents a transition area in ecological characteristics (arid transition) from the semi-arid basin to the foothills and mountains at the edge of the Northern Rockies mountain range. The southern portion of this drainage below the Spokane River represents a semi-arid region known as the Columbia Basin ecoregion. This region is characterized by a shrub-steppe (sagebrush) vegetation pattern with sparse growth of dry-land conifers like Ponderosa Pine. Precipitation is low with approximately 11.25 – 24 inches of average annual rainfall in the drainage. This is a transition area from a dryland area predominantly farmed for wheat and other grain crops into the forested foothills of the Northern Rockies ecoregion.

The Northern Rockies ecoregion is characterized by rolling hills near the outer boundaries and rising to some of the highest continental mountain peaks. WRIA 54 is on the outer boundaries of this ecoregion where dominant vegetation consists of Ponderosa pine and Douglas fir overhead canopy. The dominant land use in these forests includes timber harvest and rangeland grazing. Average annual rainfall tends to be slightly higher in the foothills of the Northern Rockies ecoregion than in the drier Columbia Basin ecoregion.

Historically, the Spokane River and some of the tributaries maintained healthy runs of salmon. The fishery served as an important seasonal harvest for regional tribes who fished the Spokane Falls area. The anadromous fishery migrated to natal streams tributary (E.g., St. Joe River) to Lake Coeur d'Alene. The settings in the Lake Coeur d'Alene basin included wetland and riparian conditions that created optimal spawning and rearing habitat.

Changes to timing and origin of nutrients introduced into an aquatic ecosystem influences endemic fish, benthic macroinvertebrate, and periphyton communities. Endemic species are highly dependent on timing and type of food sources and these are controlled by nutrients and physicochemical factors (e.g., temperature, dissolved oxygen, and pH) that promote consumption, metabolism, and growth. The control of river flow and establishment of diversions (with return flow following water use) change physicochemical characteristics in rivers that sustain expected natural communities. The biological changes eventually result in appearance of exotic species (e.g., Eurasian watermilfoil, etc.) that outcompete endemic species.

The alterations in physical and chemical characteristics in the Lake Spokane aquatic ecosystem are manifested through appearance of type and severity of nuisance biological species.

One of the most unique biological communities still present in WRIA 54 and the Lower Spokane drainage (Little Spokane River) is the long-lived freshwater mussel (Western Pearlshell; *Margaritifera falcata*). This mussel species is known to live from between 60-120 years and is distributed spatially throughout a drainage by attachment to a specific host fish species during the earliest life stage (i.e., glochidia). The primary function of this species in an aquatic ecosystem is to filter suspended organic particulates from the water column. The western pearlshell mussel also requires a stable hydrologic environment where sand is interspersed among boulder or large cobble substrates. Gradual change in quality of suspended natural organic particulates and in the hydrologic patterns (location and timing) of tributaries and the main stem of the Lower Spokane drainage have proved detrimental to the condition of this endemic freshwater mussel community. The disappearance of important salmon host species from original spatial distributions appears to be correlated with disappearance of the western pearlshell mussel. The Washington Department of Natural Resources has placed this species on the "Watch" list (may require immediate protection, but not enough is known about habitat requirements) under the Statewide Aquatic Resource Habitat Conservation Plan (HCP).

## 1.2 Development/Compilation of Background Information (Subtask 5.2.1)

**Results of Landscape Analysis**

Evaluation of mappable landscape characteristics was reviewed in order to determine pattern of land-use, corresponding geologic settings, and climate. The co-occurrence of some combination of land use and physical attributes was used to determine if there was a high or moderate risk of contaminated groundwater delivery to Lake Spokane. The landscape maps used were initially presented in the WRIA 54 Planning Unit Watershed Plan – Phase 2 Level 1 Data Compilation and Technical Assessment (Tetra Tech 2007).

Several landscape maps were used to analyze low-, medium-, and high risk areas that may convey non-point nutrient pollution to Lake Spokane (Appendix A). The following maps were used to complete this analysis:

- WRIA 54 Geology
- WRIA 54 Aquifers
- WRIA 54 Sub-Watersheds
- WRIA 54 Major Public Land Ownership
- WRIA 54 Current Land Use, Land Cover
- WRIA 54 Future Land Use
- WRIA 54 Hydrologic Soils
- WRIA 54 National Wetland Inventory
- WRIA 54 Water Quality Monitoring Locations
- WRIA 54 Department of Ecology Category 5 303(d) Listings
- WRIA 54 Average Annual Maximum Temperature
- WRIA 54 Average Annual Precipitation

Each of the coverages was examined visually for patterns to determine if individual land-use and corresponding setting characteristics could result in transfer of non-point source nutrient pollution to Lake Spokane. Patterns of convergence like presence of suburban residential development intersected with well-drained soils were interpreted as a likely area for septic leachate to migrate toward Lake Spokane. In addition, the anticipated transfer of naturally vegetated landscape (forested) in this WRIA to suburban development and agricultural land-use was identified. The future land-use map was based on current zoning of the land surrounding Lake Spokane even though it has not yet been developed based on these designations.

A description of landscape characteristics that resemble a reference condition was used to determine expectations in water chemistry and biological condition. The U.S. Environmental Protection Agency level III ecoregions were used to determine a reference description. Lake Spokane is on a boundary between the Northern Rockies ecoregion and the Columbia Basin ecoregion. The landscape characteristics used to define these two ecoregions were the focus for identifying potential risks from further land conversion and human activities in this part of the basin. Those landscape characteristics that define level III ecoregions are: soil type, potential natural vegetation, topography, and land use.

Most of the land adjoining the Lake Spokane shoreline had well-drained soils. This situation was predominant on both sides of the lake and extended to 0.5 to 1.0 miles from the shoreline. Moderately well-drained soils extended beyond this margin and away from the lake. Current land use maps show low-intensity residential development dominant on the north side of the lake. Continued residential development with on-site septic systems is considered to be a major factor in exacerbating the low dissolved oxygen concentrations already existing in Lake Spokane. Future zonation for residential development is located on both the north and south sides of the lake and is assumed to begin with low-intensity residential and developing over time into a high-intensity residential condition. Currently, high-intensity residential development is limited to the Suncrest community in Stevens County, with remaining development contained within the City of Spokane boundary and upstream of the Nine Mile area.

**Tributary Stream flow and Water Quality Data**

Data collected from the main stem river, tributaries, and in Lake Spokane were initially limited, but recent efforts by local and state agencies have expanded the spatial and temporal extent of data gathering effort. The Department of Ecology (Ecology) has maintained a small number of long-term monitoring stations in the main stem and major tributary portions of the WRIA 54 basin. Monitoring on the main stem of the Spokane River has been conducted by the Departemnt of Ecology at ten locations beginning from below Lake Spokane up to below the City of Coeur d'Alene, Idaho (J. Ross, personal communication). Lake water quality studies have been conducted by academic institutions (e.g., Eastern Washington University and Washington State University) as individual projects. Existing data reviewed by Ecology during construction of the 303(d) list (water quality impaired segments of lake or streams) reported dissolved oxygen impairment in surface water and accumulation of total PCBs in fish tissue collected from Lake Spokane.

Recent effort in characterization of nutrient flux from Lake Spokane sediments has been conducted by the City of Spokane (Owens and Cornwell 2009). The main purpose of this three year study was to determine whether "internal" sources of phosphorus could supply soluble

reactive phosphorus (SRP) to support algal blooms. The investigators found a low flux of sediment phosphorus from redox and pH-related release that were relatively low to sustain the mid-summer to mid-fall algal bloom observed in the lake on an annual basis. However, the lack of continuous monitoring data measuring pH, dissolved oxygen, and temperature along with regular measurements of algal biomass and nutrients are expected to provide background information that will further elucidate this complex problem. In addition, these experiments do not include the mineralization of organic-Phosphorus (organic-P)_through metabolic degradation of organic-P as found in studies from Lake Oswego and Klamath Lake (Tetra Tech 2004; Welch 2006). The instantaneous physicochemical conditions along with biological modification of the chemical environment will more fully explain the mechanisms that sustain algal blooms and the relative contributions from each nutrient source (or transfer between compartments). The description by these investigators indicates that nutrient flux does occur from sediment sources in Lake Spokane and that rates may vary among time periods. Total volume of algal biomass may be accounted for by more detailed studies of nutrient supply and over the longer time period in order to account for the non-uniform rate of nutrient release to the overlying water column. Also, the tests were not conducted *in situ* like those in Lake Washington where P-release was directly linked to presence of aquatic plant beds. This was similar to aerobic release of P from sediments found in Liberty Lake, WA with $^{32}P$ experiments (Gibbons 1981; Mawson and Gibbons 1983; Gibbons and Gibbons 1984).

**Wetland Inventory**

Wetland habitat occupies a large portion of the upland area from Lake Spokane (National Wetland Inventory). This upland area is located on a higher elevation plateau adjacent the lake basin. The location and function of these wetland areas serve as an important water source for sustaining existing stream flows to tributaries and as wildlife habitat (e.g., waterfowl, amphibians, reptiles, etc.). These small wetland basins may also serve as filters for runoff from an increase in residential and industrial development.

The National Wetlands Inventory, maintained by the U.S. Fish and Wildlife Service, reports the status and trends for wetlands throughout the United States. Information for these important water types is located at the following web site: http://www.fws.gov/nwi/index.html which stores coverages that can be downloaded to construct maps for locations and type of wetlands present in a drainage. Classification for wetland type dominant in the area of Lake Spokane consists of aquatic beds and emergent plants. Dominance of wetland types along the Little Spokane River and higher elevation plateaus surrounding Lake Spokane include palustrine (swamp) aquatic beds, emergent vegetation, and scrub-shrub riparian vegetation.

Wetlands surrounding Lake Spokane may contribute groundwater and may affect lake water chemistry. Non-point sources of nutrient pollution that are neither filtered nor impeded in transport toward the lake can contribute to DO depletion zones at locations where groundwater communication with surface water is identified. A map showing location and type of wetland is available for WRIA 54 at the Environmental Information Management (EIM) website maintained by the Washington Department of Ecology from the following address: http://apps.ecy.wa.gov/eimreporting/GISViewer/viewer.asp?strSessionID=40243887.

**Hydrogeological and Groundwater Data**

The dominant use of groundwater in the Lake Spokane portion of WRIA 54 is for domestic water supply (e.g., private residence and community wells). Most of the recorded well locations indicate that water supply wells are at higher elevations above Lake Spokane, but also present at private residences along the lake. In addition, there are a few wells classified as resource protection and some with multiple uses (e.g., stock watering and irrigation). A description for specific uses of groundwater is provided in Tetra Tech (2007) Chapter 3 (Figure 3-2).

A detailed analysis of groundwater inflow is presented in Chapter 4 of Tetra Tech (2007). Quantities were estimated on a monthly basis and originating from the major aquifers surrounding the Lake Spokane project area. The primary aquifers contributing groundwater inflow to the lake are: Spokane Valley Rathdrum Aquifer, Grande Ronde Basalt Aquifer, and the Wanapum Basalt Aquifer. These are located primarily to the south of the Lake Spokane project area and flow northward. Groundwater recharge to Lake Spokane surface water is rapid from the Grande Ronde Basalt Aquifer, adjacent to the reservoir on the south portion of the study area. However, the more distant Wanapum Basalt Aquifer has experienced substantial water depletion of the water table in the recent past, especially in the West Plains area of WRIA 54.

## 1.3 Data Gaps in Existing Information (Subtask 5.2.2)

Recent monitoring and modeling activity includes completion of an initial pollutant loading assessment by Ecology (WDOE 2003), Berger et al. (2001), and Ross (2008). The loading assessment (WDOE 2003) focused on point source discharges of treated effluent as well as nutrient loads originating from tributaries like Latah Creek, Little Spokane River, and the Deep/Coulee Creek complex. The data generated and reported in WDOE (2003) were re-analyzed and used to report updated results from use of the CE-QUAL-W2 (Version 3.0) model (WDOE 2004). The modeling results reported by Berger et al. (2001) provided a check on calibration from the original modeling work and expanded the predictive capability to include Lake Coeur d'Alene.

Currently, Ecology (Eastern Regional Office) is monitoring monthly at ten locations that include Spokane River main stem and points below Ninemile Dam and Long Lake Dam. Those routinely monitored stations useful for comparison to data that will be generated in this project are: 54A090 (Spokane River at Ninemile Bridge) and 54A070 (Spokane River at Long Lake). Information is available from these sites on the web at the following address: http://www.ecy.wa.gov/apps/watersheds/riv/stationlistbywria.asp?wria=54.

Historical information is reviewed and results described by more current technical work reported in WDOE (2003). The initial work completed by Patmont et al. (1985) described phosphorus (P) attenuation in the Spokane River with additional discussion describing dynamics of this analyte throughout the whole basin (Patmont 1987). The proposed monitoring program described in this Quality Assurance Project Plan (QAPP) extends this original view of the basin and includes the non-point source nutrient pollution component.

An extensive description of readily-available data has been summarized for surface water and sediments from the Lake Spokane Basin (Appendix B). In addition, a detailed description for wetland location and type recorded from the Lake Spokane Basin is reported in Appendix B.

## 1.4 Stakeholder Review and Responses

Stakeholder review comments were submitted and incorporated into this document. Technical staff from Spokane County and the Department of Ecology provided useful comments that were recorded in a Response Summary. The specific comments and the responses by the authors were provided in tabular form and can be found in Appendix C.

# 2.0 Project Description

## 2.1 Problem and Cause

Low DO in Lake Spokane and in the dam discharge is a result of eutrophication of the Spokane River and Lake Spokane. Investigation in the early 1980s determined that high nitrate concentrations in groundwater feeding the Spokane River, downstream from Spokane resulted in P as the nutrient controlling algal production (20:1) in the river and lake (Patmont et al. 1985; Patmont et al. 1987). Therefore, emphasis should be on P in the monitoring program designed to determine important non-point sources. Nitrogen (N) should still be monitored to assure that P continues to be the controlling nutrient.

## 2.2 Surface Sources of Non-Point Nutrient Pollution

Increasing P in runoff from agricultural land is caused by over-fertilization. Agricultural soil P is several times above historical levels in areas of the United States and loss of P increases when soil P levels become excessive. Loss can be through leaching to ground water or overland runoff to surface streams by erosion during storms. The importance of agricultural runoff is evident from many investigations showing increasing mass P load versus increasing percent of the watershed devoted to agricultural land-use.

Tributary streams can be an important source of nutrients, especially during storms when inputs via erosion are most likely. Therefore, inputs should be determined for storm and base flow separately. Storm sampling can be achieved with flow-activated automatic samples. Storm and base yields (or loading) from all streams can be related to basin-wide land use to illustrate the relative importance of one land use versus another.

Aerial transport of P to water can be important in agricultural landscapes. About half the P from aerial deposition during spring – early summer in the Liberty Lake area was from dry fall and mass rates were large enough to substantially raise receiving water concentrations (Belnick 1985).

## 2.3 Groundwater

Contamination of ground water via septic drainfield leachate beneath large rural housing developments has become an increasing problem in many areas. The extent of this can be determined through selection or placement of ground water wells and multispectral imaging along the shoreline of Lake Spokane. If subsurface flows are identified, flow quantity and direction can be determined by routine techniques to estimate loading from ground water to receiving streams or the lake. Determining the extent of this source in the currently developed area on the north side of Lake Spokane downstream from Nine-Mile should be a priority.

## 2.4 Stream Periphyton

Periphyton biomass was sampled from artificial and natural substrata in the Spokane River in the early 1980s. Biomass levels on natural substrata ranged from ~ 100 to ~ 600 mg chl-*a*/ $m^2$ (Welch et al., 1989). The nuisance filamentous green algae, *Cladophora* sp., represented much of the biomass. From this background, periphyton sampling on natural substrata in the Spokane River and in connecting tributaries would be a cost-effective method that integrates the effect of nutrients and other factors.

Improvement or worsening in nutrient status of streams could be easily identified by such monitoring. *Cladophora*, in the periphyton biomass, has been shown in several data sets in the United States to occur when stream total P (TP) concentration exceeds 20 µg/L. Biomass (chl-*a*) of periphyton is also directly related to TP concentration. Such monitoring for biological indicators of chemical / physical change, in this case TP, can represent a cost-effective sensing of problem sites and improving or deteriorating quality over time.

Periphyton can also represent a significant DO demand. Seasonal change in periphyton biomass can be compared with daily minimum stream DO to determine the importance of the periphyton demand.

## 2.5 Internal Loading

Much of the DO and algae problems in Lake Spokane may be attributed to internal P loading from bottom sediment in the upper shallow reaches of the reservoir. Low DO conditions occur during summer in the downstream deep portion (lacustrine zone) when the reservoir stratifies and the hypolimnion is isolated from the atmosphere. The potential sources of DO demand are hypolimnetic sediment, organic matter in the river inflow and algae produced in the reservoir. Blue-green algal blooms, which have reached 70 µg/L (chl) and more, usually occur in the upper reservoir in late summer (WDOE 2004). TP concentrations at least that high (chl:TP ratios in lakes are usually 0.3-0.5) are required for such levels of chl, and TPs as high as 58 µg/L were reported (WDOE 2004). The fact that such blooms occur when the inflowing river water contains only 27 µg/L TP means that excess TP had to originate from internal sources. Lakes with summer TP concentrations that greatly exceed inflow concentrations, as a result of net internal cycling from sediment, are not unusual (Welch and Jacoby 2001). Therefore, the eutrophic conditions in the upper reservoir may originate to a greater extent from the sediments than from the inflowing river water. As river water moves into the transition zone, sinks and enters the meta- and hypolimnion, that sediment-derived (via P) source of algal organic matter can contribute significantly to the low hypolimnetic and metalimnetic DO. This process may be more important in reservoirs than lakes, due to shorter residence time in reservoirs, that leads to higher P loads and P deposition, especially in upper reaches (Thornton et al. 1990). Dzialowski et al. (2008) determined that resuspended nutrients and meroplankton (dormant algal cells within the sediment) were significantly related to algal blooms in overlying surface water of Central Plains reservoirs. These observations were especially prevalent in shallow portions of these reservoirs when influence from wind and current were the sources for resuspension.

## 2.6 Tasks

Increasing development along the shoreline of Lake Spokane has prompted concern over introduction of non-point sources of nutrient. Impact from excessive nutrient introduction (i.e., a quantity larger than endemic biota and the physical environment can assimilate) results in establishment of nuisance aquatic plants (e.g., Eurasian watermilfoil) and algal blooms (e.g., blue-green algae). The presence of these nuisance biota limits uses for recreation contact, inhabitation by endemic aquatic life, and potable water sources (Lake Spokane not currently designated as a potable water source). The resulting organic matter production leads to low DO in the lake hypolimnion and outlet. Several goals are appropriate for examining environmental conditions and making management decisions that would enhance attainment of designated uses in Lake Spokane.
The following tasks for this project have been developed:

1. Evaluate potential impact of non-point sources of nutrients from land use types on surface water quality within Lake Spokane.
2. Evaluate potential impact of stormwater runoff within the study area on surface water quality within Lake Spokane.
3. Establish baseline water quality and long-term monitoring program to evaluate deviation from background concentrations.
4. Identify the source for any elevated levels of non-point source pollutants identified through this or other monitoring programs.
5. Evaluate the effectiveness of water quality BMPs in protecting downstream water quality.
6. Describe an educational component, such as a volunteer monitoring program.

## 2.7 Objectives

Information in this Quality Assurance Project Plan (QAPP) is organized to provide sampling and analysis methods that will generate data and interpretations necessary to address the following objectives:

1. Determine the magnitude of nutrient input from leeching septic system nutrient input (e.g., multi-spectral imaging),
2. Estimate the mass loading for nutrients from major tributaries,
3. Evaluate extent and source of non-point pollutants from tributaries,
4. Characterize magnitude of seasonal loading.
5. Determine if internal loading of TP is significant on the Riverine Zone of the lake and Transition Zones of the lake and estimate magnitude by simple mass balance model.

## 2.8 Stream Sampling (Optional)

**Spokane River Main stem**
Establish at least six sites along the river, including one upstream and one downstream from the confluence with Deep and Coulee Creeks. There are currently six monitoring sites established,

most of which probably should be retained. One exists downstream of the creek's entrance, but one should be added immediately upstream.

These sites should be sampled routinely for storm and base flow. Base flow constituent concentrations would be available from regular, twice-monthly grab samples, while storm concentrations should be obtained from flow-activated, automatic samplers. The two sources of data would provide a flow-weighted seasonal average nutrient concentration that would indicate the seasonally and biologically effective concentration reaching Lake Spokane and the parts of the river that account for that inflow concentration.

Groundwater sources to the Spokane River may be evident by comparing average, flow-weighted nutrient concentrations along reaches of the river without significant tributaries. That technique was used by Harper-Owes in the early 1980s to determine the significance of ground water nitrate.

**Tributary Streams**

Deep and Coulee Creeks are the main tributaries to the Spokane River in the nine mile area. These should be sampled above their confluence and prior to that confluence entering the Spokane River; three sites in all. These sites should be sampled by grab on a twice-monthly basis, and by a flow- activated sampler placed in the confluence above its entrance to the Spokane River to determine storm concentrations. These data will serve as background to the anticipated increasing development in these watersheds, as well as a current source to the Spokane River.

Other, smaller tributary streams should be sampled by grab in a one-event, synoptic survey to estimate the relative contribution of all sources. That technique worked well in the comprehensive study of Lake Chelan. Flow would be determined at the same time during a relatively high-flow event. If the synoptic study indicted that one or more of the smaller tributaries had a significant contribution, more intensive monitoring would be considered.

## 2.9 Water Quality Constituents to Monitor (Primary Monitoring Program)

Phosphorus, both soluble reactive (SRP) and TP is the most important constituent ultimately controlling the DO levels in the river, Lake Spokane and its discharge. Analytical procedures are extremely important. Laboratory quality control can be acceptable, while determined concentrations in the river may be in error, especially for TP due to different digestion procedures and contamination. SRP should be determined on samples filtered through P-free filters using the EPA 365.1 ascorbic acid method. TP should be determined by the same method for SRP following digestion with persulfate according to Standard Methods (APHA 2005). A contract laboratory that can meet these rigorous reporting limit and laboratory performance requirements is required for analysis of P forms.

Nitrate-N and total N (by persulfate digestion) should also be determined as an indicator of ground water sources, because nitrate is highly soluble and could be used as a tracer.

Other constituents to monitor include temperature, turbidity, pH, sodium, specific conductance and total and fecal coliform content. All of these can be used to indicate sources of contamination.

**Internal Loading from Lake Spokane Sediments**

Internal loading in the unstratified reaches of the reservoir may be an important source for TP during the summer low-flow period. This sampling effort reflects the need to characterize nutrient concentrations in sediment and determine if there is potential for bioavailability. In addition, the more detailed quantification of nutrients in sediment addresses objectives for this study. There is some indication that internal loading from these upper reaches was ignored during analyses to set a TMDL in the 1980s. Characterization of phosphorus attenuation and contributions from point- and non-point sources in surface waters was contributed by Patmont et al. (1985) and Patmont et al. (1987).

Reservoirs usually have relatively distinct limnetic zones identified by physicochemical characteristics that are represented by a gradient in constituent concentration as the inflow moves through increasing volumes, and hence increasing water retention times, toward the dam. So the initial task will be to identify the riverine, transition, and lacustrine zones based on past data. Much of the TP is sequestered in these zones, which usually do not stratify thermally. Although water overlying sediments in these zones is usually oxic, internal P loading may still occur, as it often does in many shallow lakes (Welch and Cooke 1995).

Internal loading of TP in these upper lake zones may account for a large fraction of the algae (organic matter) produced there. This organic matter would then be distributed through inflow into the meta- and hypolimnia of the down reservoir, stratified lacustrine (lake environment) zones and account for much of the low DO problem in the hypolimnion and the reservoir discharge. Prolific blue-green blooms observed in the upper end of the lake have been noted from previous field studies (WDOE 2004) indicating the greater bioavailability of nutrient and light to fuel this algal growth. One of the pathways proposed for phosphorus attenuation in Lake Spokane was due to in-lake processes that included biological uptake by periphyton communities and macrophyte beds (Patmont 1985). WDOE (2004) reported that following phosphorus removal upstream of the lake, low hypolimnetic dissolved oxygen conditions in the lower end of Lake Spokane persisted. In-lake processes (i.e., biological uptake of phosphorus) that result in re-distribution of settleable organics at points downstream in Lake Spokane is a reasonable conclusion based on previous analysis of phosphorus sources and exchange among water, sediment, and biota.

The magnitude of internal loading can be calculated from seasonal inflow volume, inflow TP content and twice monthly TP concentration data from representative sites in the two upper zones (i.e., riverine and transition zones). A mass balance or “bathtub” type model can also be calibrated to identify the magnitude of internal loading. Previous monitoring site locations and data will need to be reviewed to define zone reaches and appropriate sampling sites for this task.

The same constituents to be monitored in streams should be determined in the lake and at three or more depths in the water column. DO, temperature, conductance and pH should be determined at one-meter intervals.

**Precipitation**

Phosphorus content should be determined in bulk and wet fall (rain-containing phosphorus in dry and wet forms. Review of data collected in the mid-1980s from the Liberty Lake area show very high TP concentrations in wet and dry fall during spring and early summer. Some of these levels were in the 100s of µg/L.

One location for a unit to monitor wet and dry fall (use a rain gage) on a weekly- or twice-monthly basis should be adequate.

**Periphyton**

Biological indicators have some advantages over chemical constituents in detecting water quality problems and recording the alleviation of those problems. Stream periphytic (attached) algae are indicators of nutrient enrichment. Recently, the occurrence of a major nuisance filamentous green alga, *Cladophora*, at TP concentrations of 20-30 µg/L has been widely recognized. Moreover, the presence of this indicator, and at relatively high biomass, can reflect an integrated response to variable TP concentrations over a period of a month or more, while twice-monthly samples for TP concentration do not capture the monthly average level to which the attached algae were exposed. *Cladophora* is present in the Spokane River and total periphytic biomass has reached high levels of 600 mg chl/$m^2$ or so. The goal for water quality could be to lower TP concentrations to a level below which *Cladophora* does not flourish (20-30 µg/L) which should keep maximum biomass at <100 – 200 mg/$m^2$ chlorophyll-*a* level recommended to prevent unwanted effects on DO and/or aesthetically unacceptable conditions, i.e., a high percent coverage of substrate with filamentous algae (see EPA 2001 Streams and Rivers Nutrient Criteria Guidance Manual). Periphyton should be collected by scraping the attached material from natural substrata (i.e., rocks) at or near the established water quality monitoring sites on a monthly basis.

One approach to substrata collection is to select ten rocks in a transect across the stream bottom on a random basis. The entire rock surface should be scraped with the material kept on ice in a plastic bag until chlorophyll-*a* can be extracted for analysis in the laboratory. To do that the material is dispersed in a volume of water from which sub-samples are drawn for chl-*a* and species composition. The area of each rock should be determined with width, height and length measurements in the field and the use of an equation for surface area so that biomass (chl-*a*) can be expressed per unit area. A comprehensive description of methods is available in the literature.

# 3.0 Organization and Schedule

The purpose of this document is to present the quality assurance project plan (QAPP) for collecting water quality and other data to assess the chemical, physical, and biological characteristics of non-point sources of pollution affecting Lake Spokane, Washington. A team of technical professionals will conduct journey-level scientific investigations that include: 1) collection of environmental data (routine monitoring and source-tracing), 2) collection and interpretation of multi-spectral imaging, and 3) oversight of a volunteer sampling team trained and coordinated by technical professionals. Sampling training and effort will be coordinated by technical staff representing partners from the WRIA 54 Watershed Planning Unit.

This QAPP provides general descriptions of the work to be performed to collect the samples, the standards to be met, and the procedures that will be used to ensure that the data are scientifically valid and defensible and that uncertainty has been reduced to a known and practical minimum. It describes the procedures used to obtain concentrations of the desired chemical analytes and other parameters of concern.

The organizational aspects of a program provide the framework for conducting tasks. The organizational structure can also facilitate project performance and adherence to quality control (QC) procedures and quality assurance (QA) requirements. Key project roles are filled by those persons responsible for ensuring the collection of valid data and the routine assessment of the data for precision and accuracy, as well as the data users and the person(s) responsible for approving and accepting final products and deliverables. The key personnel and responsibilities for the Nine Mile Area Non-Point Source Monitoring Study in Spokane County and Stevens County are listed in Table 3.0-1.

**Table 3.0-1.** Project/Task organization and responsibility summary.

| Personnel | Responsibility | Address/E-Mail | Phone Number |
|---|---|---|---|
| WRIA 54 Planning Unit Member | Project Manager | TBD | ---.---.---- |
| Name, Position, Agency | Project Lead | TBD | |
| Name, Position, Agency | Field Lead | TBD | |
| Name, Position, Agency | Quality Assurance Officer (QAO) | TBD | |
| Name, Position, Agency | Data Manager | TBD | |
| Name, Position, Agency | Technical Staff | TBD | |

Each component of the Nine Mile Area Non-point Source Monitoring Study has specific milestones and products. The project schedule contains several deliverables in draft and final form. The schedule for each of these products is outlined here:

**Table 3.0-2.** Project deliverables and target dates for the Nine Nile Area Non-point Source Monitoring Study.

| Deliverables | Target Date |
|---|---|
| Final Approved QA Project Plan | TBD |
| Sampling Start/End | TBD |
| Draft Study Report | TBD |
| Final Study Report | TBD |
| Submit Data to EIM/STORET | TBD |

Note: TBD (To be determined) will be replaced by actual Target Dates once funding is secured to conduct field studies and generate field/laboratory data.

## 3.1 Budget

The cost estimates for conducting monitoring in this project are partitioned based on each of the tasks reported in Section 2.0 and addressed with information generated from descriptions of the objectives. Some of the tasks and associated monitoring activities can be conducted separately from the others in order to implement this monitoring plan on an incremental basis. Each segment of the monitoring programs described in this QAPP are listed in Table 3.1-1. The budget estimates for each monitoring program are estimated individually and based from Table 3.1-1. The number of samples suggested for collection in each monitoring program can be found in Section 6.0.

**Table 3.1-1.** Summary of costs for a comprehensive list of water quality parameters suggested for analysis.

| MATRIX | PARAMETER | METHOD | MINIMUM REPORTING LIMIT (mg/L) | UNIT COST |
|---|---|---|---|---|
| WATER | TOTAL-P | EPA 365.1 | 0.002 | $15.00 |
| WATER | NITRATE + NITRITE | EPA 353.2 | 0.010 | $15.00 |
| WATER | SRP | EPA 365.1 | 0.001 | $15.00 |
| WATER | SRP FILTRATION | | | $5.00 |
| WATER | AMMONIA | EPA 350.1 | 0.005 | $15.00 |
| WATER | ALKALINITY | EPA 310.1 | 1.00 | $15.00 |
| WATER | CALCIUM | EPA 200.7 | 0.100 | $10.00 |
| WATER | SODIUM | EPA 200.7 | 0.500 | $10.00 |
| WATER | METALS PREP | | | $12.00 |
| WATER | SULFATE | EPA 375.4 | 1.00 | $15.00 |
| WATER | CHLORIDE | EPA 325.3 | 0.50 | $15.00 |
| WATER | TOC | EPA 415.1 | 0.250 | $35.00 |
| WATER | TSS | EPA 160.2 | 0.50 | $15.00 |
| WATER | TDS | EPA 160.1 | 5.00 | $15.00 |
| WATER | TS | EPA 160.3 | 5.00 | $10.00 |
| WATER | CHLa/PHAEOa | SM1810200 | 0.0001 | $30.00 |
| WATER | METALS PREP | | | $12.00 |
| TOTAL COST | | | | $259.00 |

Note: 1. Highlighted parameters are discretionary and may be used in addition to TS (Total Solids) if the signal from nonpoint sources of pollution is more easily detected.
2. PHAEOa ~ Phaeophytin-*a* (phaeophytin-*a* represents the inactive fraction of the total chlorophyll-*a* photosynthetic pigment measured from a sample).
3. Standard turnaround time for analysis of laboratory samples is 21 Days.

**Task 1** Budget (Transect Sampling)

| Parameter | No. of Samples* | Unit Cost | Total |
|---|---|---|---|
| NO3+NO2 (nitrate+nitrite nitrogen) | 1,672 | $15 | $25,080 |
| SRP (soluble reactive phosphorus) | 1,672 | $15 | $25,080 |
| NH3 (ammonia nitrogen) | 1,672 | $15 | $25,080 |
| TP (total phosphorus) | 1,672 | $15 | $25,080 |
| TS (total solids) | 1,672 | $10 | $16,720 |
| Cl (chloride) | 1,672 | $15 | $25,080 |
| SO4 (sulfate) | 1,672 | $15 | $25,080 |
| Alkalinity | 1,672 | $15 | $25,080 |
| Na (sodium) | 1,672 | $10 | $16,720 |
| Ca (calcium) | 1,672 | $10 | $16,720 |
| TOC (total organic carbon) | 1,672 | $35 | $58,520 |
| Chl-*a* + speciation of phytoplankton (chlorophyll-*a)* | 1,672 | $30 | $50,160 |

**Total: $339,440**

- Calculation for no. of samples = [(7 transects x 3 locations x 4 depths) + (mid-depth & bottom-depth at middle location)] x 19 events
- Blanks and Duplicates = (1 blank + 1 duplicate)/event

**Task 2** Budget (Stormwater Sampling)

| Parameter | No. of Samples | Unit Cost | Total |
|---|---|---|---|
| NO3+NO2 (nitrate+nitrite nitrogen) | 1,220 | $15 | $18,300 |
| SRP (soluble reactive phosphorus) | 1,220 | $15 | $18,300 |
| NH3 (ammonia nitrogen) | 1,220 | $15 | $18,300 |
| TP (total phosphorus) | 1,220 | $15 | $18,300 |
| TS (total solids) | 1,220 | $10 | $12,200 |
| Cl (chloride) | 1,220 | $15 | $18,300 |
| SO4 (sulfate) | 1,220 | $15 | $18,300 |
| Alkalinity | 1,220 | $15 | $18,300 |
| Na (sodium) | 1,220 | $10 | $12,200 |
| Ca (calcium) | 1,220 | $10 | $12,200 |
| TOC (total organic carbon) | 1,220 | $35 | $42,700 |

**Total: $207,400**

- Calculation for no. of samples = 5 creeks x 24 samples x 10 events
- Blanks and Duplicates = (1 blank + 1 duplicate)/event

**Task 3** Budget (Baseline Information)
Included as uppermost transect in Lake Spokane from Task 1.

**Task 4** Budget (Internal Loading; Sediment Samples)

| Parameter | No. of Samples | Unit Cost | Total |
|---|---|---|---|
| TP | 149 | $25 | $3,725 |
| Mobile P | 149 | $25 | $3,725 |
| TOC | 149 | $45 | $6,705 |
| % Solids/HOA | 149 | $10 | $1,490 |
| Fe-P (iron-bound phosphorus) | 149 | $25 | $3,725 |
| Al-P (aluminum-bound phosphorus) | 149 | $25 | $3,725 |

**Total: $23,095**

- Calculation for no. of samples = 7 transects x 3 replicates/transect x 7 core layers x 1 event
- Blanks and Duplicates = (1 blank + 1 duplicate)/event

**Multi-Spectral Imaging**

Multi-spectral imaging requires both field data collection and interpretation of imagery collected from the shoreline region of the lake. The images from this type of monitoring will be generated from the total length of the shoreline.

| Spectrum Imaging | Cost/Unit | Total |
|---|---|---|
| Flight Time, Local Transportation, and Data Interpretation | $1,200/mile + $10,000 mobilization (54 miles of shoreline) | $74,800 |
| Whole Imaging (all spectral ranges) | $1,200/mile (single zone: riverine, transition, lacustrine) | $25,000/zone |

**Total: ($74,800 x 2 seasons) = $149,600**

**Groundwater Monitoring**

| Parameter | No. of Samples | Unit Cost | Total |
|---|---|---|---|
| NO3+NO2 (nitrate+nitrite nitrogen) | 60 | $15 | $900 |
| SRP (soluble reactive phosphorus) | 60 | $15 | $900 |
| NH3 (ammonia nitrogen) | 60 | $15 | $900 |
| TP (total phosphorus) | 60 | $15 | $900 |
| TS (total solids) | 60 | $10 | $600 |
| Cl (chloride) | 60 | $15 | $900 |
| SO4 (sulfate) | 60 | $15 | $900 |
| Alkalinity | 60 | $15 | $900 |
| Na (sodium) | 60 | $10 | $600 |
| Ca (calcium) | 60 | $10 | $600 |
| TOC (total organic carbon) | 60 | $35 | $2,100 |

**Total: $9,500**

- Calculation for no. of samples = 4 locations x 12 events
- Blanks and Duplicates = (1 blank + 1 duplicate)/event

**Labor Estimates**

| Project Task | Field Preparation | Field Work | Data Management | Analysis/Report Writing |
|---|---|---|---|---|
| *Task #1* (Transect Sampling) | $3,200 | $9,120 | $15,200 | $22,400 (160 hrs) |
| | | | | |
| *Task #2* (Stormwater Sampling) | $3,200 | $24,000 | $8,000 | $11,200 (80 hrs) |
| | | | | |
| *Task #3* (Baseline Sampling) | | | | |
| Initial Survey | Included with Task #1 | | | |
| *Long-Term | | | | |
| *Task #4* (Source Tracing) | | | | |
| Internal Loading | $3,200 | $1,200 | $800 | $16,800 (120 hrs) |
| Groundwater | $3,200 | $1,920 | $9,600 | $8,400 (60 hrs) |
| Multi-spectral Imaging | $3,200 | $6,400 | | $11,200 (80 hrs) |

**Total (for initial project): $162,240**

- Assume $80.00/hr Field Staff
- Assume $140.00/hr Senior Scientist (Data Analysis/Report Preparation)
- Time Estimates for each Sampling Program (8 hr work days):
  - Transect Sampling = 3 field staff x 2 days/event x ***19 events***
  - Stormwater Sampling = 3 field staff x 2 days/site x 5 sites x ***10 events***
  - Groundwater Sampling = 2 field staff x 1 day/event x ***12 events***
  - Internal Loading = 3 field staff x 5 days/event x ***1 event***
  - Multi-spectral Imaging = 1 Field Staff x 5 days/event x 2 ***events***
- Assume Field Preparation will take 1 Field Staff 5 days for each event
- Data Management: assume 1 Field Staff @ 10 hrs/event for data entry
- Analysis/Report Writing: assume 1 Senior Scientist

* Long-term baseline sampling is conducted at 4 of the Lake Spokane Reservoir transects on a monthly basis for 5 years (60 months or events) and involve 2 Field Staff for 1 day/event.

## 3.2 Priority of Task Implementation

The monitoring strategies described in this QAPP can be implemented separately in order to reduce the burden of cost. Each of the monitoring strategies will build upon the base of information informing on source and magnitude of non-point pollution in the Ninemile area of WRIA 54. The following is the suggested order for implementing each monitoring strategy:

1. Transect Sampling (nutrient loads)
2. Internal Loads (sediment transport)
3. Multi-Spectral Imaging (nutrient sources)
4. Stormwater Sampling (nutrient sources)
5. Groundwater Characterization (nutrient sources)

# 4.0 Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the types of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality and quantity needed to support specific decisions.

## 4.1 Decision (Data) Quality Objectives

Data, or decision, quality objectives determine when data will be used to select between management alternatives or to determine compliance with a standard. Management decisions for improving lake quality by using monitoring data will require generation of an adequate quantity of data influenced by numbers, locations, and frequency of samples from sites that must be analyzed. A set of data eventually used to make management decisions will meet various standards or comply with minimum requirements of a statistical evaluation and have the ability to distinguish between two environmental conditions (e.g., impaired or not-impaired) with an acceptable level of uncertainty.

The quality of an environmental monitoring program can be evaluated in three steps: (1) establishing scientific assessment quality objectives, (2) evaluating program design to evaluate whether the objectives can be met, and (3) establishing assessment and measurement quality objectives that can be used to evaluate the appropriateness of the methods being used in the program. The quality of a particular data set is some measure of the types and amount of error associated with the data.

Sources of error or uncertainty in statistical inference are commonly grouped into two categories:

1. *Sampling error:* The difference between sample values and in situ "true" values from unknown biases due to sampling design. Sampling error includes natural variability (spatial heterogeneity and temporal variability in population abundance and distribution) not specifically accounted for in a design (for design-based inference), and variability associated with model parameters or incorrect model specification (for model-based inference).
2. *Measurement error:* The difference between sample values and in situ "true" values associated with the measurement process. Measurement error includes bias and imprecision associated with sampling methodology, specification of the sampling unit, sample handling, storage, preservation, identification, instrumentation, and the like.

The data requirements for this project encompass aspects of laboratory analysis and database management to reduce sources of errors and uncertainty in the use of the data. Data needs are determined based on the requirements for making management decisions to protect or improve Lake Spokane water quality and on the criteria for eventual use of lake data in regulating impaired water quality (e.g., 303d listing process). Criteria for identifying impaired lake conditions are based on the current 303(d) Listing Policy developed under delegated authority by the Washington Department of Ecology (http://www.ecy.wa.gov/programs/wq/303d/index.html).

## 4.2 Measurement Quality Objectives

### Type and Frequency of Laboratory Quality Control Samples

For samples analyzed at a commercial laboratory, the type and frequency of the quality control samples to be analyzed are summarized in Table 4.0-1 and Table 4.0-2. Additional quality control sampling will be conducted in the field and is detailed in Section 8.0 Quality Control Procedures.

**Table 4.0-1.** Laboratory quality control samples.

| Type of Quality Control Sample | Description |
|---|---|
| Method Blank | Reagent grade sample matrix analyzed to provide an indication of laboratory contamination. |
| Check Sample | Generally purchased, prepared independently from analytical standards and used to provide an indication of the accuracy of the analytical determination. |
| Laboratory Duplicate | A second aliquot of a sample, processed in exactly the same manner. |
| Matrix Spike | An aliquot of a sample to which known quantities of analytes are added, processed in exactly the same manner. |
| Field Duplicate | A split sample, labeled in a similar manner as regular samples, submitted to laboratory, and processed in exactly the same manner. |

### Precision

Precision is a measure of the scatter in the data due to random error that is expected primarily from sampling and/or analytical procedures. Laboratory duplicates for assessment of precision will be analyzed at a frequency of about 10 percent of the total number of samples submitted to the laboratory or at least one per sample batch. In addition, field duplicates will be collected for approximately 10 percent of samples submitted to the laboratory. For sample results which exceed the reporting detection limit (RDL), the relative percent difference (RPD) will be less than or equal to 20 percent.

This QC calculation also addresses uncertainty due to natural variation and sampling error. Precision is calculated from two duplicate samples by relative percent difference (RPD) as follows:

$$RPD = \frac{|C_1 - C_2|}{Mean(C_1, C_2)} x100$$

where $C_1$ = the first of the two values and $C_2$ = the second of the two values.

For laboratory sample results with values less than 5 units, the precision criterion will be less than or equal to 1.5 units rather than the RPD to account for the effect of smaller values on percent differences. No criteria are presented for duplicates which are below the RDL, as these data are provided for informational purposes only. For instance, where one result is below the RDL, professional judgment will be used in determining the compliance of the data to project requirements.

**Table 4.0-2**. Frequency of laboratory quality control samples.

| Parameter | Matrix | Check Standards | Method Blanks | Analytical Duplicates | Matrix Spikes | Field Duplicates |
|---|---|---|---|---|---|---|
| Total Phosphorus | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Soluble Reactive Phosphorus | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Ammonia | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Total Nitrogen | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Chlorophyll-*a* | Water | N/A | N/A | One per analysis batch of 20 samples | N/A | Minimum 10% of samples |
| Turbidity | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Total Solids | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Alkalinity | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Hardness | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Calcium | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Sodium | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Nitrate+Nitrite-N (Total Persulfate Nitrogen) | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |
| Chloride | Water | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples | Minimum 10% of samples |

NA ~ not applicable

**Bias**

Bias provides an indication of the accuracy of the analytical data, as provided by both method blanks and percent recovery of target analytes from reagent and field sample matrix. Check samples will be used to provide compliance criteria for bias. The percent recovery of the matrix spikes and standard reference materials will be less than or equal to +/- 20 percent.

Method blank samples will be analyzed with each batch of samples. Results for method blank samples should be less than the minimum detection limit for each parameter.

**Accuracy**

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures. Sample handling procedures and procedures for verification of data influence the accuracy of results.

Analytical laboratory accuracy is normally determined by the percent recovery of the target analyte in spiked samples and also by the recoveries of the surrogates in all samples and Quality Control samples. Laboratory accuracy ranges are specified in the contract laboratory Quality Management Plan and depend on the parameter being measured. Accuracy is calculated as follows:

$$\%Rec = \frac{\text{Analyzed value}}{\text{True value}} \times 100$$

The Spokane County Technical Lead will ensure the contract laboratory accuracy by meeting %Recovery (Rec) values specified by EPA methods and listed in Table 4.0-3.

In addition, performance of field equipment and operation of meters will be evaluated by meeting relative percent difference goals for each of the parameters (Table 4.0-4). Accuracy for field measurements cannot be measured directly, but can be evaluated based on description of equipment performance.

**Table 4.0-3.** Measurement quality objectives for laboratory analysis.

| | Precision | | Bias/Accuracy | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Analytical Duplicate Samples** | **Field Duplicate Samples** | **Check Standard (LCS)** | **Matrix Spikes** | **Method Blanks** | **Lowest Concentrations of Interest** |
| | **Relative Percent Difference (RPD)** | **Relative Percent Difference (RPD)** | **% Recovery Limits** | **% Recovery Limits** | **Units** | **Units of Concentration** |
| **Surface Water** | | | | | | |
| Total Phosphorus | ±20 [a] | ±20 [a] | ±10 | ±20 | < RL | Reporting Limit [b], µg/L |
| Soluble Reactive Phosphorus | ±20 [a] | ±20 [a] | ±10 | ±20 | < RL | Reporting Limit [b], µg/L |
| Ammonia | ±20 [a] | ±20 [a] | ±10 | ±20 | < RL | Reporting Limit [b], µg/L |
| Total Nitrogen (Total Persulfate Nitrogen) | ±20 | ±20 | ±10 | ±20 | < RL | Reporting Limit [b], µg/L |
| Turbidity | ±5, greater at low levels | ±5, greater at low levels | N/A | N/A | N/A | NTU |
| Total Solids | ±20 [a] | ±20 [a] | N/A | N/A | N/A | mg/L |
| Chlorophyll-*a* | ±20 [a] | ±20 [a] | N/A | N/A | N/A | Reporting Limit [b], µg/L |
| Chloride | ±20 | ±20 | ±10 | ±20 | < RL | mg/L |
| Nitrate-nitrite | ±20 | ±20 | ±10 | ±20 | < RL | Reporting Limit [b], µg/L |
| Alkalinity | ±20 [a] | ±20 [a] | ±10 | N/A | N/A | Reporting Limit [b] mg/L as $CaCO_3$ |
| Hardness | ±20 [a] | ±20 [a] | ±5 | ±20 | < RL | mg/L |
| Calcium | ±20 [a] | ±20 [a] | ±5 | N/A | < RL | mg/L |
| Sodium | ±20 [a] | ±20 [a] | ±5 | N/A | < RL | mg/L |
| **Sediment** | | | | | | |
| TP | ±20 [a] | | ±10 | N/A | < RL | mg/kg |
| SRP | N/A | N/A | N/A | N/A | N/A | N/A |
| Mobile P | ±20 [a] | | ±10 | N/A | < RL | mg/kg |
| TOC | ±20 [a] | ±20 [a] | ±10 | N/A | < RL | mg/kg |
| % Solids/HOA | ±20 [a] | N/A | ±10 | N/A | < RL | % |
| Fe-P (iron-bound phosphorus) | ±20 [a] | N/A | ±10 | N/A | < RL | mg/kg |
| Al-P (Aluminum-bound phosphorus) | ±20 [a] | N/A | ±10 | N/A | < RL | mg/kg |

[a] For sample results with values of less than 5 units, the precision criterion will be less than or equal to 1.5 units rather than the RPD to account for the effect of smaller values on percent differences.

[b] The Required Reporting Limit (or Minimum Detection Limit) is listed in Table 5.0-1.

**Table 4.0-4**. Measurement quality objectives for field measurements.

| | **Precision (from replicate measurements** | **Bias/Accuracy** | **Lowest Values of Interest** |
|---|---|---|---|
| **Parameter** | **Relative Percent Difference (RPD)** | **(% Recovery) (deviation from true value)** | **Units of Measurement** |
| Dissolved Oxygen (meter) | 5 | N/A | Minimum detection limit [b] |
| Dissolved Oxygen (LDO)[C] | 10 | N/A | Minimum detection limit [b] |
| Conductivity | 5 | N/A | Minimum detection limit [b] |
| pH | 5 | N/A | 4.0 units |
| Temperature | 5 | N/A | 0 $^{o}$C |
| Secchi Disk Transparency | 0.1 m[a] | N/A | 0.1 m |
| River and Lake Level | 0.5 inches | N/A | 0.5 inches |

[a] Replicate Secchi Disk measurements should be within 0.1m.
[b] The Minimum Detection Limit is listed in Table 5.0-1.
[C] Luminescent Dissolved Oxygen probe.

# 5.0 Sampling Process Design (Experimental Design)

## 5.1 Sampling Design and Rationale

Nutrient introduction into Lake Spokane has been identified as a primary cause for low dissolved oxygen concentrations during portions of the year. Control of the nutrient input has been partially addressed with allocation of treated effluent discharge from permitted facilities along the main stem of the Spokane River above Lake Spokane. In addition, the TMDL completed in 1998 by Ecology has suggested elimination of on-site septic systems and development of a regional non-point source pollution reduction program. A comprehensive evaluation of nutrient introduction from non-point sources, however, has not been completed and a strategy for measuring this input is described here in further detail.

An overview of potential sources for nutrient introduction has been described in detail in Section 2.0. This discussion also suggests biological evaluations (e.g., periphyton) be used to detect subtle response from non-point nutrient sources and if increased concentrations of P are contributing to degradation of water quality. The proposed monitoring strategies address each of the potential sources of non-point nutrient contributions and methods that would detect presence of this pollutant and directly address tasks described in Section 2.0. The Sampling Process Design is described here based on each of these tasks:

**Task 1**. Evaluate potential impact of non-point sources of nutrients on surface water quality within Lake Spokane.

Several transects are identified for characterization of nutrient load at points along the lake and from various input sources proposed for monitoring in this QAPP. The location of transects at points along Lake Spokane represent a method for sampling that isolates input from distinct land uses and tributaries that convey nutrients during stormwater runoff events and through groundwater contributions. Measurements made at each of the transects and through additional input characterizations will include loading estimates so that perspective on percentage of contributions can be described.

Also, characteristic yields (and/or runoff concentrations) of TP from land-use types have been used to fractionate stream TP loads determined in respective watersheds containing these land-uses. Such a procedure has been used to determine absolute loads from respective areas of land-use types in the watershed for Lake Sammamish (Perkins et al. 1997).

The following is a list of land uses recognized in the Lake Spokane basin that may have some influence in modifying water quality before reaching surface water and that enable partitioning of effects from each:

- Agriculture (crop and pasture)
- Residential/Suburban Development (stormwater/septic inputs)
- Grassland (serves as background conditions)
- Forested

**Task 2**. Evaluate potential impact of stormwater runoff within the study area on surface water quality within Lake Spokane.

Stormwater nutrient inputs will be estimated by considering obvious points for conveyance to Lake Spokane. Location of sites for measuring surface water that has potential to reach the lake are as follows:

- Stormwater outfalls (especially in developments)
- Gullies
- Small tributaries

**Task 3.** Establish baseline water quality and long-term monitoring program to evaluate deviation from background concentrations.

Surface and groundwater entering the Lake Spokane basin from upstream have elevated input of nutrient pollution concentrations that are well-documented in WDOE (2003). Determining baseline conditions for comparison to other locations within the Lake Spokane basin will be based on information collected from one of the 7 lake transects described earlier in Task 1. The location of this transect will be at Nine Mile Bridge (at Charles Rd.) and serve as a baseline for comparisons between successive transect conditions. This comparison between the baseline and other transects is important in order to determine direction of change in water quality characteristics.

**Task 4.** Identify the source for any elevated levels of non-point source pollutants identified through this or other monitoring programs.

Several non-point pathways for introduction of nutrients into Lake Spokane exist and will be measured for contribution to the nutrient load. Past monitoring has focused on characterizing surface water conditions throughout the lake water column. This type of characterization of water quality is continued as part of Task 1 with additional sources measured as follows:

**Internal loading**
TP introduction into the water column from the sediment as source of internal loading will be determined with a TP mass balance on the two upper reservoir zones and by a bath tub type mass balance model. Also, core sediment samples will be collected to characterize P fractions at incremental depths in each sediment core.

**Multi-Spectral Imaging**
Temperature differences between groundwater input and the receiving surface water of the lake will be identified through a series of images that measure heat throughout a broad range of the light spectrum. Each range of the light spectrum is sensitive to specific temperature ranges and magnitude of difference between input and receiving water source. The advantage of using multi-spectral imaging is the applicability for determining groundwater-surface water exchange in each of the seasons.

The spectral bands used to examine influence of groundwater as it emerges into surface water extends to the adjacent landscape. The imaging used in this method will identify areas on the landscape that serve as sources for nutrient pollution along the shoreline of Lake Spokane. The

following are the spectral bands that will be considered for examination of nutrient pollution along the shoreline:

| | |
|---|---|
| Blue | wavelength from 450-520 nm (nanometers) |
| Green | wavelength from 515-600 nm |
| Red | wavelength from 600-690 nm |
| Near-Infrared | wavelength from 750-900 nm |
| Mid-Infrared | wavelength from 1550-1750 nm |
| Mid-Infrared | wavelength from 2080-2350 nm |
| Thermal Infrared | wavelength from 10,400-12,500 nm |

Combinations of two or more of these wavelengths will be combined in order to discern specific nutrient conditions originating from the landscape and into the surface water.

**Groundwater**

Groundwater characterization will be completed by collection of water samples and by determining the direction of flow (e.g., groundwater-surface water exchange). Multi-spectral imaging is useful for determining location and extent of incoming groundwater to Lake Spokane and groundwater sampling sites will be established by using the former as guide for site determination.

**Task 5.** Evaluate the effectiveness of water quality BMPs in protecting downstream water quality.

Evaluation of BMP (Best Management Practices) effectiveness along with site location and frequency of monitoring is determined from site-specific conditions. Application of specific BMPs in locations throughout the Lake Spokane basin will be determined once the monitoring effort is complete. The BMP Guidance produced by the WDOE (2006) provides examples for establishing an effectiveness monitoring program in addition to a comprehensive list of additional guidance documents located in the appendix.

- Use Ecology (WDOE 2006) Monitoring Guidance for evaluating effectiveness of BMPs from CAFO and Dairy Operations.

**Task 6.** Describe an educational component, such as a volunteer monitoring program.

Volunteer assistance with monitoring effort will provide two beneficial results: 1) greater awareness of issues and pollution elimination challenges in the Lake Spokane basin, and 2) valuable field assistance to technical professionals conducting large, and complex sample collection programs. The assistance of field volunteers can be extended, in some cases, to management of data and in preparation of information for final analysis. Volunteers will be supervised by technical professionals during each step of the monitoring program to ensure compliance with measurement quality objectives (MQOs) and in documentation of field observations, field instrument calibration, and chain-of-custody procedures for sample shipment to the contract laboratory.

## 5.2 Sampling Locations and Frequencies

The first four tasks described in Section 5.1 require collection of chemical data and spectral imaging. In some cases (e.g., Task 1 and Task 2) efforts for data collection can be used to address objectives established for each of these tasks. The following description of proposed study sites and design for sampling (at discrete sites/transects) are presented in descriptive and map form (Figure 5.2-1). The proposed transect locations and discrete sites for sampling will be field-verified prior to final location. Once selections are made for sites they will be monumented by using a GPS locational unit demarcating both ends of a transect or a single location for discrete sites.

**Task 1.** Evaluate potential impact of non-point sources of nutrients on surface water quality within Lake Spokane.

A cross-sectional profile of Lake Spokane will be characterized at each of seven transects and at the mouth of a major tributary (Little Spokane River). These transects will be used to estimate nutrient loads moving between transects and input sources from tributaries, groundwater flow, and stormwater events. The following descriptions provide detail for location and frequency of sample collection:

- Establish 8 Transects (grouped as riverine/transition/lacustrine in main stem Lake Spokane):
- 7 transects along Lake Spokane (3 – riverine; 2 – transition; 2 – lacustrine)
    a. 1 transect at bottom end of Little Spokane River
- Transect Sampling:
    a. 1 site at each bank (location to provide a surface, 1m, 2m, and 3m sample) [Left bank & Right bank]
    b. 1 site in the middle of the transect (determine the thalweg from the river) [water column profile at middle site on each transect]
- Use time-of-travel to determine timing for transect site visits
    a. use CW-Qual-2E model for determining time of travel between transects
    b. compare adjacent transects to determine change in analytes
- Parameters characterized:
    NO3+NO2 (nitrate+nitrite nitrogen)
    NH3 (ammonia nitrogen)
    SRP (soluble reactive phosphorus)
    TP (total phosphorus)
    TS (total solids)
    Cl (chloride)
    SO4 (sulfate)
    Alkalinity
    Na (sodium)
    Ca (calcium)
    TOC (total organic carbon)
    Chl-*a* + speciation and enumeration of phytoplankton (chlorophyll-*a)*
    Lake Level

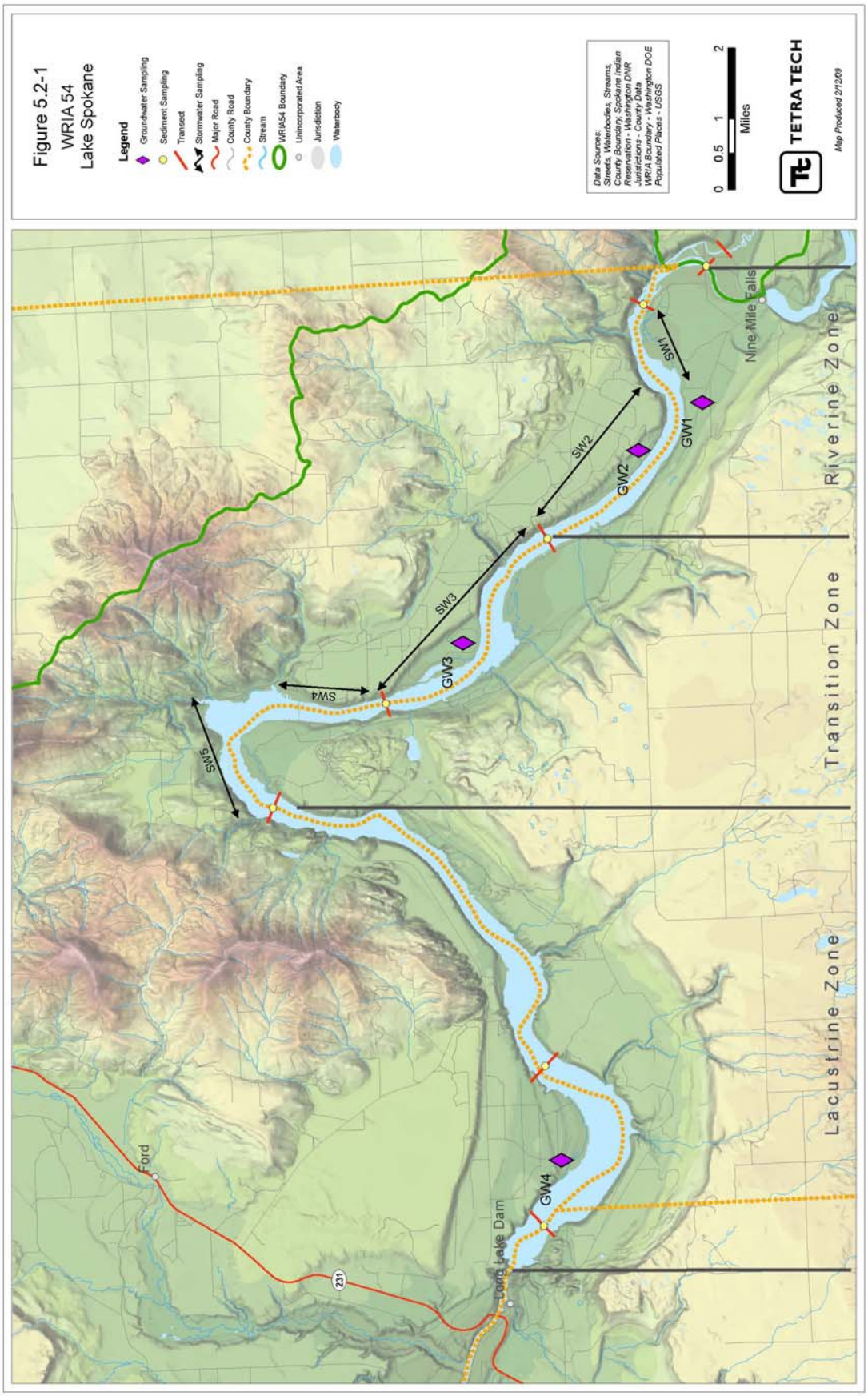
Figure 5.2-1
WRIA 54
Lake Spokane
Legend
Groundwater Sampling
Sediment Sampling
Transect
Stormwater Sampling
Major Road
County Road
County Boundary
Stream
WRIA54 Boundary
Unincorporated Area
Jurisdiction
Waterbody
Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Region Recreation Water Bodies - DNR
Jurisdictions - County Data
WRIA Boundary - Washington DOE
Populated Places - USGS
0 0.5 1 2
Miles
TETRA TECH
Map Produced 2/12/09
Nine Mile Falls
Riverine Zone
Transition Zone
Lacustrine Zone
Long Lake Dam
Ford
231
SW1
SW2
SW3
SW4
SW5
GW1
GW2
GW3
GW4

**Task 2.** Evaluate potential impact of stormwater runoff within the study area on surface water quality within Lake Spokane.

Five intermittent creek sites and/or swales will be identified (mainly on the north side of Lake Spokane) to characterize input of nutrients during storms of various intensities and duration. These five sits represent likely stormwater outfalls from above and below the residential developments, gullies emptying into Lake Spokane, and from campground areas at approximately a mid-way distance down the lake. The samples will be characterized for nutrient concentrations and contribution of load (if possible; requires establishment of flow-rating curve or instantaneous flow measurements during beginning and end of the sampling interval for each storm event). The following description details the sampling sites and frequency of visits necessary to characterize stormwater contribution to the nutrient load:

- Parameters (same as above for Task 1)
- 5 Creek sites and/or swales visited during multiple storm events.
- Storm events include short-duration thunderstorms and long-duration general storms.*
- Hourly/bi-hourly samples collected for a 24-hr period from the beginning of each storm event.

* The short-duration thunderstorm occurs in Eastern Washington from late spring through early fall. These thunderstorms produce high intensity rainfall in localized areas for brief periods of time. The long-duration general storm occurs mostly from late fall through the winter months in Eastern Washington. These long-duration storms are punctuated by dry periods between rainfall events and last for up to several days. (storm event descriptions are cited from the Stormwater Management Manual for Eastern Washington 2004)

**Task 3.** Establish baseline water quality and long-term monitoring program to evaluate deviation from background concentrations.

Sampling effort is the same described for Task 1 above. The purpose for future comparisons of conditions at this transect to successive locations is to determine how nutrient load changes over space and time (e.g., seasons or years). This transect serves as background for determining change in nutrient loads.

- Background Condition will be established from characterization of surface water quality at Nine Mile Bridge (Charles Rd.)

In addition, a long-term monitoring program will be established by sampling at select transects identified for Task #1. Transects that will be sampled are:

- Transect #1 (Ninemile Bridge)
- Transect #2 (below confluence with Little Spokane River)
- Transect #4 (below sub-urban residential development)
- Transect #6 (before deep-water region of Lake Spokane)

Samples will be collected from surface-, mid-depth, and near the bottom from the thalweg along each transect. Periphyton samples will be collected along the margins of each of these transects.

**Task 4.** Identify the source for any elevated levels of non-point source pollutants identified through this or other monitoring programs.

Three sampling programs are described for meeting objectives outlined for Task 4: internal loading, groundwater sampling, and landscape analysis through multi-spectral imaging. Each of the sampling programs will isolate contribution of nutrients to Lake Spokane and describe the timing and location for non-point source nutrient input. The following descriptions for each monitoring program are as follows:

Internal Loading:

- Sediment coring at each of the seven transect sites on Lake Spokane described in Task 1.
- Location of sediment coring at thalweg location along each transect.
- 3 replicates of sediment samples collected at each transect site.
- Analysis for parameters in cores at discrete depths [0cm, 5cm, 10cm, 15cm, 20cm, 25cm, 30cm]
- Parameters analyzed for each core interval above:
  - TP
  - SRP
  - Mobile P
  - TOC
  - % Solids/HOA
  - Fe-P (iron-bound phosphorus)
  - Al-P (aluminum-bound phosphorus)

Multi-Spectral Imaging:

- Imaging from all shorelines in Lake Spokane
- Multiple spectrum evaluation of shoreline surface water conditions will enable differentiation of receiving water temperature/groundwater temperature mixing
- Results from interpretation of multi-spectral images used to establish groundwater sampling locations in receiving water (establish a grid network to determine shape and extent of the groundwater plume).

Groundwater:

- Site locations for deployment of sampling devices based on shoreline development (size of development and placement in the Lake Spokane basin)
- Piezometers used for collecting water samples; seepage meters used for determining direction of flow (into/out of the ground with respect to surface water)
- One piezometer per site; one seepage meter per site
  Parameters for analysis same as for Task 1.

## 5.3 Order (Timing) of Sampling

Non-point source pollutants enter Lake Spokane at different seasons throughout the year with mobility influenced primarily by climatic events. Each of the tasks addresses potential source

and pathway for introduction of nutrient pollution into Lake Spokane and accounts for optimal time of year when pollution is either detectable or loading is greatest to surface water. In some cases, a division of the year that differentiates wet- from dry seasons is used as a contrast to estimate the magnitude of nutrient pollution load introduced during a time period. Distinguishing seasons and differences in pollution load is used as a guide to suggest abatement of pollution by using BMPs (best management practices).

The following are descriptive examples for sampling dates and frequencies suggested for satisfying study objectives in each of the tasks (graphical presentation of sampling frequency and timing is presented in Table 6.1-1):

**Task 1**

- Sampling Intervals
  Nov – March (monthly visits)
  April – October (every two weeks)

**Task 2**

- Rainfall events and frequency of monitoring effort:
  Oct. – Dec. rainfall (3 events)
  Feb. – April snowmelt (3 events)
  May – June (2 events)
  July – Oct. (2 events)

**Task 3**

- The same sampling strategy, frequency of sampling, and parameters measured will be used along the uppermost transect identified in Task 1 to characterize background condition.
- The long-term monitoring program will be implemented during the interim between years when intensive transect sampling occurs. Monitoring at the thalweg location along Transects 1, 2, 4, and 6 and at surface, mid, and bottom depths will occur monthly for at least five-year intervals.
- Periphyton will be collected from natural substrate once per year along margins of Transect 1, 2, 4, and 6.

**Task 4**

Internal Loading:

- Sediment coring at each of the seven transect collected once during August.

Multi-Spectral Imaging:

- Imaging completed for select seasons (late spring and fall)

Groundwater:

- Sample collection each month.
- Parameters for analysis same as for Task 1.

## 5.4 Representativeness

Sample representativeness will be addressed at two distinct steps in the data collection process. During sample collection, the use of generally accepted sampling procedures in a consistent

manner throughout the project will ensure that representative samples are obtained. During sub-sampling within the laboratory, samples will be mixed by inverting several times to ensure that the analytical sub-sample is representative of the sample container contents.

**Lake Spokane Water Quality**

Representativeness will be achieved through collection of samples aimed at capturing the complexity and dynamics of the lake. Lake Spokane will be sampled to characterize water quality at multiple depths to adequately describe nutrient levels and other conditions related to dissolved oxygen. Sampling will be concentrated during summer to determine worst-case conditions and magnitude of internal P loading.

**Tributaries**

Data will be gathered to characterize water quality constituents during dry and wet seasons of the year. Sample collection will be conducted less frequently during the dry season as ambient conditions remain similar throughout this period of time. Sample collection will increase in frequency during wet season portions of the year in order to characterize ambient conditions and the influence from stormwater events. Stormwater samples will be collected with automated sampling devices (e.g., ISCO® samplers) in order to characterize storm events that present combinations of duration and intensity (i.e., distribution of precipitation quantity with time). Additional detail is provided for description of storm events in Eastern Washington and the characteristics that will be described by stormwater monitoring (see Section 5.2, Task 2). Loading estimates will be separated into base and storm flow.

**Multi-Spectral Imaging of Lake Spokane Shoreline**

Sources of non-point nutrient input will be identified by describing the fractions originating from: the Spokane River (upstream), internal loading within the lake (sediment origins), and from groundwater sources along the lake shoreline. Presence of nutrients from adjoining land will reveal relative levels through coloration and intensity on the multi-spectral images. The groundwater sources of nutrients will be described using surrogate measures as markers (e.g., thermal imaging, Cl content) that indicate the presence and intensity of groundwater contribution to surface water of Lake Spokane.

Multi-spectral imaging will reveal the locations of groundwater input by examining several distinct spectral ranges. Each of the spectral images provides some evidence for the presence of groundwater input by revealing colorimetric contrasts between lake water and groundwater. The combination of images generated for this analysis will provide a detailed description for spatial extent of groundwater input.

## 5.5 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and are entered into the data management system. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Therefore, every effort is made to avoid accidental or inadvertent sample or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data. Samples will be stored and transported in unbreakable (plastic) containers wherever possible. All sample processing (sub-sampling, sorting, identification, and enumeration) will occur in a controlled environment within the laboratory. Field personnel will assign a set of continuous identifiers to a batch of samples.

Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} x100$$

where $V$ = the number of measurements judged valid and $T$ = the total number of measurements taken

For this project, sampling will be considered complete when no less than 90 percent of the samples collected during a particular sampling event are judged valid. At any time where data are not complete, decisions regarding re-sampling and/or re-analysis will be made by Spokane County. These decisions will take into account the project data quality objectives as presented above.

Completeness will also be judged by comparison to the monitoring parameters and frequency laid out in the monitoring schedule. For this criterion, completeness is defined as the number of measurements taken divided by the number of measurements scheduled. While the goal for this criterion is 100 percent completeness, a lower percent completeness may be acceptable for a volunteer monitoring program.

## 5.6 Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, SOPs (Standard Operating Procedures), and QA (Quality Assurance) guidelines.

Data comparability generated throughout the Nine Mile Study Area will be ensured through application of standardized sampling procedures and convergence with methods and practices of existing monitoring programs (e.g., Washington Department of Ecology), analytical methods (e.g., state-accredited laboratories), units of measurement, and detection limits. The sampling results will be tabulated in a database for comparison between sampling events and sampling sites.

Method detection limits and laboratory methods for surface water quality variables analyzed in the Nine Mile Area Non-Point Source Monitoring Program are listed in Table 5.0-1.

**Table 5.0-1.** Reporting limits and analytical methods for surface water and sediment data.

| Water Quality Parameter | Units | Minimum Reporting Limit | Accuracy | Method |
|---|---|---|---|---|
| **Surface Water** | | | | |
| Total Phosphorus, TP | µg/L | 2.0 | ±2 | EPA 365.1 |
| Soluble Reactive Phosphorus, SRP | µg/L | 1.0 | ±2 | EPA 365.1 |
| Nitrate+Nitrite-N | µg/L | 10 | ±10% | EPA 353.2 |
| Total Nitrogen (Total Persulfate Nitrogen) | µg/L | 50 | ±10% | SM 4500 |
| Ammonia-N | µg/L | 5.0 | ±10% | EPA 350.1 |
| Total Solids | mg/L | 5.0 | ±10% | EPA 160.3 |
| Chlorophyll-*a*, Chl *a* (speciation) | µg/L | 0.1 | ±0.5 | SM1810200 |
| Secchi Disk Transparency | m | 0.1 | ±0.2 | Black/White Secchi Disk |
| Turbidity | NTU | 0.10 | ±10% | EPA Method 180.1 |
| Chloride | mg/L | 0.50 | ±10% | EPA 325.3 |
| Alkalinity | mg/L | 1.00 | ±10% | EPA 310.1 |
| SO4 | mg/L | 1.00 | ±10% | EPA 375.4 |
| TOC | mg/L | 0.250 | ±10% | EPA 415.1 |
| Ca | mg/L | 0.100 | ±10% | EPA 200.7 |
| Na | mg/L | 0.300 | ±10% | EPA 200.7 |
| Temperature | ºC | 0.5 | ±0.5 | [a] Thermometer |
| | | 0.01 | ±0.1 | [a] Thermistor |
| Dissolved Oxygen | mg/L | 0.2 (test kit)<br>0.01 (meter) | ±0.4 (test kit)<br>±0.2 (meter) | Winkler titration or dissolved oxygen meter |
| pH | pH units | 0.1 | ±0.2 | pH meter |
| Conductivity | µmhos/cm | 5 | ±1 | Conductivity meter |
| [b] River/Lake level | inches | 0.5 | ±0.5 | Depth gage |
| **Sediment** | | | | |
| TP | mg/kg | 5.00 | ±20% | EPA 351.1, EPA 365.1 |
| Mobil-P | mg/kg | 2.00 | ±20% | WELCH & RYDIN |
| TOC | % | 0.10 | ±20% | EPA 9060 |
| % Solids/HOA | % | 1.0 | ±10% | EPA 160.3 |
| Fe-P (iron-bound phosphorus) | mg/kg | 2.00 | ±20% | WELCH & RYDIN |
| Al-P (Aluminum-bound phosphorus) | mg/kg | 2.00 | ±20% | WELCH & RYDIN |

Note:
[a] Calibration of the field thermometer will occur twice annually (e.g., once during the cold season and once during the hot season) using a NIST-approved calibration thermometer.
[b] Select locations of the main stem river, tributary, and lake will be monitored for level (staff gage, wire weight gage, or tape down) in order to estimate flow for determining loading estimates of nutrients and other pollutants.

# 6.0 Sampling Procedures

Sampling methods focus on characterization of surface water chemistry (e.g., dissolved oxygen and pH) and some of the physical properties (e.g., temperature and conductivity). The collection of samples prescribes collection periods, handling procedures, and identification procedures that minimize and identify systematic error in the Nine Mile Area Non-point Source Monitoring Study. Performance expectations of the samplers described in this section records information that can be used for data verification and validation.

Achieving accuracy in data generation begins with a sampling procedure that is well conceived, described, and carefully implemented (WSDOE 2001). The sampling locations, sample types, sampling equipment, and methods were briefly described in *Section 2.0 Project Description*. This section of the QAPP discusses the details of the sample collection method and the sample handling and labeling procedures (U.S. EPA 1990).

## 6.1 Sampling Schedule

Lake and river sampling will occur in three Index Periods: one characterizing stable, low flow periods from mid-July through mid-October, and the second from mid-March through end of June to characterize spring runoff, and the third from November through end of February to characterize stormwater runoff events. Measurements will be taken at pre-determined locations for characterizing water quality in each component of the study area and during specific periods of the year (e.g., optimal times for characterizing water quality conditions) based on information reported in Table 6.1-1.

**Table 6.1-1.** Monitoring schedule in WRIA 54 and timing/frequency for collection of samples.

| Sampling Routine | Jan. | Feb. | Mar. | Apr. | May | Jun | Jul | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task #1 | Monthly | | | Every 2 weeks | | | | | | | Monthly | |
| Task #2 | | 3 events | | | 2 events | | 2 events | | | 3 events | | |
| Task #3 (Initial Survey) | Monthly | | | Every 2 weeks | | | | | | | Monthly | |
| Task #3 (Monthly Sampling) | Monthly Sampling for Long-Term Monitoring (Transects 1, 2, 4, and 6) | | | | | | | | | | | |
| Task #3 (Periphyton) | Once per year (August) | | | | | | | | | | | |
| Task #4a | | | | | | | | Once | | | | |
| Task #4b | | | | One Set | | | | | | One Set | | |
| Task #4c | Monthly | | | | | | | | | | | |

Note:

Task #2 - Volunteers can assist with operating automated sampling devices.
Task #4a - Internal Loading evaluation from upper Lake Spokane sediments.
Task #4b - Multi-Spectral Imaging evaluation along the shoreline.
Task #4c - Groundwater characterization.

## 6.2 Sample Collection and Handling

Recommended sample sizes, containers, preservation techniques, and holding times for measurement of the conventional water quality parameters are listed in Table 6.2-1. Sample containers will be kept closed until each set of sample containers is filled. All samples will be placed immediately in a cooler and kept cool and dark until delivered to the lab.

Water samples will be collected for each monitoring program using specific devices that minimize potential for contamination and that enable samples to be collected safely. Each of the monitoring programs presents challenges in locating and collecting a representative water sample. The following collection devices and locations for sampling will be used for each monitoring program:

1. Ambient Main stem River and Tributary Sampling: cleaned collection vessel from boat, bank or bridge location
2. Internal Loading: Van Veen grab (sediment) and Van Dorn bottle (surface water)
3. Stormwater: cleaned collection vessel from bank or bridge location
4. Groundwater: Piezometer (in-ground) and bank sample (receiving water)
5. Shoreline: bank sample (shallow depths) and Van Dorn bottle (deeper water)

Note:

a. Bank sampling will be conducted by filling collection bottles supplied by the contract laboratory.
b. Bridge samples will be collected with a collection bucket (stainless steel or HDPE) and cleaned with either 10% HCL or 10% $H_2SO_4$.
c. Van Veen sediment grab and Van Dorn surface water sampler are dropped from a boat in order to collect samples.

Total phosphorus, soluble reactive phosphorus, and chlorophyll-*a* samples will be collected in polyethylene or glass bottles provided by the laboratory. Sample bottles and laboratory glassware for lake-related sampling shall be reserved for ultra-low P waters (i.e. lakes) and can never be used for sampling or analyzing wastewater or agricultural runoff where there is a potential to exceed 100 µg/L. All sample bottles are to be acid washed with 1N HCL six times followed by 6 rinses with de-ionized water (for low-level nutrient analysis and to ensure acid is rinsed away, especially in soft water). A small amount of magnesium carbonate will be added to the chlorophyll-*a* sample bottles for preservation. Dissolved oxygen samples will be collected in glass bottles.

Whenever possible, samples will be processed within the recommended holding time. However, when volunteers are available for monitoring duties there may be a delay on delivery of samples when collected on weekends; not delivered to the laboratory until Monday. This would exceed the recommended holding time for select variables like chlorophyll *a*, turbidity, and soluble reactive phosphorus samples. Lab results from samples exceeding holding times may be accepted as usable data depending on sample storage conditions following collection. Data Management Section 9.0 further outlines how to record variation from QAPP protocol or DQOs (Data Quality Objectives).

**Table 6.2-1**. Containers, preservation techniques, and holding times for measurement of water quality and sediment parameters.

| Parameters | Sample Container | Sample Volume | Preservation | Recommended Holding Time |
|---|---|---|---|---|
| **Surface Water** | | | | |
| Total Phosphorus | Polyethylene, Glass | 50 ml | Cool, <4ºC | 28 days |
| Soluble Reactive Phosphorus | Polyethylene, Glass | 125 ml | Filter within 12 hours, Cool <4ºC | 48 hours |
| Total Nitrogen | Polyethylene, Glass | 125 mL | Cool,<4° C | 28 days |
| Ammonia | Polyethylene, Glass | 125 mL | Cool,<4° C | 48 h |
| TOC | HDPE | 1 L | Cool,<4° C | 28 days |
| Turbidity | HDPE | 2 L | Cool, <4° C | 2 days |
| Totals Solids | Polyethylene | 1000 mL | Cool, <4° C | 7 days |
| Calcium | HDPE | 250 mL | HNO3 | 6 months |
| Sodium | HDPE | 250 mL | HNO3 | 6 months |
| Chlorophyll-*a* | Polyethylene, Glass | 1000 ml | Cool, 4ºC 0.2% saturated $MgCO_3$ | Filter within 24 hours |
| Nitrate-nitrite | Polyethylene, Glass | 125 mL | Cool, 4° C | 48 h |
| Alkalinity | Polyethylene, Glass | 100 mL | Cool, 4° C | 14 days |
| Hardness | HDPE | 250 mL | Cool to 4°C, HNO3 | 6 months |
| Chloride | HDPE | 100 mL | Cool, <4° C | 28 days |
| **Sediment** | | | | |
| TP | Polyethylene, Glass | 10 g | Cool, <4° C | 28 days |
| Mobile P | Polyethylene, Glass | 10 g | Cool, <4° C | No regulation, 28 days |
| TOC | Polyethylene, Glass | 10 g | Cool, <4° C | 28 days |
| % Solids/HOA | Polyethylene, Glass | 10 g | Cool, <4° C | 6 months |
| Fe-P (Iron-bound phosphorus) | Polyethylene, Glass | 10 g | Cool, <4° C | No regulation, 28 d |
| Al-P (aluminum-bound phosphorus) | Polyethylene, Glass | 10 g | Cool, <4° C | No regulation, 28 d |

## 6.3 Field Recording Methods

When visiting a sampling station, the sample collector will record the following information on water-proof field sheets. Detailed information on field observations should include the following:

- Date
- Time
- Names of sampling personnel
- Number/type of samples collected
- Weather
- Descriptions of any photographs taken
- On-site field measurement (e.g., Secchi disk depth, temperature, water level)
- Algal and aquatic plant abundance
    - (include identification of observed plant species, note location with a GPS reading, record depth of plant community, and estimate stem count per unit area; for positive species identification wrap plant sample in a moist paper towel, place in freezer bag, and transport to laboratory for storage in a refrigerator)
- Color of water
- Unusual conditions (changes in land uses, presence of oil sheens, odors, nuisance conditions).

## 6.4 Sampling Identification and Custody

Each sample bottle will have a waterproof sample identification label or tag. All sample bottles will be labeled with an indelible marker before the time of collection. Sample labels will include station designation, date, time, collectors' initials and type of sample. Special analyses to be performed and any pertinent remarks will also be recorded on the label.

All water quality samples will be delivered by courier to the contract commercial laboratory. Samples will be accompanied by the sample tracking forms with sample numbers, requested analyses, number of bottles, bottle sizes and contact information. An example of the sample tracking (or Chain-of-Custody) form that may be used for the Nine Mile Area Non-Point Source Monitoring Program is presented in the Appendix D.

Water samples will be collected, placed in the labeled transfer bottles, and delivered to the laboratory as soon as possible following collection. A list of bottleware for each parameter, including the container types and preservatives, that will be supplied by the laboratory and used to collect samples is in Table 6.2-2. This table also lists handling requirements for samples collected in the Nine Mile study area. The samples taken for laboratory analysis will be stored in coolers containing re-sealable bags of ice. The temperature inside the coolers and acid preservation for samples will be verified by the receiving laboratory as a component of field quality control.

All samples will be transferred to the receiving analytical laboratory using Chain of Custody forms. The sample Chain of Custody form (included in Appendix D) acts as a record of sample

shipment and a catalog of the contents of each shipment (coinciding with information on the field record), in addition to maintaining a complete record of evidentiary custody transfer. It will contain the following, at a minimum:

- Sampler's name
- Project name
- Page number (e.g., 1 of 1)
- Sample location (facility name, waste stream, sampling point)
- Collection date and time
- Sample number
- Number of containers
- Type of analysis required
- Laboratory recipient signature
- Laboratory receipt date and time

Immediately following the packing of each shipping container, each container (cooler) will be secured with packaging tape.

# 7.0 Measurement Procedures

All analysis methods used for this project are approved standard analytical methods approved for use by the EPA and Ecology (Table 5.0-1). Water quality parameters including pH, dissolved oxygen, conductivity and temperature will be measured in the field during each sampling event using a YSI®, Hydrolab®, or other similar multi-parameter probe. Routine maintenance on the multi-parameter probe will be conducted according to schedules described in the manual provided by the manufacturer and recorded in the maintenance log for each instrument. All technical maintenance or repairs of the instrumentation while in use will be reported to the suppliers' trained staff upon completion of each sampling event for suggestions on corrective action.

The contracted laboratory for the program must be Ecology-certified for drinking-water analyses, and this lab will perform all other physicochemical analyses for this study. The contract laboratory QMP (Quality Management Plan) must be on file with Ecology detailing their quality assurance procedures.

## 7.1 Field Sampling Procedures and Laboratory Analysis Procedures

Procedures describing field sampling are fully described in Section 6 and Appendix A. Laboratory Analysis procedures are described in Section 5. All water sample analyses except the field measurements of temperature, Secchi disk transparency, DO (dissolved oxygen), conductivity, and pH will be completed by fully qualified subcontract laboratories. The analytical chemistry methods to be used, as well as the sample volume requirements, detection limits, and holding times, will be consistent with the laboratory's QA and QC plans and SOPs.

## 7.2 Calibration of Equipment

Care will be taken to ensure that the multi-parameter probes used for field measurement are calibrated and adjusted prior to sampling by using known buffer solutions (low ionic strength buffers) that are included with the instrument. The multi-parameter probes will be calibrated following the manufacturer's designated procedures. Field measurements that exceed the normal range of values for each parameter will require that a calibration check of the instrument be completed upon return from the field. If the calibration check falls outside the acceptable calibration limits, the instrument will be re-calibrated and a new field measurement will be taken at the site. All calibration checks and remediation actions taken will be recorded on field forms and in calibration logs and be available upon request.

Laboratory turnaround times must be within 10 to 20 working days. Any issues regarding analytical data quality will be resolved by the Spokane County Program Director through regular communication with the laboratory project manager.

Laboratory analytical procedures will follow U.S. EPA (1983, 1991) or APHA et al. (1998) methods. Detection limits and methods are summarized in Section 5 and in Table 5.0-1.

**Table 7.0-1.** Measurement methods for laboratory analysis of surface water and sediment samples.

| Analyte | Sample Matrix | Samples [Number/ Arrival Date] | Expected Range of Results | Reporting Limit (RL) | Sample Prep Method | Analytical (Instrumental) Method |
|---|---|---|---|---|---|---|
| Total Phosphorus | Water | 2,940 | | 2.0 µg/L | Persulfate, autoclave | EPA 365.1 |
| Soluble Reactive Phosphorus | Water | 2,940 | | 1.0 µg/L | 0.45u filtration | EPA 365.1 |
| Total Nitrogen | Water | 2,940 | | 50 µg/L | Persulfate, autoclave | SM 4500 |
| NO3+NO2-N | Water | 2,940 | | 10 µg/L | None | EPA 353.2 |
| Ammonia-N | Water | 2,940 | | 5.0 µg/L | None | EPA 350.1 |
| Alkalinity | Water | 2,940 | RL to 100 mg/L | 1.00 mg/L | None | EPA 310.1 |
| Hardness | Water | 2,940 | RL to 100 mg/L | 1.00 mg/L | None | Standard Methods 2340C [c] |
| Chloride | Water | 2,940 | | 0.50 mg/L | None | EPA 325.3 |
| Sulfate | Water | 2,940 | | 1.00 mg/L | None | EPA 375.4 |
| Calcium | Water | 2,940 | | 0.100 mg/L | None | EPA 200.7 |
| Sodium | Water | 2,940 | | 0.500 mg/L | None | EPA 200.7 |
| Chlorophyll *a* | Water | 1,672 | | 0.1 µg/L | Acetone Extraction | SM1810200 |
| Dissolved Oxygen (DO)[d] | Water | 2,940 | RL to 12 mg/L | <0.1 mg DO/L | None | Standard Methods 4500-O G [c] |
| pH [d] | Water | 2,940 | pH 3-9 | pH<1 | None | Standard Methods 4500-$H^+$ [c] |
| Temperature [d] | Water | 2,940 | 0-30 $^0$C | 32$^o$C | None | Standard Methods 2550B [c] |
| Conductivity [d] | Water | 2,940 | RL to 200 µsiemens/cm | 1 Microsiemens/cm[e] | None | USGS NFM 6.3.3A-SW |
| Turbidity | Water | 2,940 | RL to 40 NTU | 0.10 NTU | None | EPA Method 180.1 |
| Total Organic Carbon (TOC) | Water | 2,940 | | 0.250 mg/L | None | EPA 415.1 |
| TP | Sediment | 149 | | 5.00 | TKN Digestion, TP Analysis | EPA 351.1, EPA 365.1 |
| Mobile-P | Sediment | 149 | | 2.00 | KCl extraction | WELCH & RYDIN |
| TOC | Sediment | 149 | | 0.10 | Purge IOC | EPA 9060 |
| % Solids/HOA | Sediment | 149 | | 1.0 | None | EPA 160.3 |
| Fe-P (iron-bound phosphorus) | Sediment | 149 | | 2.00 | Dithionate/HCO3 extraction | WELCH & RYDIN |
| Al-P (aluminum-bound phosphorus) | Sediment | 149 | | 2.00 | NaOH extraction | WELCH & RYDIN |

NOTES:

a. For EPA Method 200.8 analytes in water and in solids, the reporting limits (RLs) are 5 times the method detection limits specified in the method. The RLs for analytes in water were determined by selection ion monitoring, whereas the analytes in solids were determined in a scanning mode – see table 7 in the method.
b. EPA Method 1631 has a reporting limit of 0.5 ng/L. This extremely low level is not deemed necessary for this investigation.
c. All Standard Methods are from Standard Methods for the Examination of Water and Wastewater, 21st Edition, American Public Health Association, 2005
d. This is a field measurement.
e. Cell chosen, based on anticipated conductance will determine reporting limit.
f. Method provides semi-quantitative determination of sulfide comments considered "acid insoluble" in Solid sample (e.g., CuS and $SnS_2$).
g. Expressed in method as Contract Required Detection Limit (CRDL)

# 8.0 Quality Control

Data quality is addressed, in part, by consistent performance of valid procedures documented in Standard Operating Procedures (SOPs). It is enhanced by the training and experience of project staff (Section 3.0) and documentation of project activities (Section 5.0). This QAPP and other supporting materials will be distributed to all sampling personnel. A QC Officer will ensure that samples are taken according to the established protocols and that all forms, checklists, and measurements are recorded and completed correctly during the sampling event.

To establish the precision, accuracy, and representativeness of data obtained from the sampling effort, QC samples for laboratory analyses will be analyzed according to methods reported in Table 5.0-1 and collected at the frequency described in Figure 4.0-2. Three types of QA and QC samples will be analyzed during each sampling event: field blanks, sample QC, and laboratory QC.

**Field blanks** will be collected during each sampling event for all the chemical parameters listed in Section 4.2 to ensure that no contamination was introduced during sample collection, preservation, and handling. At the same time samples are collected, field blanks will be prepared by running analyte-free deionized water through the same equipment used to collect the samples, collecting it in the appropriate sample containers, and preserving it with the same procedures used to preserve the samples. The field blanks will be collected, stored, shipped, and analyzed with the associated samples. In addition, a transport blank will be included in the cooler to determine if cross-contamination among samples occurs. If field blank target analyte concentrations are detected, the field blanks will be examined to determine the source of contamination.

Analyte concentrations measured in samples collected during the event will be considered valid when no corresponding field blank analyte concentrations are detected or when the sample analyte concentrations are at least 10 times the field blank analyte concentrations. If a sample analyte concentration is at least 5 times but less than 10 times the field blank analyte concentration, the laboratory will report the numerical result as an upper limit of the true analyte concentration by the laboratory. If a sample analyte concentration is less than 5 times the field blank sample concentration, the results for that analyte will be considered unacceptable, and the result will be reported as undetected using the value as the limit of quantitation for the sample.

Deviations from the method quality objectives of this study will be noted and brought to the attention of the appropriate organization's QAO (Quality Assurance Officer), manager, or county lead, who will initiate the corrective action.

**Analytical QC** samples must be collected for 10 percent of the samples for each sampling event. The additional volumes collected for analytical QC are used to perform duplicate and spiked sample analyses or matrix spike and matrix spike duplicate analyses, depending on method requirements. For the purpose of this collection, sample QC will be evaluated using the criteria established in Table 5.0-1 (Target analytes, analysis methods, and quantitation limits), and as detailed in the reference methods and the laboratory QA Plan. Any results noted as deviating

from program or laboratory QC acceptance criteria require immediate investigation, and thorough documentation as detailed in the assessment and response actions of this QAPP. Corrective actions might vary widely from re-preparation and reanalysis to disqualification of sample data for use. Under no circumstances will outlying sample or QC results be submitted without a detailed explanation. The Project Manager should be contacted immediately regarding deviations for which there is not a suitable analytical corrective action due to holding time or other restrictions, so that recollection can be requested, if possible.

In addition, **laboratory QC** analyses will be performed concurrently with sample preparation and analysis. Laboratory QC includes analysis of appropriate reagent or method blanks for each analytical method or technique, as well as analysis of laboratory control sample or certified standard reference materials as appropriate. Method and reagent blanks should be free from analytes of interest at levels above the project quantitation limits. The same criteria applied to field blanks will be applied to laboratory blanks in sample data interpretation for use. (Analyte concentrations measured in samples collected during the event will be considered valid when no corresponding field blank analyte concentrations are detected or when the sample analyte concentrations are at least 10 times the field blank analyte concentrations. If a field blank analyte concentration is at least 5 times, but less than 10 times the sample analyte concentration, the numerical result will be reported as an upper limit of the true analyte concentration by the laboratory. If a blank sample analyte concentration is less than 5 times the sample analyte concentration, the results for that analyte will be considered unacceptable.)

Following data entry operations, all spreadsheets or database printouts will be proofread using the original handwritten field and laboratory data sheets, where available. Someone other than the data entry specialist will conduct this review.

Measurement performance criteria for data to be collected during this project are discussed in the following sections.

## 8.1 Precision

Precision is a measure of internal method consistency. It is demonstrated by the degree of mutual agreement between individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. Precision of sampling methods is estimated by taking duplicate samples at the same sampling station at approximately 10 percent of the sites, usually at the final sampling point(s). Duplicate sampling for this system, due to its current impairment status, might indicate significant variability for some parameters because of differing amounts of suspended biological (algal) and organic materials. The usability assessment will include consideration of this condition in evaluating field duplicates as a measure of the entire measurement system. Although precision evaluations within 20 percent relative percent difference (RPD) are generally considered acceptable for water quality studies and analyses, no data validation or usability action will be taken for results in excess of the 20 percent limit. Instead, the results will be noted and compared with the balance of the parameters analyzed for a more comprehensive assessment before any negative assessment, disqualification, or exclusion of data.

This QC calculation also addresses uncertainty due to natural variation and sampling error. Precision is calculated from two duplicate samples by RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{\overline{(C_1, C_2)}} \times 100\%$$

where $C_1$ = the first of the two values and $C_2$ = the second of the two if precision is to be calculated from three or more replicate samples (as is often the case in laboratory analytical work), the relative standard deviation (RSD) will be used and is calculated as

$$RSD = \frac{s}{\overline{\chi}}$$

where $\chi$ is the of the replicate samples, and *s* is the standard deviation and is determined by the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}\left(\chi_i - \overline{\chi}\right)^2}{n-1}}$$

where $\chi_i$ is the measured value of the replicate, $\overline{\chi}$ is the mean of the measured values, and *n* is the number of replicates.

For this project, duplicate field samples will be collected to assess sampling precision and field blanks will accompany samples to assess the potential for contamination in the sample collection process.

## 8.2 Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is determined by using a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. EPA now recommends that the term *accuracy* not be used and that *precision* and *bias* be used instead.

Because accuracy is the measurement of a parameter and comparison to a *truth*, and the true values of environmental physicochemical characteristics cannot be known, use of a surrogate is required. Accuracy of field measurements will be assumed to be determined through use of precision. Accuracy of laboratory chemical measurements will be determined by analysis of matrix spikes and matrix spike duplicates, laboratory control samples (fortified blanks), and other method-specified QC samples. Analyses for specific nutrients will include the use of spiked samples or certified standard reference materials, where appropriate, to determine percent recovery. In the absence of manufacturers' certified range, the recoveries for spiked analytes

should not exceed ± 20 percent of the true values to be acceptable (unbiased). Bias is assessed in terms of recovery of a known value for control samples and matrix spikes and is calculated as follows:

***% Recovery (LCS):***

$$\%\,\mathrm{Recovery} = \frac{analyticalresult}{truevalue} \times 100\%$$

***% Recovery (MS):***

$$\%\,\mathrm{Recovery} = \frac{\left(spikedsampleresult - sampleresult\right)}{amountspiked} \times 100\%$$

The accuracy of field equipment for the measurement of temperature, DO, conductivity, salinity, and pH will be determined at a minimum of two points that span the expected range of values for these parameters. Instruments used and procedures for determining accuracy include the following:

**Temperature sensors**:

The accuracy of temperature sensors used in this project will be checked using a standard thermometer.

**DO sensors**:

The accuracy of DO sensors and methods used in this project will have higher standards based on performance of the optical probes. The LDO (luminescent dissolved oxygen) sensor uses luminescent technology that results in the lowest level of drift over continuous use. Calibration is completed using air-saturated water equilibrated over a 12-24 hour period. Determination of dissolved oxygen concentration is adjusted according to barometric pressure at the time of calibration and the probe meter adjusted to the calculated dissolved oxygen concentration.

**Conductivity sensors**:

The accuracy of the salinity and conductivity sensor used in this project will be checked using the autocal solution provided by the manufacturer. The conductivity sensor is calibrated from the autocal solution, which contains a certified 0.449 µS/cm solution (or other low-level conductivity solution).

**pH sensors**:

The accuracy of pH sensors used in this project will be checked using calibration solution provided by the manufacturer (or equivalent quality), which contains any two of three buffersolutions (pH 4, pH 7, pH 10). These solutions will be low-ionic strength with meter calibration accounting for temperature of the solution at the time of meter adjustment.

## 8.3 Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter, and variations at a sampling point, a process condition, or an environmental condition. It therefore addresses the natural variability or the spatial and temporal heterogeneity of a population. The number of sampling points and their location within the study area will be examined to ensure that representative sample collection of each area of the watersheds and each target analyte series occurs. Multiple sampling episodes will be conducted over a period of 6 months to obtain sufficient data to determine analyte concentration variability.

## 8.4 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To achieve this objective, every effort is made to avoid accidental or inadvertent sample or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Samples will be stored and transported in unbreakable (plastic) containers wherever possible. All sample processing (sub-sampling, sorting, identification, and enumeration) will occur in a controlled environment within the laboratory. Field personnel will assign a set of continuous identifiers to a batch of samples.

Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} \times 100\%$$

where $V$ = the number of measurements judged valid and $T$ = the total number of measurements planned. For this project, sampling will be considered complete when no less than 90 percent of the samples collected during a particular sampling event are judged valid.

## 8.5 Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, SOPs, and QA guidelines.

**Table 8.0-1.** Quality Control samples; sample types and frequency.

| | Matrix | Field | | Laboratory (%) | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | | **Blanks** | **Replicates** | **Check Standards** | **Method Blanks** | **Analytical Duplicates** | **Matrix Spikes** |
| Total Phosphorus | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Soluble Reactive Phosphorus | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Total Nitrogen | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Nitrate+Nitrite -Nitrogen | Water | 1 | 1 | Minimum monthly (frequency not specified in method) | Two reagent blanks after instrument calibration before sample analysis | Minimum 10% of samples | Minimum 10% of samples |
| Ammonia | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Chloride | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Calcium | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Sodium | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Total Organic Carbon (DOC)[a] | Water | 1 | 1 | After each new calibration curve, or at least quarterly | Filter blank per analysis batch of 20 samples | One per analysis batch of 20 samples | One per analysis batch of 20 samples |
| Totals Solids | Water | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples | |
| Alkalinity | Water | 1 | 1 | N/A | One per analysis batch of 20 samples | One per analysis batch of 20 samples | N/A |
| Hardness | Water | 1 | 1 | Minimum once per quarter | One per analysis batch of 20 samples | Minimum 10% of samples | Minimum 10% of samples |
| Chlorophyll-*a* | | | | | | | |
| Dissolved Oxygen (DO) | Water | N/A | N/A | N/A | N/A | N/A | N/A |
| pH | Water | N/A | N/A | N/A | N/A | N/A | N/A |
| Temperature | Water | N/A | N/A | N/A | N/A | N/A | N/A |
| Conductivity | Water | N/A | N/A | N/A | N/A | N/A | N/A |
| Turbidity | Water | N/A | N/A | Minimum once per quarter | One per analysis batch of samples | Minimum 10% of samples | N/A |
| TP | Sediment | 1 | 1 | One per analysis | One per analysis | One per analysis batch of 20 samples | N/A |

| Parameter | Matrix | Field | | Laboratory (%) | | | |
|---|---|---|---|---|---|---|---|
| | | Blanks | Replicates | Check Standards | Method Blanks | Analytical Duplicates | Matrix Spikes |
| Mobile-P | Sediment | 1 | 1 | One per analysis | One per analysis | One per analysis or every batch of 20 samples | N/A |
| TOC | Sediment | 1 | 1 | One per analysis | One per analysis | One per analysis or every batch of 20 samples | N/A |
| % Solids/HOA | Sediment | 1 | 1 | N/A | N/A | One per analysis or every batch of 20 samples | N/A |
| Fe-P (iron-bound phosphorus) | Sediment | 1 | 1 | One per analysis | One per analysis | One per analysis or every batch of 20 samples | N/A |
| Al-P (aluminum-bound phosphorus) | Sediment | 1 | 1 | One per analysis | One per analysis | One per analysis or every batch of 20 samples | N/A |

# 9.0 Data Management Procedures

Samples will be documented and tracked on Field Data Record forms, Sample Identification labels, and Chain of Custody records (Appendix A). The Field Task Leader will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer. Spokane County will maintain copies of these forms in the project files. A sampling report will be prepared following each sampling event. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by Spokane County or contractors), the Spokane County QAO (Quality Assurance Officer) will be notified immediately (with an accompanying explanation of the problems encountered).

Laboratory data will be managed in accordance with established protocols. The data will be submitted to Spokane County and shared with the Department of Ecology in hard copy and in electronic database format, as well as scanned data recorded on CD-ROM. The electronic data will be submitted in a format to be negotiated with the lab. At a minimum, the electronic data files will include the date and time of sample collection, date received, date of preparation or analysis, requested parameter, analytical batch ID, results, and data qualifiers. Electronic data will be provided for all samples and QC, including laboratory blanks, control samples, duplicates, and spiked samples analyzed in a format compatible with the requirements of Spokane County's (or Contractor) statistical and modeling software routines. Hard copy data packages will be paginated, fully validated raw data packages that include an analytical narrative with a signed certification of compliance with this QAPP and all method requirements; copies of Chain of Custody forms; sample inspection records; laboratory sample and QC results; calibration summaries; example calculations by parameter; and copies of all sample preparation, analysis, and standards logs adequate to reconstruct the entire analysis. The CD-ROM data will include a full copy of the paginated report scanned and stored in portable document format (PDF) for potential future submission to the client, if requested, and for long-term storage in the project files. Initially, the full raw data package will be submitted to the Spokane County QAO for assessment of compliance with the program goals and guidance.

All computer files associated with the project will be stored in a project sub-directory by Spokane County (subject to regular system backups) and will be copied to disk for archive for 5 years subsequent to project completion (unless otherwise directed).

Data obtained during sampling activities will be entered into field notebooks.
The following is a list of data information that will be kept at Spokane County or the contract laboratory for review upon request:

- Field equipment and chemicals maintenance, cleaning and calibration records;
- Field notebooks;
- Sample Data Sheets;
- Photographs of sampling stations and events;
- Chain-of-Custody forms;

- Laboratory equipment maintenance, cleaning and calibration records;
- Laboratory bench sheets, control charts, and SOPs;
- Records of QA/QC problems and corrective actions (field and/or laboratory);
- Laboratory data QC records;
- Records of data review sheets;
- Duplicate, performance evaluation records and other QA/QC control records (field and laboratory); and
- Data review, verification and validation records.

Data handling equipment will include computer software applications Microsoft Excel® and Access®. Data will be entered into the Access® database in a form compatible with requirements of the statewide database entry into STORET (short for STOrage and RETrieval). Requirements for data entry will be based on EPA guidance.

Field notebooks will be filled out using *Write in the Rain*® ink or pencil, and will not be erased. Changes will be made by crossing out errors, initialing, and adding correct information. Field notebooks will be bound with numbered pages.

Laboratory data results will be recorded on laboratory data sheets, bench sheets and/or in laboratory logbooks for each sampling event. These records as well as control charts, logbook records of equipment maintenance records, calibration and quality control checks, such as preparation and use of standard solutions, inventory of supplies and consumables, check-in of equipment, equipment parts and chemicals will be kept on file at the laboratory.

Any procedural or equipment problems will be recorded in the field notebooks. Any deviation from this Quality Assurance Project Plan will also be noted in the field notebooks. Data results will include information on field and/or laboratory QA/QC problems and corrective actions.

Standard turnaround time for the analytical samples taken to the contract laboratory will be seven to ten working days.

Chain-of-custody forms will be kept with the sample during transport and will accompany data results back to Spokane County. Training records and data review records will be kept on file at Spokane County and be available on request. All sample analysis records and documents are kept at the contract laboratory and will be available for inspection at any time. In addition to any written report, data collected for the project will be provided electronically via a CD-ROM or e-mail ZIP file in a STORET compatible format.

All records will be retained by the contract laboratory for five years. All project records at Spokane County should be retained permanently.

A Microsoft Access data management system should be developed for use in analyzing and interpreting results. The system should be a relational database that enables the analyst to aggregate data from a variety of tables and identify correlates among media and settings in each study reach.

# 10.0 Audits and Reports

Upon completion of periodic sampling activities, the Project Leader will summarize sampling team progress. Following completion of field sampling, the Project Leader will prepare a field sample collection summary (detailed listing of all sampling participants, sampling locations, and specimens collected) for review by the Project Manager.

Following the completion of each data quality assessment, the Quality Assurance Officer or designee will prepare a Data Quality Assessment Report and submit copies to the Project Manager for inclusion in project records. The data quality assessment will include any required qualification of data based on observations, relevant laboratory or field QC analyses, or other observations that might affect data quality. The laboratory data can then be incorporated into final sampling event reports to consolidate the information corresponding to each event.

When required, reports summarizing incidents of technical direction requests from laboratory or field staff, required corrective actions, and any other issues affecting data quality or usability will be submitted to the Project Leader. These observations will be compiled and submitted in interim QA reports where warranted, in informal file memoranda to the Project Manager for inclusion in the project files. These regular QA reports and memoranda, along with routine data quality assessments performed throughout the data collection will be the basis of the final QA report for this collection effort.

## 10.1 Audits

Should the sampling staff, laboratory personnel or Quality Assurance Officer find errors in sampling or analysis, the Quality Assurance Officer (QAO) will notify the Project Manager and the party responsible for the error or deficiency and recommend methods of correcting the deficiency. The responsible party will then take action to correct the problem and will report corrections to the QAO and Project Manager.

The Quality Assurance Officer will review the QA/QC procedures used for the sampling and analytical program. Procedures for this review, included in Section 8, will meet the data quality criteria specified in Section 4. The Quality Assurance Officer will report these assessment records in the Draft and Final Reports.

## 10.2 Reports to Management

Sampling results will be summarized in the draft and final reports completed for this project. These reports will include the field and laboratory results of project assessments listed above. Reports will be submitted to the Project Manager at Spokane County. Email updates will be submitted to the Project Manager after each sampling event providing notification of any issues or problems for which corrective actions have been taken. The results of all corrective actions or data quality assessments will be reported to the Project Manager from Spokane County upon completion.

Standard reporting formats will be developed and approved by Spokane County Managers. These will be used to produce interim and final reports following completion of this study. Consistency in reporting of progress, data generation, and interpretations will be maintained in order to improve comparability between related studies and where data-sharing is needed between monitoring efforts that address each of the project tasks (*e.g.*, mass loading analysis, stormwater runoff, internal loading, groundwater loading, etc.).

# 11.0 Data Verification and Validation

Data validation and review services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. All Field Data forms and Chain of Custody forms will be reviewed by the Project Leader (assisted by the QAO, as needed) for completeness and correctness. The Project Leader will be responsible for reviewing data entries and transmissions for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results to the measurement performance criteria summarized in Section 4.2 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the Program Manager. Analytical data provided by the laboratories will be reviewed before its release by the laboratory QAO, and laboratory manager, and will include a certifying statement that the data included have been reviewed for compliance with the reference methods and this QAPP.

The Project Lead or designee will review all Field Data Record forms and Chain of Custody forms. The Project QAO will review a minimum of 5 percent of the Field Data Record forms and other records. Any discrepancies in the records will be reconciled with the appropriate associated field personnel and will be reported to the Project Lead. Laboratory validation and verification methods are outside the scope of this QAPP; however, it is expected that the laboratory validation and verification will include an assessment of completeness and method compliance, including verification of sample calculations and of any required manual data entry. The analytical narrative reports will include discussions of attainment of the program goals as established herein. Samples submitted to the sample analysis laboratory will include Chain of Custody forms documenting sampling time and date. This information will be checked by the analytical laboratory to ensure that holding times have not been exceeded. Violations of holding times will be reported (by the laboratory) to the Project Lead, who will consult with the Project QAO to develop corrective action recommendations and define any recommended technical directives. Finally, the Project Manager will be consulted with deficiencies, observations, and findings, as well as with corrective action and technical directive recommendations for consideration and approval.

Data verification and validation includes completeness of data entry into a data management system, correctness of data entry, and assurance that entries fall within the expected range for each analyte. These exercises prevent generation of poor results when analyzing data for cause-and-effect relationships or for status of environmental resources. Missing or incorrect data can bias description of environmental resources and result in false conclusions.

## 11.1 Data Review, Validation & Verification Requirements

Analytical results will be reviewed and validated in accordance with EPA documents, including the *USEPA Guidance on Environmental Data Verification and Validation* (EPA QA/G-8), 2002b; the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 540/R-94/012), 1999; and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 540/R-94/013), 1994b. Tetra

Tech will conduct data review and validation using the following methods on 10% of the primary project samples, including their associated quality control duplicates and laboratory quality control samples.

- A review of sample handling and analytical and field data for completeness, accuracy, holding time compliance, and quality control (QC) sample frequency compliance.
- Evaluation of laboratory blank samples.
- Evaluation of the accuracy and precision of field duplicate samples, laboratory control samples (LCS), and matrix spike/spike duplicate (MS/MSD) samples.
- Assignment of data qualifiers, when necessary, to reflect limitations identified in the data assessment process.
- Estimation of completeness.

## 11.2 Validation and Verification Methods

The following procedures will be used to determine if data meets the measurement and data quality objectives and criteria specified in Section 4. If data QA/QC procedures do not meet the specified criteria, the Quality Assurance Officer will review all field and laboratory records to determine the cause. If equipment failures are limiting the usability of the data, calibration and maintenance procedures will be reviewed and changed as needed. If sampling or analytical procedures are the source of failures, methods will be reviewed to resolve the errors. Any changes or modifications to quality control procedures will be approved by the Project Manager prior to inclusion in the QAPP.

**Review of Sample Handling**

Proper sample handling techniques are required to ensure sample integrity. During data review, the sample handling procedures identified below are evaluated to determine potential effects on data quality.

- Review of field sample collection and preservation procedures to determine whether they were completed in accordance with the requirements specified by the analytical methods.
- Review of chain-of-custody documentation to ensure control and custody of the samples was maintained.
- Review of sample holding times between sample collection, extraction, and analysis (see Table 6.2-1 in Section 6).
- Review of sample conditions upon receipt at the contract laboratory.
- Review of Quality Assurance/Quality Control (QA/QC) Samples. Specific procedures for review of QA/QC samples are included in the sections below.

**Laboratory Blank Samples**

Laboratory blank samples (method and instrument blanks) are laboratory-prepared, analyte-free samples used to detect the introduction of contamination or other artifacts into the laboratory sample handling and analytical process. These blanks play an especially important role in sampling programs involving trace-level analyses or analytes that are common solvents found in a laboratory. None of the analytes of concern for this project are common laboratory contaminants. If a contaminant is discovered in the analytical sample at less than five times the

concentration it is found in the laboratory blank, it will be considered a laboratory contaminant. Otherwise, it will be reported as an environmental contaminant.

**Laboratory Control Samples**

Laboratory control samples are used to assess analytical performance under a given set of standard conditions. Synthetic samples, containing some or all of the analytes of interest at known concentrations, are prepared independently from calibration standards. The samples consist of laboratory control samples (LCS) and laboratory control sample duplicates (LCSD). Laboratory control samples will be analyzed with each analytical batch. LCS may be used to estimate analytical accuracy and precision by comparing measured results to actual concentrations. LCS/LCSD percent recoveries will be checked on laboratory reports to ensure they are within the limits set by the EPA methods listed in Table 4.0-3.

LCS are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess the laboratory's internal precision. The analytical precision is expressed by the relative percent difference (RPD) (equation 11.2-1). Analytical precision and accuracy should meet the method criteria listed in Table 4.0-3 in Section 4.

$$\frac{X_1 - X_2}{X_{ave}} x100 = RPD$$

$X_1$ = duplicate no. 1
$X_2$ = duplicate no. 2
$X_{ave}$ = mean of two sample duplicates
RPD = relative percent difference

**Matrix Spike and Matrix Spike Duplicates**

Matrix spike samples are actual field samples to which known amounts of select compounds (one, or more, of the analytes of interest) are added. Both spiked and unspiked aliquots (sample portions) are analyzed. The difference between the concentration of the spike compound(s) in the spiked and unspiked aliquots is compared to the amount of spike added before the extraction process. Since actual samples are used for the recovery determination, the matrix effects can be evaluated. Usually expressed as a percentage of the mass of the spiked amount, spike recovery is the measurement of accuracy anticipated for the sample matrix. Percent recoveries will be compared to EPA method specific recoveries listed in Table 4.0-3.

Matrix spike samples are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess sample reproducibility and the laboratory's internal precision. The analytical precision is expressed by the RPD between the measurement results of the two duplicate samples. Analytical precision and accuracy should meet the criteria provided in Table 4.0-3. MS/MSD samples will be run on each batch of samples.

**Field Duplicate Samples**

Field duplicate samples will be collected simultaneously with a primary project sample. Duplicates are treated in the same manner as the primary sample during all phases of sample collection, handling, and analysis. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process (i.e., QC purposes). At least one duplicate field sample will be collected and submitted blind to the laboratory during each sampling date for this program.

Analytical results will be reviewed for agreement with each other or their respective reporting limits and evaluated for comparability. Estimated results quantified below the reporting limit and qualified with a "J" flag are not considered significant for the purpose of data agreement. The comparison between project and field duplicate sample results should meet RSD (relative standard deviation) criteria for each method listed in Table 4.0-3.

**Reporting Limits**

The reporting limits are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory conditions. For many analytes, the reporting limit analyte concentration is selected by the laboratory as the lowest non-zero standard in the calibration curve. Sample reporting limits vary based on sample matrix and dilution of the samples during analysis. Reporting limits should be equal to or below the PQLs (Practical Quantitation Limits) provided in Table 7.0-1 for each method.

**Data Qualification**

Qualifiers will be applied to QC samples when acceptance criteria are not met and corrective action is not performed or is unsuccessful. These same qualifiers will be applied to the associated sample data, as defined in the following table.

Table 11.2-1. Data Qualifiers.

| Qualifier | Description |
|---|---|
| J | The analyte was positively identified, the quantitation is estimated. |
| U | The analyte was analyzed for, but not detected. The associated numerical value is at or below the method detection limit (MDL). |
| F | The analyte was positively identified but the associated numerical value is below the reporting limit (RL). |
| R | The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria. |
| B | The analyte was found in an associated blank, as well as in the sample. |
| M | A matrix effect was present. |
| H | Analysis was performed outside of the recommended holding time. |

**Completeness**

Completeness is calculated after the QC data have been evaluated, and the qualifiers have been applied to the sample data. Invalid results, broken or spilled samples, and samples that are unable to be analyzed for other reasons are included in the assessment of completeness. The criteria and calculation to determine completeness are provided in Section 5. If data cannot be qualified to meet completeness goals, Tetra Tech will consult with the Project Manager to determine if additional sampling should be performed to accomplish data quality objectives.

## 11.3 Reconciliation with User Requirements

The Project Manager will review all data deliverables upon receipt from the lab. Laboratory results will be checked for data qualifiers entered by the lab to ensure that sample collection and preservation procedures were adequate and that laboratory analysis procedures met quality assurance objectives. Any outstanding issues will be addressed immediately with the lab and/or sampling staff to ensure that project quality assurance objectives are met.
The Project Manager and Quality Assurance Officer will review and validate the data during interim reporting to management and final reporting stages of the project. If there are any problems with quality sampling and analysis, these issues will be addressed immediately and methods will be modified to ensure that data quality objectives are being met. Modifications to monitoring will require notification to the Project Manager and subsequent edits to the approved QAPP.

# 12.0 Data Quality (Usability) Assessment

As soon as possible following completion of the sample collection and analyses, Spokane County will assess the precision, accuracy, and completeness measures and compare them with the criteria discussed in Section 4.0. This will be the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. Any problems encountered in meeting the performance criteria (or uncertainties and limitations in the use of the data) will be discussed with the project QA personnel and will be reconciled if possible.

All analytical data will be assessed to determine their suitability for use in characterization of the system and for incorporation along with the existing data into models appropriate for developing TMDLs for the watershed. This assessment will be conducted first by laboratory management and QA staff and then by the Spokane County Project Managers with the assistance of the QAO. Uncertainties and limitations in the use of these data and interpretation of results will be discussed with regulatory agencies like Ecology and EPA, and it is expected that data will be qualified, where necessary, using the conventions outlined in EPA's *National Functional Guidelines for Inorganic Data Review* (USEPA 2002). These conventions afford the capability to flag the data and include an estimation of potential bias, where appropriate, as well as providing recommendations for the interpretation of results in the data report.

## 12.1 Interpreting Data

**Task 1**
Nutrient loads will be calculated from sample data collected at each of these transects. The frequency of data collection and multiple transects (e.g., seven transects along the reservoir) allows for a three-dimensional characterization (e.g., width of reservoir, depth at each transect, and longitudinal profile) of nutrient conditions. The nutrient loads will be calculated by using averages from the cells defined by each of the sampling locations along the transect (e.g., four compartments) and two depth zones (e.g., upper 3 meters, mid depth, and near bottom).

A simple "bath tub" model will be used to determine relative change of nutrient load between transects. Changes identified between the transects will be explained by nutrient loads and sources generated from monitoring information describing stormwater contribution, measurable groundwater input, and internal loading estimates. Loading estimates calculated for each of the transects serves as a basis for explaining source and magnitude of nonpoint source nutrient contributions.

**Task 2**
Nutrient contributions from stormwater will be measured during representative storm events so that changes in nutrient loads estimated between transects can be explained. All locations for storm event monitoring will be collecting data instantaneously so that timing of nutrient input (e.g., delay and magnitude of nutrient load) can be used to determine the lag time between event and input into the receiving water.

**Task 3**

Annual characterizations of nutrient loads will be made at this uppermost transect and summarized by season (with arithmetic mean and standard deviation). Comparison of successive downstream transects with seasonal summaries from the background transect will be reported as percent of change and direction of change from the mean condition. An expression standardized as a percent of baseline condition will account for inter-annual variability caused by differing hydrologic cycle and climate pattern influences. In addition, background and downstream transect loading estimates will be compared to available water quality expectations (e.g., criteria and/or TMDL Implementation Plan goals) so that regulatory decisions would benefit through a continuous feedback loop when modifying permits and other regulatory tools.

Long-term monitoring at Transects 1, 2, 4, and 6 will be visited monthly for at least a five-year period in order to generate at least 60 observations for each of the parameters. Trends in parameter condition can be determined with the seasonal Kendall trend test. This is a non-parametric trend analysis used when parameters from data sets resemble non-normal distributions. In addition, description of pattern over time will be determined by use of box plots and graphics that compare means with standard deviations.

**Task 4**

Several additional nutrient input pathways will be identified and estimated for percent contribution to overall load between transects. These nutrient sources include: internal loading, groundwater input, and identification of locations and extent of groundwater input through multi-spectral imaging. Internal loading is suspected of contributing a large portion of available phosphorus forms readily used by phytoplankton and algae in the upper reservoir. Mobilization and timing of nutrient input will identify the relative concentrations available for growth and proliferation of nuisance algae.

Groundwater input of nutrients from developed margins of Lake Spokane may have a larger influence on loading than previously thought. The development of major portions of Lake Spokane with on-site septic systems will be evaluated for potential of nutrient contributions to surface water. Direct sampling near the shore of Lake Spokane using piezometers will provide some indication for presence and magnitude of nutrient concentrations that potentially migrate to the surface water. Once characterization of groundwater at each of the designated settings is established, this information may be extrapolated to other similar settings around the lake in order to determine risk from groundwater contamination.

An important mapping exercise in this monitoring plan involves a photographic technique called multi-spectral imaging. This type of information gathering doesn't directly measure the nutrient loading along the margins of Lake Spokane, but does indicate the extent to which groundwater exchanges with surface water. Interpretation of potential groundwater plumes around the lake coupled with characterization of groundwater chemistry will enable some estimate for percentage of nutrient loading from groundwater sources.

**Task 5**

Once the source and magnitude of nonpoint nutrient sources are identified a plan for abating this pollution will be formulated. Abatement of nonpoint source pollution is accomplished with identification and implementation of effective best management practices (BMPs). Common BMPs are determined and applied based on the type of land use and nutrient pollutants generated by the human activity. Implementation of BMPs will be determined by identifying the most effective order of application and ensuring that a maintenance program for BMPs is designed. Following the implementation of an adequate number of BMPs an effectiveness monitoring program will be developed that serves as a feedback loop (adaptive management). Application, maintenance, and revision of BMPs in the basin will optimize the chance for success in minimizing nutrient delivery to Lake Spokane.

# 13.0 References


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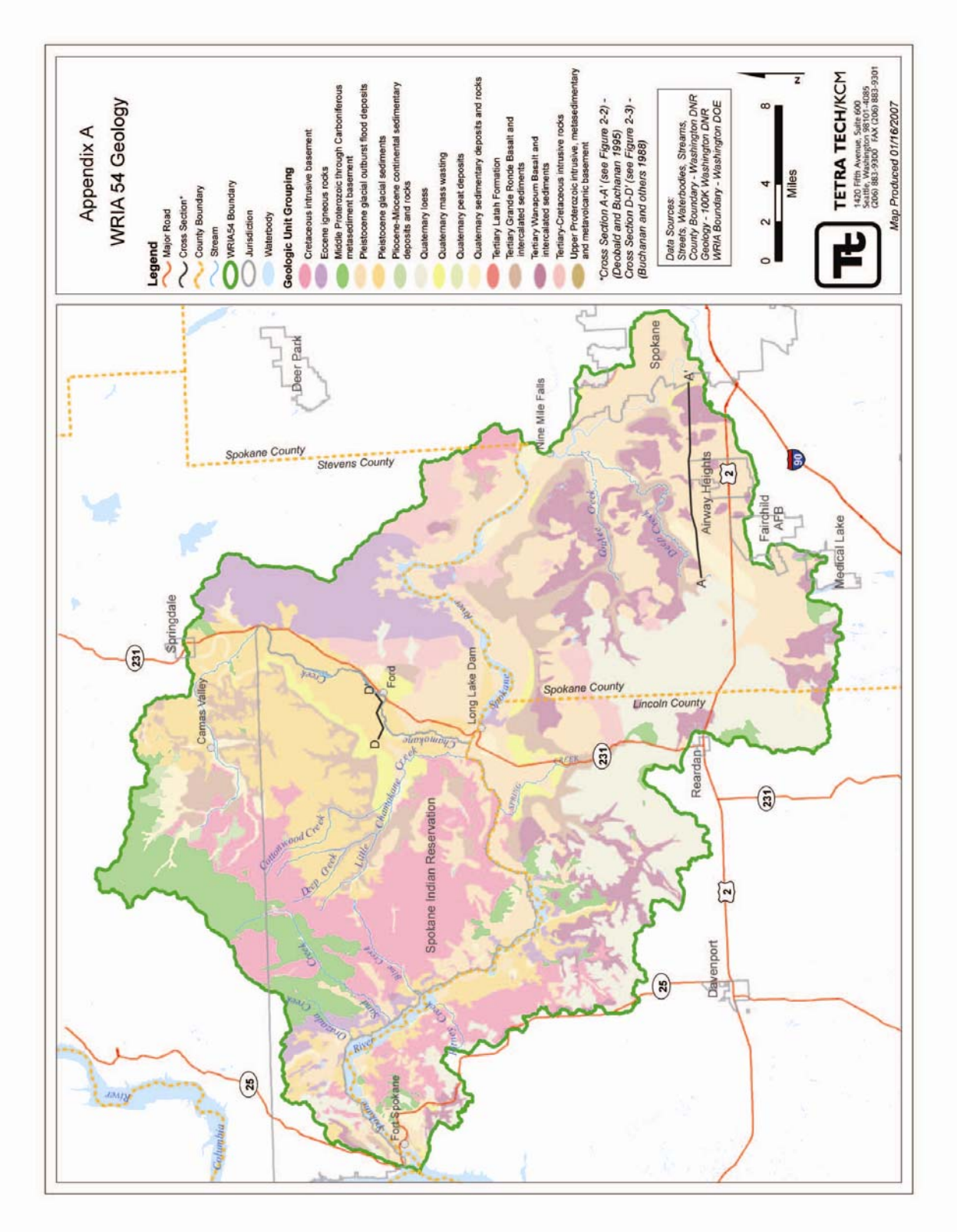
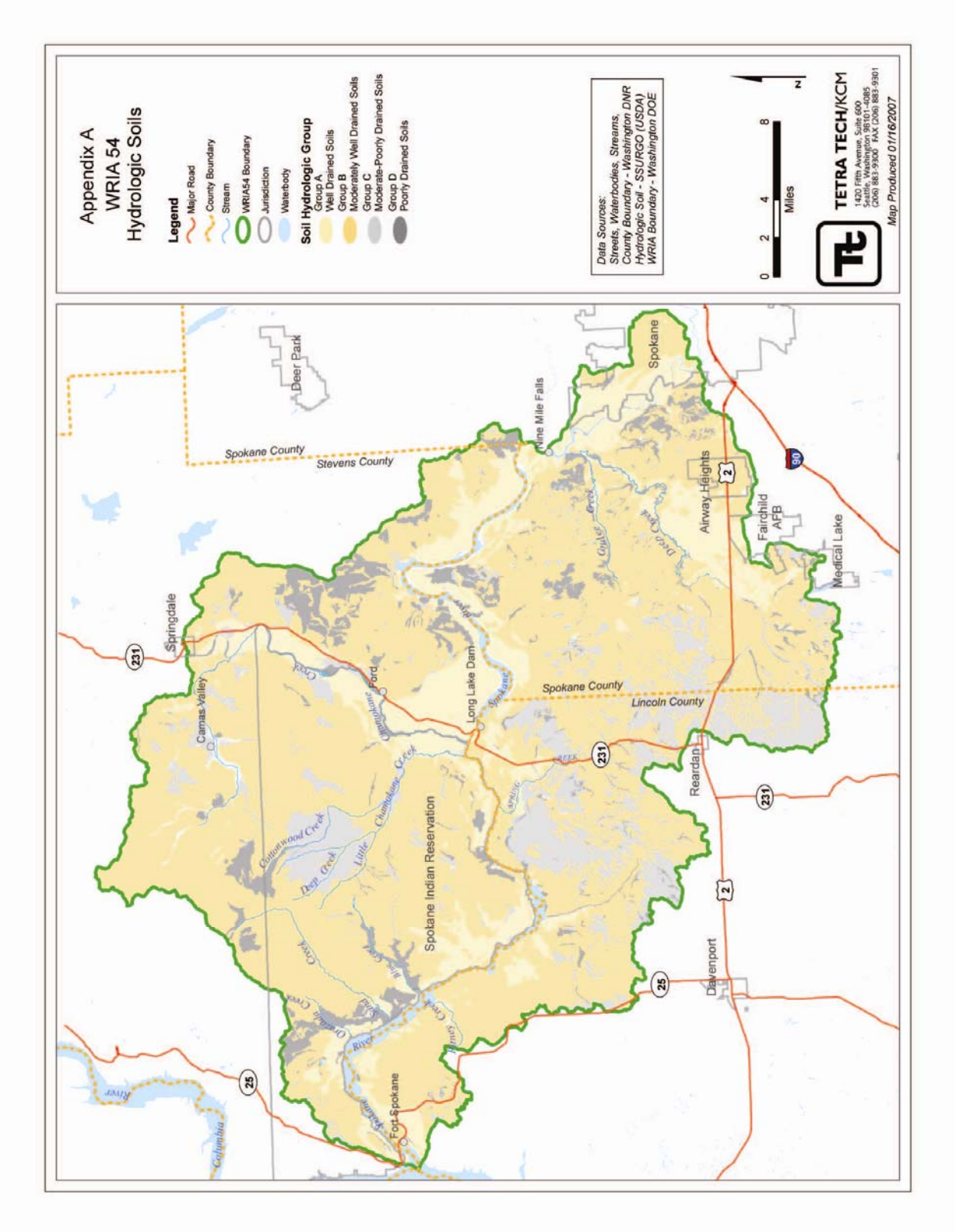
# Appendix A
## Landscape Information

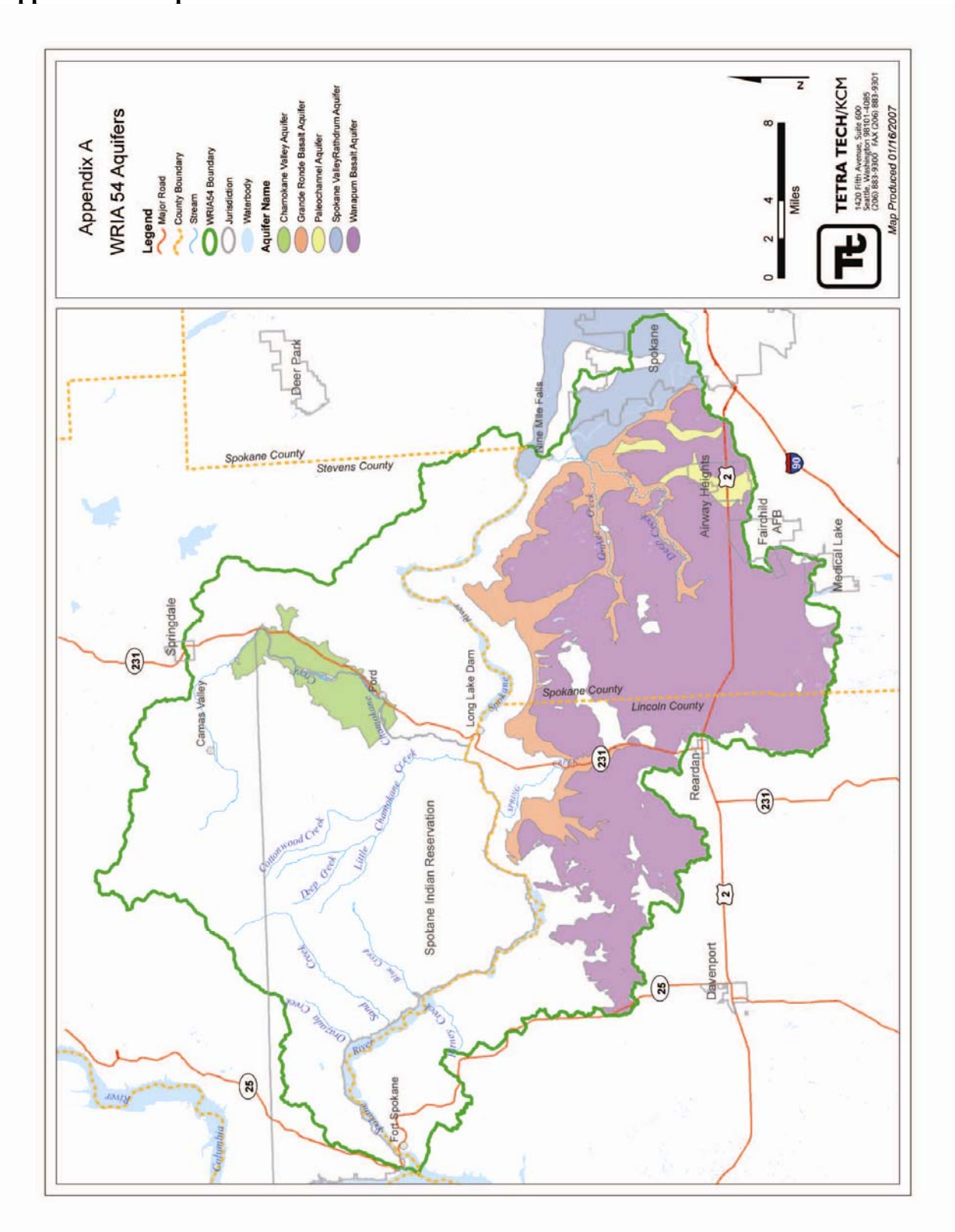
# Appendix A - Geology



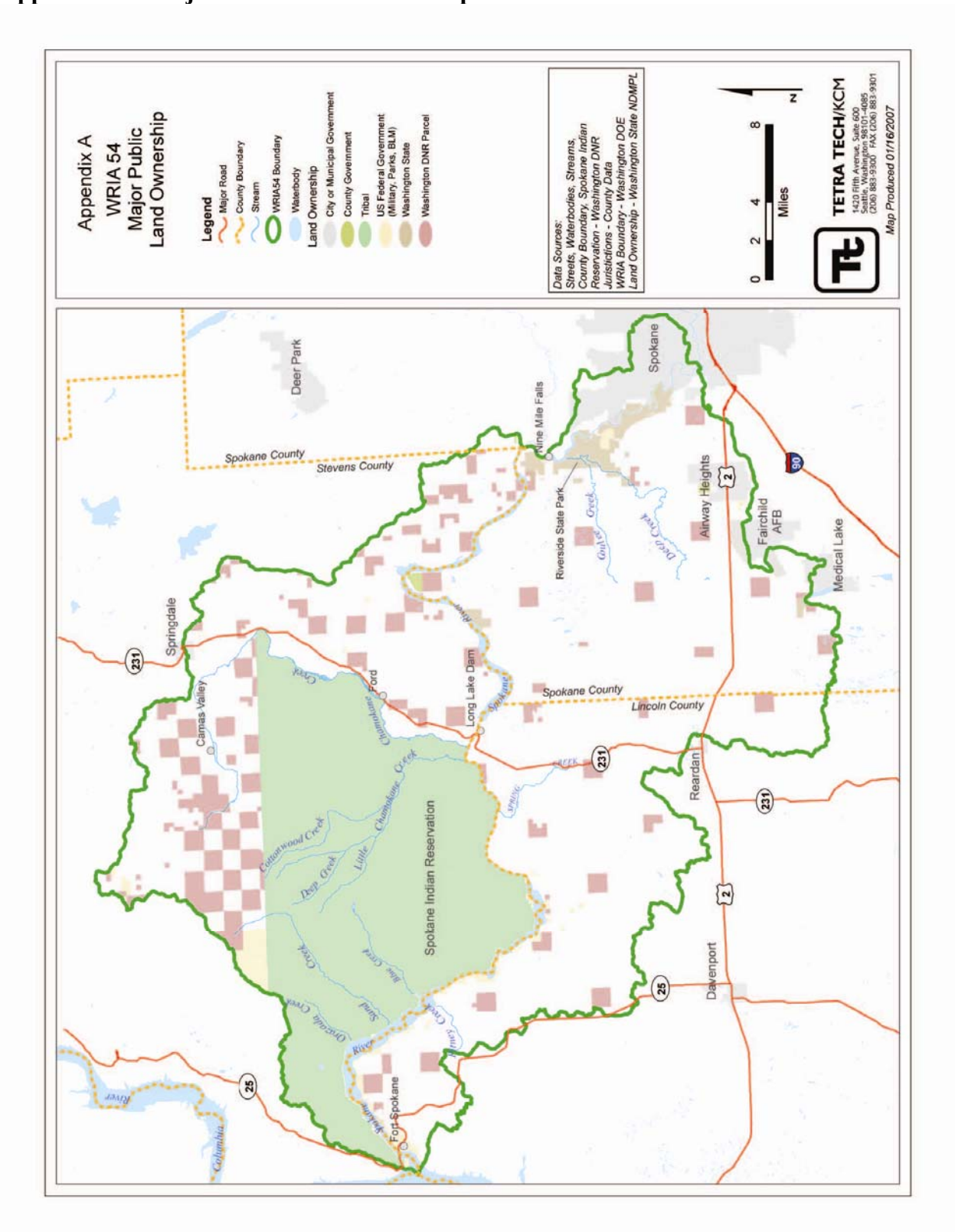
# Appendix A – Hydrologic Soils



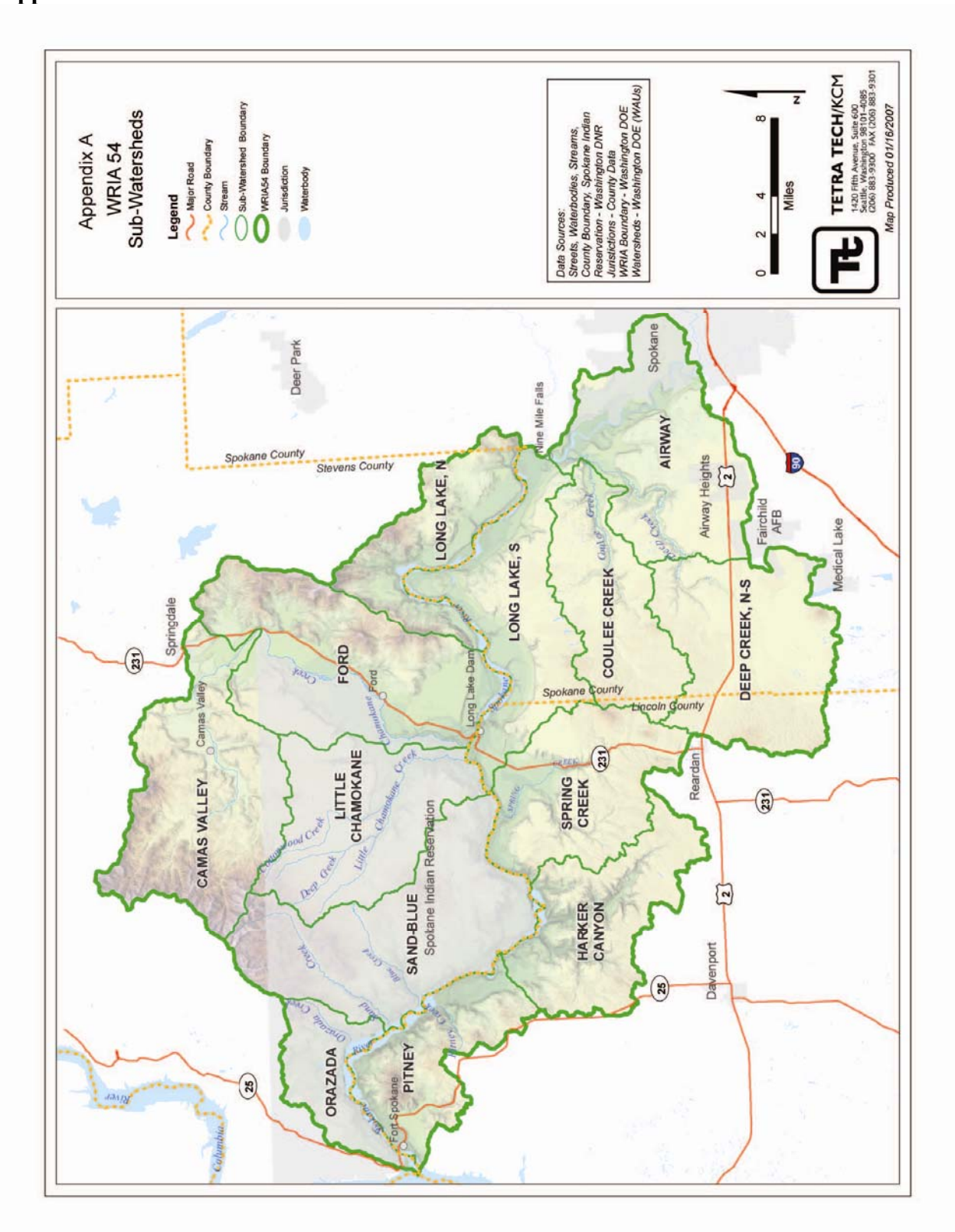
## Appendix A – Aquifers



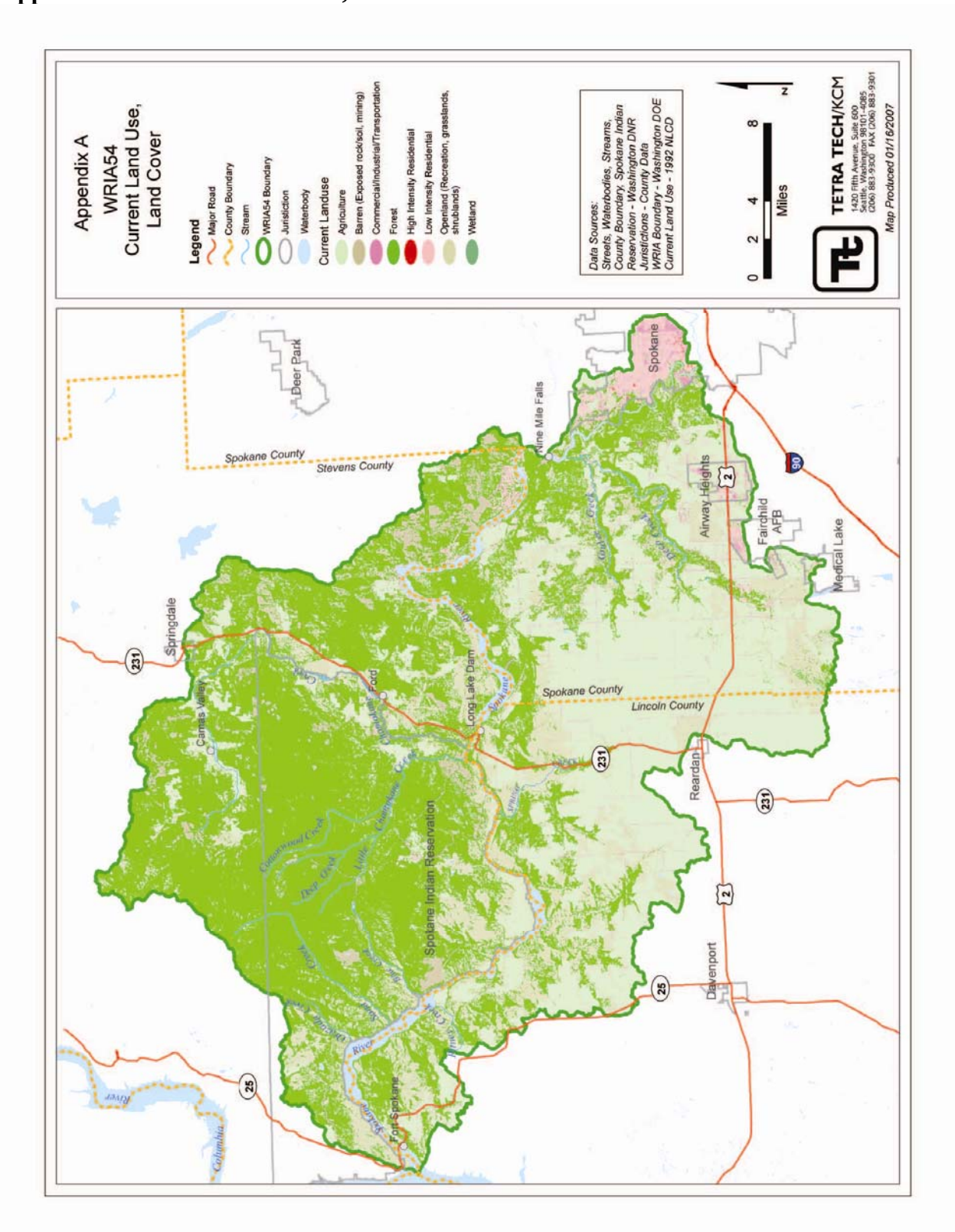
# Appendix A – Major Public Land Ownership



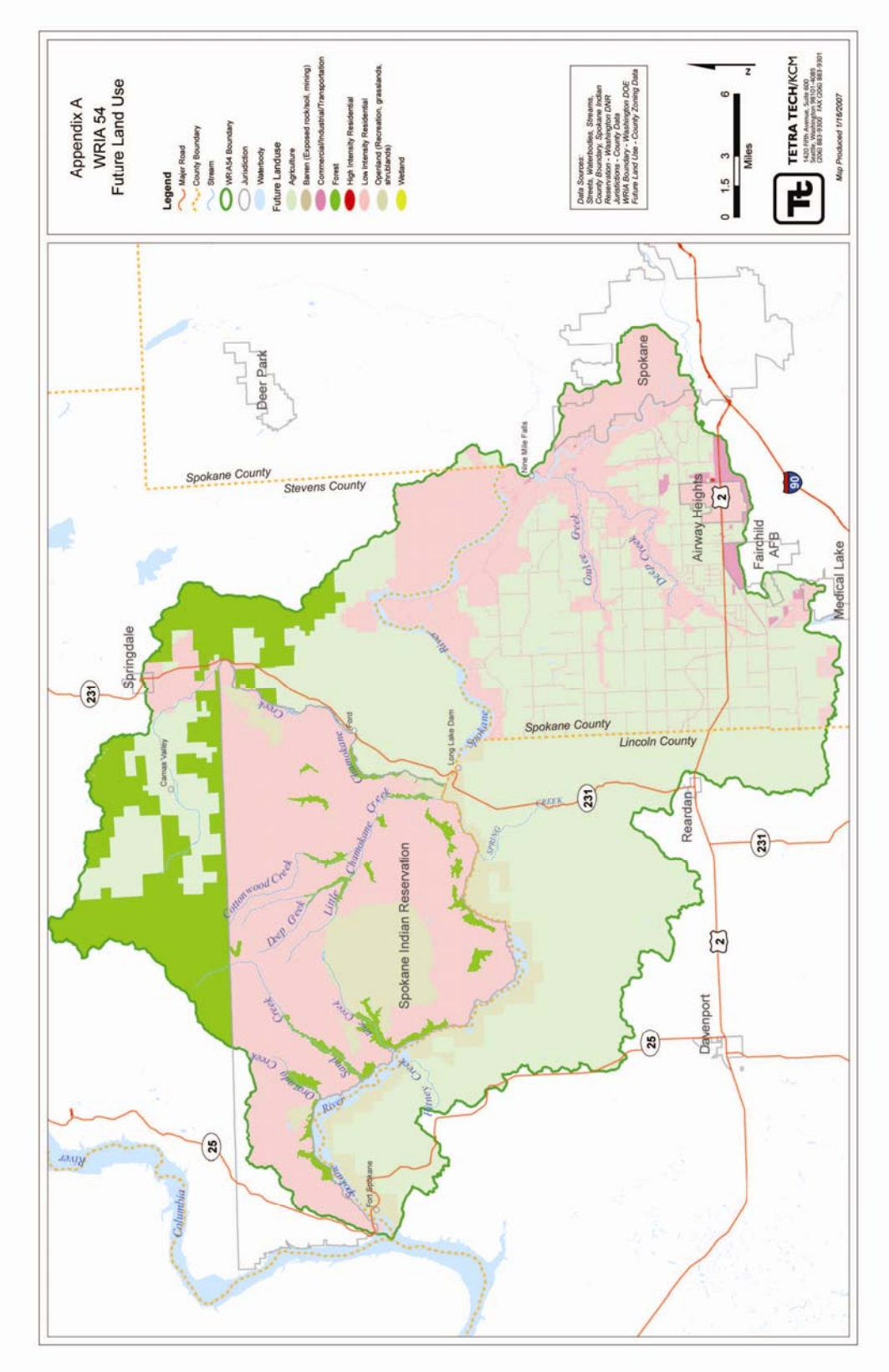
# Appendix A – Sub-Watersheds



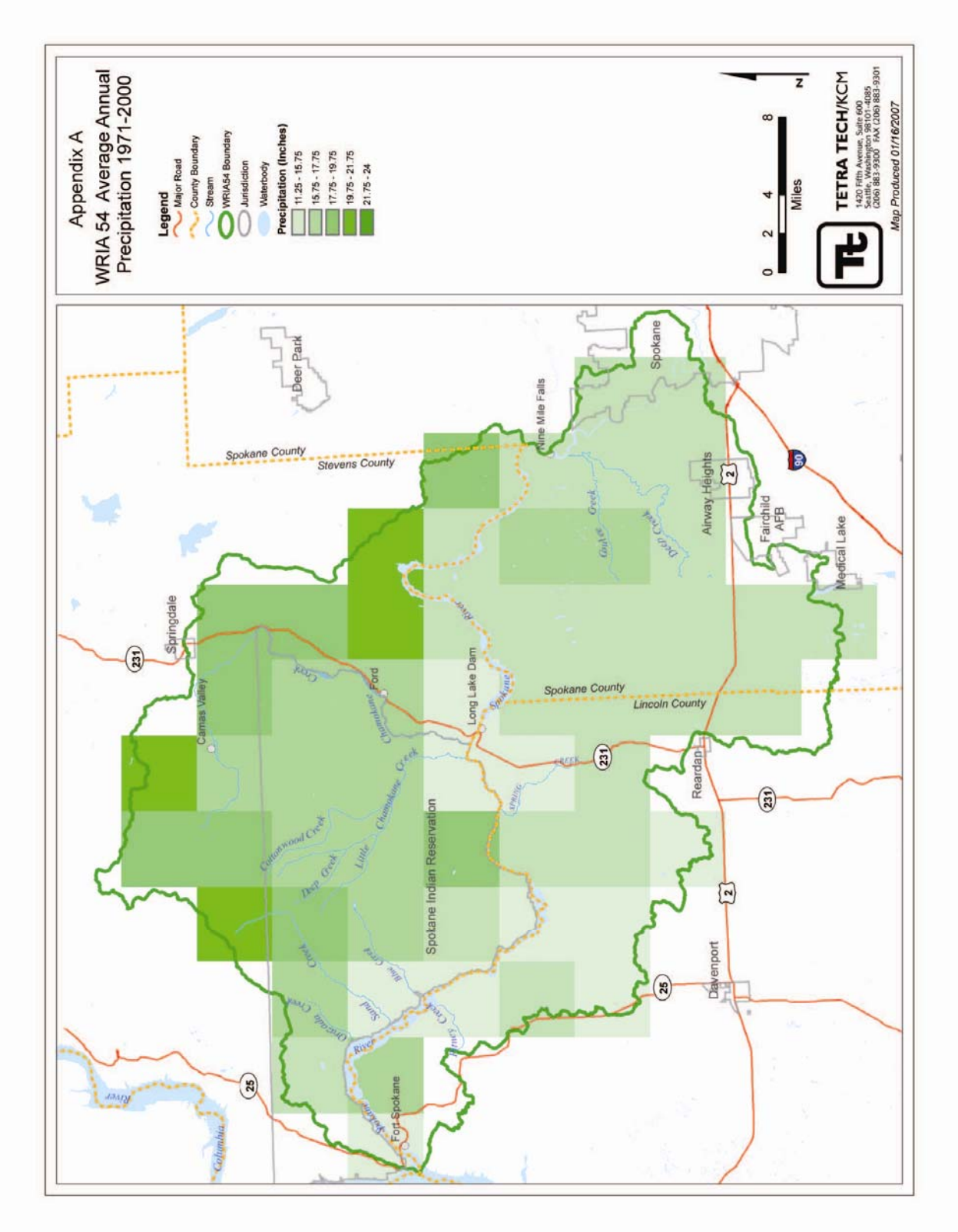
# Appendix A – Current Land Use, Land Cover



# Appendix A – Future Land Use



## Appendix A – Average Annual Precipitation 1971-2000



# Appendix A – Average Annual Maximum Temperature 1971-2000

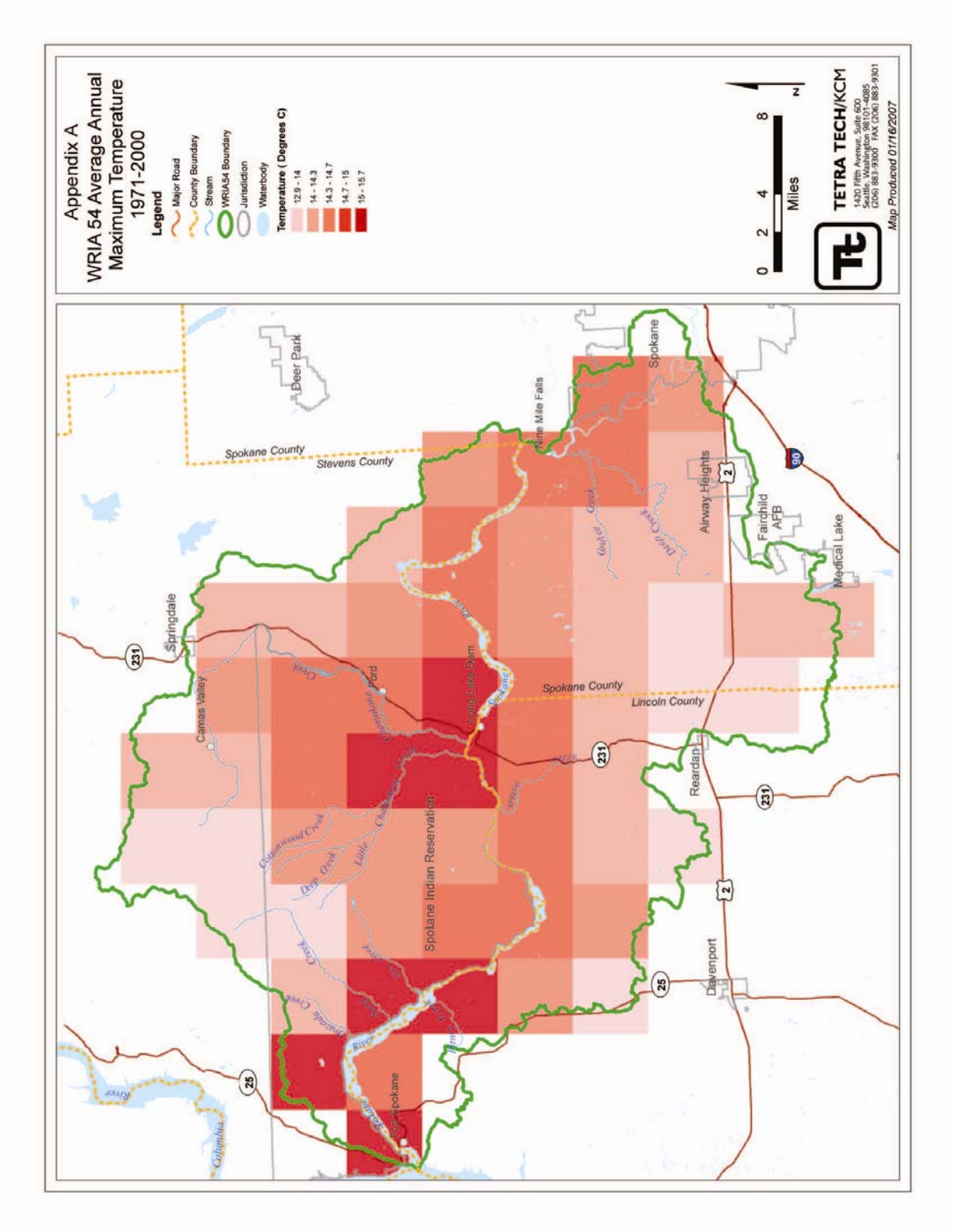
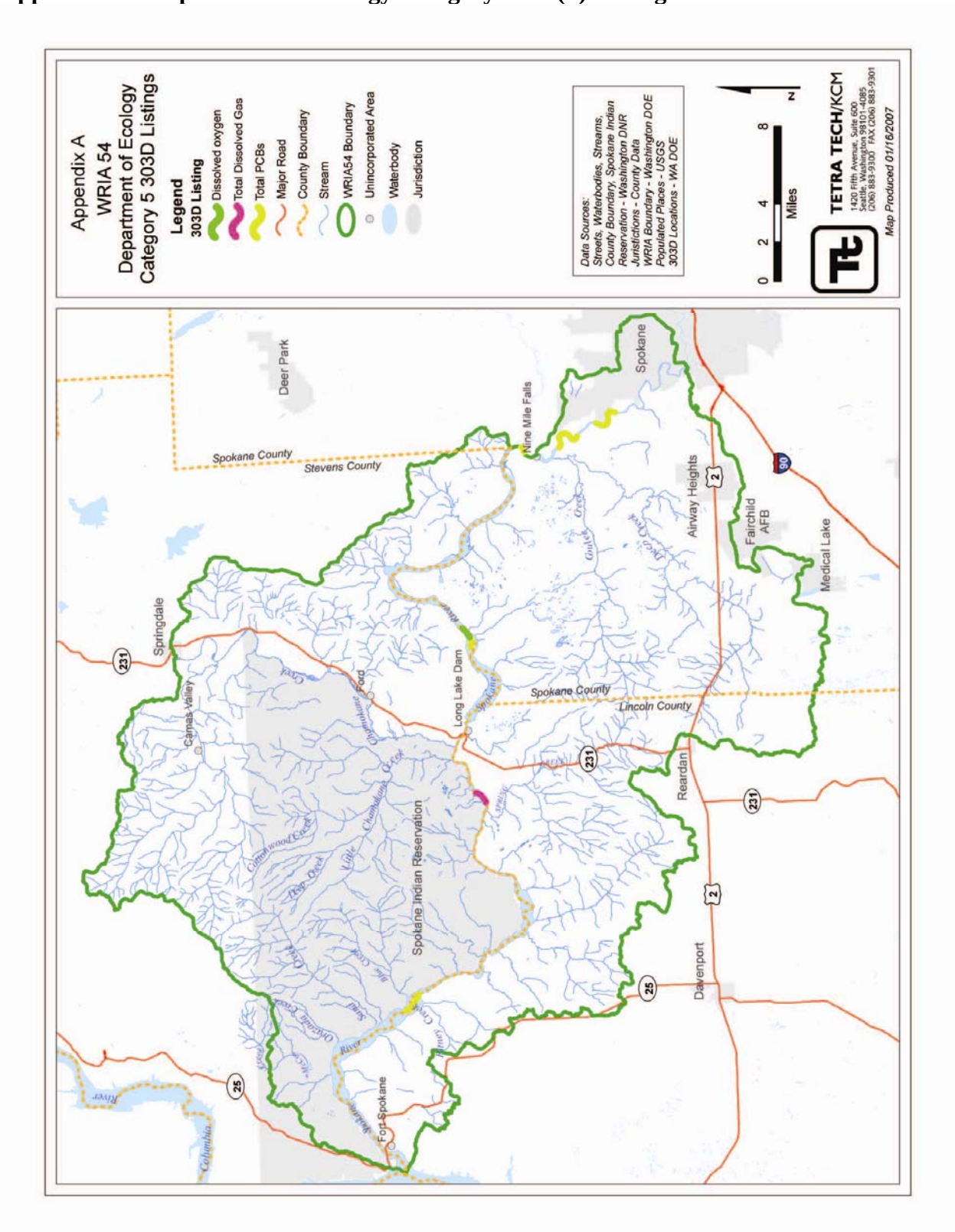
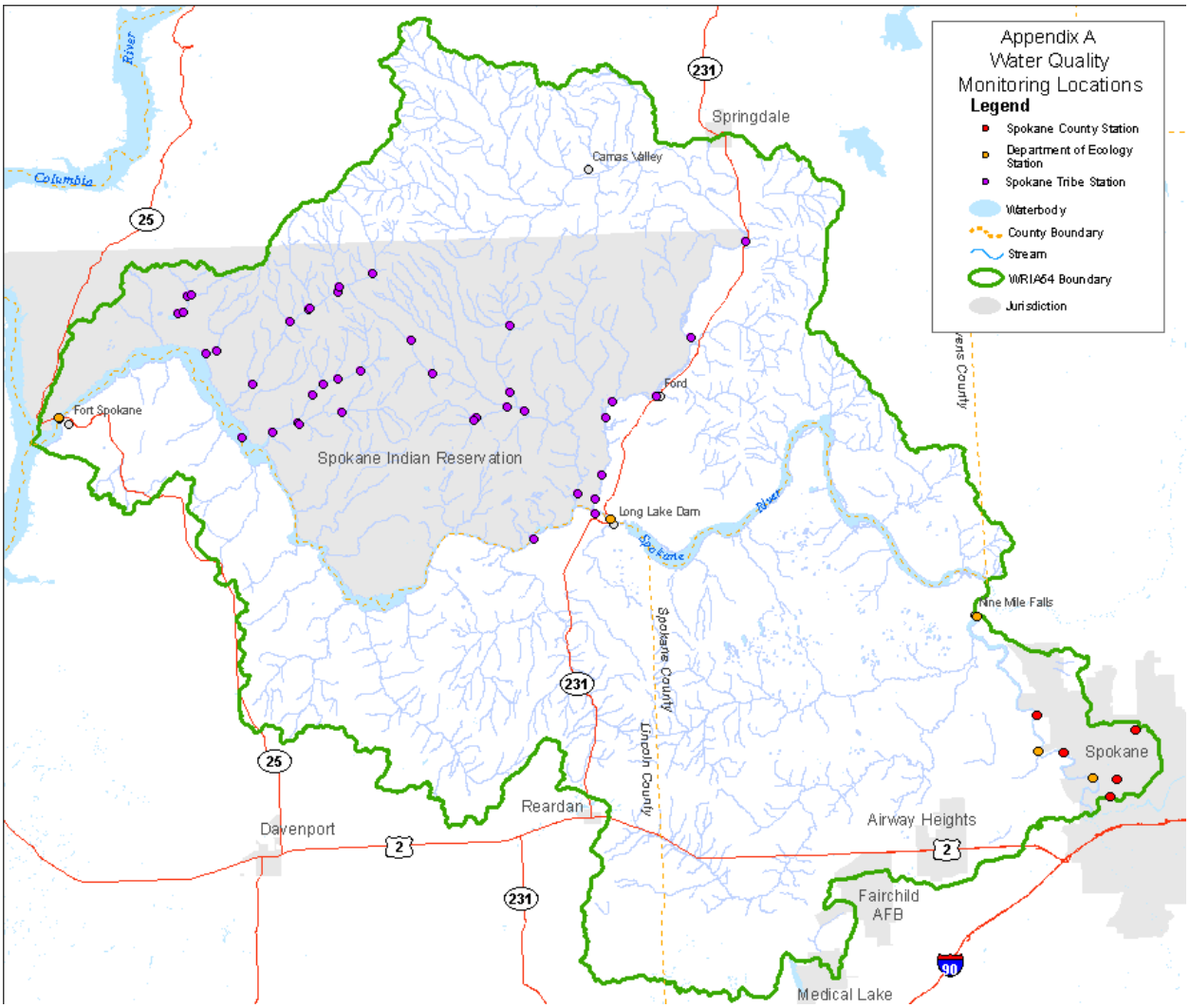



**Figure 1**

# Appendix A – Department of Ecology Category 5 303(d) Listings



# Appendix A – Water Quality Monitoring Locations



# Appendix B
## Surface Water, Sediment and Wetland Inventory: Summary of Available Data

| Water Body | Location ID | Location Name | Period of Record | Parameters Measured | Type of Sampling | Study | Author |
|---|---|---|---|---|---|---|---|
| Spokane River | 54A089 | Spokane River 2mi blw Ninemile Dam | 4/18/1971 to 1/17/1972 | Alkalinity, Ammonia, Conductivity, DO, Fecal Coliform, Hardness, Nitrate, Nitrite, Ortho-Phosphorus, pH, Temperature, TP, TKN, TSS, Turbidity | Surface Water | Statewide River and Stream Ambient Monitoring-Pre 1980 | ECY-EAP |
| Little Spokane River | LitlSpokR | Little Spokane River near SR291 | 10/2/2003 | DOC, PCBs, TOC, TSS | Surface Water | Spokane River PCB TMDL | ECY-EAP |
| Upper Long Lake | Long03 | Upper Long Lake (Long03) | 9/20/2002 | Conductivity, Temperature, DO, pH; Mercury, TOC | Surface Water; Sediment | Screening Survey of Mercury Levels in Fish Tissue | ECY-EAP |
| Spokane River | SPK58.1 | Spokane River Nine Mile Bridge | 8/25/1999 to 9/27/2000 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TDS, TOC, TPN | Surface Water | Spokane River BOD TMDL | ECY-EAP |
| Spokane River | 54A090 | Spokane River @ NineMile Bridge | 11/30/1970 to 9/25/1973; 6/11/2000 to 9/10/2000; 5/9/2007 to 3/10/2008 | Alkalinity, Ammonia, BP, Conductivity, DOC, DO, Fecal Coliform, Flow, Hardness, Nitrate, Nitrite, Nitrate+Nitrite, Ortho-Phosphorus, TP, Temperature, TDS, TKN, TOC, TPN, TSS, Turbidity | Surface Water | Statewide River and Stream Ambient Monitoring-WY2000 to present; Statewide River and Stream Ambient Monitoring-Pre 1980 | ECY-EAP |
| Long Lake | LONSP11 | Long (Spokane) 1 | 5/26/1990 to 8/22/1990 | Conductivity, DO, pH, Temperature, Secchi Disk Depth | Water Column | Statewide Lake Monitoring | ECY-EAP |

| Water Body | Location ID | Location Name | Period of Record | Parameters Measured | Type of Sampling | Study | Author |
|---|---|---|---|---|---|---|---|
| Little Spokane River | 55B070 | Little Spokane River Near Mouth | 11/30/1970 to 3/10/2008 | Alkalinity, Ammonia, Arsenic, BP, Cadmium, COD, Chlorophyll, Chromium, Conductivity, Copper, DOC, DO, Enterococci, Fecal Coliform, Flow, Hardness, Lead, Mercury, Nickel, Nitrate, Nitrite, Nitrate+Nitrite, Ortho-Phosphorus, pH, TP, Silica, Silver, Air Temperature, Water Temperature, TDS, TKN, TOC, TPN, TSS, Turbidity, Zinc | Surface Water | Statewide River and Stream Ambient Monitoring-WY2000 to present; Statewide River and Stream Ambient Monitoring-Pre 1980; Statewide River and Stream Ambient Monitoring-1980 to 1988; Statewide River and Stream Ambient Monitoring-WY1989 through WY1999; Continuous Stream Temperature Monitoring | ECY-EAP |
| Little Spokane River | LitlSpokBr | Little Spokane River @ SR291 Bridge | 1/29/2004 to 5/12/20047 | DOC, PCBs, TOC, TSS | Surface Water | Spokane River PCB TMDL | ECY-EAP |
| Little Spokane River | LSK56.4 | Little Spokane River | 8/25/1999 to 8/30/2001 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TDS, TOC, TPN | Surface Water | Spokane River BOD TMDL | ECY-EAP |
| Little Spokane River | LSRTMDL-26 | ECY 55B070-Little Spokane R. Near Mouth | 5/12/2005; 9/8/2005 to 9/12/2005; 10/18/2005 | Carbamate Pesticides, Herbicides, Nitrogen Pesticides, Organophosphorus Pesticides, Semi-Volitiles, Ammonia, Conductivity, DO, Nitrite+Nitrate, pH, Salinity, Temperature, TP, TSS, Turbidity | Surface Water | Little Spokane River Bacteria, Phosphorus, and Temperature TMDL Surveys | ECY-EAP |
| Long Lake | LL5 | Long Lake Sampling Site #5 | 8/16/2000; 9/26/200 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TDS, TOC, TPN, Secchi Disk Depth | Water Column | Spokane River BOD TMDL | ECY-EAP |
| Long Lake | Long02 | Upper Long Lake (Long02) | 9/20/2002 | Conductivity, Temperature, DO, pH; Mercury, TOC | Surface Water; Sediment | Screening Survey of Mercury Levels in Fish Tissue | ECY-EAP |

| Water Body | Location ID | Location Name | Period of Record | Parameters Measured | Type of Sampling | Study | Author |
|---|---|---|---|---|---|---|---|
| Long Lake | SPOKNR99SRG-09 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | LL4 | Long Lake Sampling Site #4 | 8/16/2000; 9/26/2000 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TDS, TOC, TPN, Secchi Disk Depth | Water Column | Spokane River BOD TMDL | ECY-EAP |
| Long Lake | SPOKNR99SRG-08 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-07 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | Long01 | Upper Long Lake (Long01) | 9/20/2002 | Alkalinity, Conductivity, DO, Hardness, pH, Temperature, Secchi Disk Depth; Mercury, TOC | Surface Water; Sediment | Screening Survey of Mercury Levels in Fish Tissue | ECY-EAP |
| Long Lake | SPOKNR00SRG-04 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR00SRG-05 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | LL3 | Long Lake Sampling Site #3 | 6/6/2000 to 9/26/2000; 8/8/2001 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Iron, Manganese, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Silicon, Sulfates, Temperature, TDS, TOC, TPN, Secchi Disk Depth | Water Column | Spokane River Biological Effects; Spokane River BOD TMDL | ECY-EAP |
| Long Lake | SPOKNR99SRG-02 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-03 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-01 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-01A | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |

| Water Body | Location ID | Location Name | Period of Record | Parameters Measured | Type of Sampling | Study | Author |
|---|---|---|---|---|---|---|---|
| Long Lake | SPOKNR99SRG-12 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | LL2 | Long Lake Sampling Site #2 | 8/16/2000; 9/27/2000; 8/30/2001 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TDS, TOC, TPN, Secchi Disk Depth | Water Column | Spokane River BOD TMDL | ECY-EAP |
| Long Lake | SPOKNR99SRG-18 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-19 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | TumTum | Long Lake @ Tum Tum | 1/29/2004; 2/24/2004 | DOC, PCBs, TOC, TSS | Surface Water | Spokane River PCB TMDL | ECY-EAP |
| Long Lake | LL1 | Long Lake Sampling Site #1 | 6/6/2000 to 9/27/2000; 8/8/2001 to 8/30/2001 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Iron, Manganese, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Silicon, Sulfates, Temperature, TDS, TOC, TPN, Secchi Disk Depth | Water Column | Spokane River BOD TMDL | ECY-EAP |
| Long Lake | LONGLKLOW | Lower Long Lake | 10/2/2003; 4/13/2004; 5/11/2004 | DOC, PCBs, TOC, TSS | Surface Water | Spokane River PCB TMDL | ECY-EAP |
| Long Lake | SPK40.8 | Spokane River (River Mile 40.8) | 9/25/2006 | Chlorophyll, DOC, Alkalinity | Surface Water | Mercury Trends in Freshwater Fish 2006 | ECY-EAP |
| Long Lake | SPOKNR99SRG-16 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-17 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-13 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Long Lake | SPOKNR99SRG-15 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus, Sulfides | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |

| Water Body | Location ID | Location Name | Period of Record | Parameters Measured | Type of Sampling | Study | Author |
|---|---|---|---|---|---|---|---|
| Spokane River | 54A070 | Spokane River at Long Lake (USGS) | 8/15/1959 to 3/18/1981; 5/9/2007 to 3/10/2008 | Alkalinity, Ammonia, BP, Conductivity, DOC, DO, Fecal Coliform, Flow, Hardness, Nitrate, Nitrite, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TKN, TOC, TPN, TSS, Turbidity | Surface Water | Statewide River and Stream Ambient Monitoring-WY2000 to present; Statewide River and Stream Ambient Monitoring-Pre 1980; Statewide River and Stream Ambient Monitoring-1980 to 1988 | ECY-EAP |
| Spokane River | BLWLONG | Below Long Lake Monitoring Station | 5/12/1997 | Cadmium, Copper, Hardness, Lead, Zinc | Surface Water | Metals in Spokane River during spring run-off in 1997 | ECY-EAP |
| Long Lake | LL0 | Long Lake Sampling Site #0 | 8/16/2000; 9/27/2000 | Alkalinity, Ammonia, Chloride, Chlorophyll, Conductivity, DOC, DO, Nitrite-Nitrate, Ortho-Phosphorus, pH, TP, Temperature, TDS, TOC, TPN, Secchi Disk Depth | Water Column | Spokane River BOD TMDL | ECY-EAP |
| Long Lake | LLK33.9 | Long Lake Outlet | 8/25/1999 | Alkalinity, Ammonia, Chloride, Conductivity, DOC, Nitrite+Nitrate, Ortho-Phosphorus, TP, TOC, TPN | Surface Water | Spokane River BOD TMDL | ECY-EAP |
| Long Lake | SPOKNR99SRG-14 | Long Lake Sediment | 1/1/1999 | Metals, Mercury, TOC, Phosphorus | Sediment | Spokane River Basin Surface Bulk Samples | Martin Payne |
| Spokane River | SpokR@Lldam | Spokane River at Long Lake Dam | 5/13/1986; 8/26/1986 | Arsenic, Cadmium, Conductivity, Copper, Hardness, Lead, Mercury, pH, Temperature, TSS, Zinc | Surface Water | Metals Contamination in Lake Roosevelt | ECY-EAP |

| Longitude | Latitude | Adjacent Body of Water | Location | Wetland Type |
|---|---|---|---|---|
| -117.536614 W | 47.786836 N | Long Lake | Downstream of Nine Mile Dam, Left Bank | Forested |
| -117.532376 W | 47.787703 N | Long Lake | Downstream of Nine Mile Dam, Right Bank | Shrub/Scrub |
| -117.532534 W | 47.789745 N | Long Lake | Downstream of Nine Mile Dam, Right Bank | Shrub/Scrub |
| -117.532637 W | 47.792235 N | Long Lake | Downstream of Nine Mile Dam, Right Bank | Shrub/Scrub |
| -117.530921 W | 47.783427 N | Little Spokane River | Downstream of SR291 Bridge, Left Bank | Shrub/Scrub |
| -117.530505 W | 47.786005 N | Little Spokane River | Downstream of SR291 Bridge, Right Bank | Shrub/Scrub |
| -117.528083 W | 47.787125 N | Little Spokane River | Downstream of SR291 Bridge, Left Bank | Shrub/Scrub |
| -117.528895 W | 47.788838 N | Little Spokane River | Downstream of SR291 Bridge, Left Bank | Emergent |
| -117.530257 W | 47.789361 N | Little Spokane River | Downstream of SR291 Bridge, Left Bank of Arm | Emergent |
| -117.541781 W | 47.799682 N | Long Lake | Downstream of Little Spokane River Confluence, Right Bank | Shrub/Scrub |
| -117.544043 W | 47.7998 N | Long Lake | Downstream of Little Spokane River Confluence, Right Bank | Emergent |
| -117.552401 W | 47.803455 N | Long Lake | Right Bank | Forested |
| -117.552282 W | 47.800701 N | Long Lake | Left Bank | Emergent |
| -117.560652 W | 47.798139 N | Long Lake | Left Bank | Aquatic Plant Bed |
| -117.566673 W | 47.797577 N | Long Lake | Mid-Channel, near aquatic plant bed | Aquatic Plant Bed |
| -117.624104 W | 47.830778 N | Long Lake | Right Bank (RM 50, USGS) | Aquatic Plant Bed |
| -117.623561 W | 47.830744 N | Long Lake | Right Bank (RM 50, USGS) | Forested |
| -117.639129 W | 47.831125 N | Long Lake | Left Bank (RM 50, USGS) | Aquatic Plant Bed |
| -117.638002 W | 47.83069 N | Long Lake | Left Bank (RM 50, USGS) | Emergent |
| -117.651995 W | 47.831643 N | Long Lake | Left Bank | Aquatic Plant Bed |
| -117.65466 W | 47.835009 N | Long Lake | Left Bank | Aquatic Plant Bed |
| -117.656618 W | 47.836891 N | Long Lake | Left Bank | Aquatic Plant Bed |
| -117.657779 W | 47.836675 N | Long Lake | Left Bank | Forested |
| -117.658243 W | 47.838194 N | Long Lake | Left Bank | Emergent |
| -117.654647 W | 47.843161 N | Long Lake | Right Bank | Aquatic Plant Bed |
| -117.652102 W | 47.840939 N | Long Lake | Right Bank | Emergent |
| -117.651672 W | 47.841051 N | Long Lake | Right Bank | Forested |
| -117.659051 W | 47.850239 N | Long Lake | Right Bank | Aquatic Plant Bed |
| -117.661439 W | 47.854291 N | Long Lake | Right Bank | Aquatic Plant Bed |
| -117.664049 W | 47.862099 N | Long Lake | Right Bank | Shrub/Scrub |
| -117.661415 W | 47.87512 N | Long Lake | Right Bank near Sunshine Shores | Aquatic Plant Bed |
| -117.659756 W | 47.876669 N | Long Lake | Right Bank near Sunshine Shores | Forested |
| -117.658871 W | 47.879623 N | Long Lake | Willow Bay | Aquatic Plant Bed |
| -117.657438 W | 47.879221 N | Long Lake | Willow Bay | Aquatic Plant Bed |
| -117.667789 W | 47.877149 N | Long Lake | Willow Bay, Left Bank | Aquatic Plant Bed |
| -117.65845 W | 47.882955 N | Long Lake | Willow Bay, near trailer park | Aquatic Plant Bed |
| -117.661486 W | 47.885108 N | Long Lake | Downstream of Willow Bay, Right Bank | Aquatic Plant Bed |
| -117.662462 W | 47.887251 N | Long Lake | Downstream of Willow Bay, Right Bank | Aquatic Plant Bed |
| -117.661882 W | 47.88903 N | Long Lake | Downstream of Willow Bay, Right Bank | Aquatic Plant Bed |
| -117.660641 W | 47.892954 N | Long Lake | Sunset Bay | Aquatic Plant Bed |
| -117.66119 W | 47.895168 N | Long Lake | Sunset Bay | Forested |
| -117.666294 W | 47.893784 N | Long Lake | Sunset Bay | Aquatic Plant Bed |
| -117.68265 W | 47.89051 N | Long Lake | Right Bank (RM 45, USGS) | Aquatic Plant Bed |
| -117.681805 W | 47.884752 N | Long Lake | Left Bank (RM 45, USGS) | Aquatic Plant Bed |
| -117.703303 W | 47.867771 N | Long Lake | Right Bank (RM 43, USGS) | Aquatic Plant Bed |
| -117.745341 W | 47.833958 N | Long Lake | Right Bank (RM 40, USGS) | Aquatic Plant Bed |
| -117.748907 W | 47.834082 N | Long Lake | Right Bank (RM 40, USGS) | Emergent |
| -117.80047 W | 47.818856 N | Long Lake | Right Bank (upstream of RM 35, USGS) | Aquatic Plant Bed |
| -117.830133 W | 47.8283 N | Long Lake | Left Bank (downstream of RM 35, USGS) | Aquatic Plant Bed |

# Appendix C
## Response Summary to Reviewer Comments

DM = Dave Moore (Washington Department of Ecology, Eastern Region Office)
JR = Jim Ross (Washington Department of Ecology, Eastern Region Office)

DM1

| Reviewer | Comment | Response |
|---|---|---|
| DM1 | Was this the extent of the analysis? It's pretty thin if it is. | The landscape analysis did not use a model approach (e.g., ATtILA; U.S. EPA) for determining convergence points of landscape covers where water quality may be impaired. Rather, the visual analysis presented obvious intersections where known water quality issues were identified from existing water quality or biological data. |
| DM2 | The most current study by Cusimano is from 2004 (04-03-006). | Acknowledged. The Cusimano 2004 citation was added and reports the same data used in the 2003 report was used in the 2004 report, but re-analyzed with the CE-QUAL-W2 model (Version 3.0). |
| DM3 | Note: This could be a potential delta elimination item for one of the Dischargers per the draft DO TMDL. You may want to make that link here. | The comment is noted. Currently, the DO TMDL is in draft form and there is no formalized process established for determining pollution credits as per the delta elimination system. |
| DM4 | Reference? I'm not aware of much data to support this. (referring to a statement that did not cite information confirming high concentrations of phosphorus in sediments) | Sediment data reported in the Ecology EIM database reports phosphorus concentrations in sediments of Lake Spokane from below the confluence with Little Spokane River down to the Long Lake Dam. |
| DM5 | Where is this data? (referring to a statement that links DO demand to hypolimnetic sediment) | Qualifier added to the statement that speculates source for low dissolved oxygen near the sediment/surface water boundary. |
| DM6 | Confusing as worded. (Comment refers to sentence structure and the necessity for revision.) | Revised the statement to include three separate observations. Used previous results from sediment and surface water sampling to indicate relative contributions of phosphorus from sediment and surface water. Indicated blue-green blooms observed in the upper end of Long Lake (Lake Spokane) from 2001 studies. |
| DM7 | Reference | Included specific citation for Standard Methods for Examination of Water and Wastewater. |
| DM8 | What about SOD from sediments in the deeper parts of the lake, closer to and at the dam? | Comment noted. However, the objectives outlined by the Watershed Planning Unit indicated that the primary interest is on nutrients in media and potential sources. The DO TMDL addresses the linkage between nutrients and DO concentrations. |
| DM9 | Example? (Referring to the statement that there is an indication that 1980's research did not address internal nutrient loading) | Provided citations from 1980's research that indicate absence of sediment characterization. |
| DM10 | This section is unclear. Are you talking about the shallow upper portions of Lake Spokane where algae growth is most prevalent? If so, you should specifically identify this. It's unclear what you mean by transition zones – transition to slower water, deeper water? | Clarified reference to zones by defining characteristics that will be used to identify these transition points along Lake Spokane. |

| | | |
|---|---|---|
| DM11 | Same question as in comment #8. What data indicate the DO shortage is solely due to decomposing organic matter generated at the upper end of the lake? | Previous studies by Patmont (1985) and Cusimano (2004) indicate potential phosphorus sources and identify dynamics for phosphorus movement in the lake that indicates the origin and fate of nutrient re-distribution. |
| DM12 | Maybe you should develop a map showing the proposed zones. (referring to identification and location of the Lake Spokane zones; riverine, transition, and lacustrine) | Figure 5.2-1 reports the location and length of each zone in Section 5. Section 2 provides a description of setting and relates why specific water quality parameters should be measured. |
| DM13 | I want to make sure this is done if full consideration and not at cross-purposes to the DO TMDL NPS committee. A statement early in the document would be nice to mention how this fits in with that effort. (referring to designation of a person without consulting with the NPS Committee) | Specific name for Project Manager re-placed with the generic "WRIA 54 Planning Unit Member". |
| DM14 | Is there any way to add a column here to show the number of samples and total cost? (refers to Table 3.1-1 where a comprehensive list is provided for all Tasks) | We prefer to leave Table 3.1-1 as a comprehensive list of parameters analyzed for all tasks for the following reasons: 1) the guidelines for preparing QAPPs recommends use of a comprehensive table so that analysis methods can be found in one location, and 2) there are numerous tasks for monitoring in this document and they each report the number of samples and total costs for each analyte. The number of samples differ for each Task, but we could aggregate the total number of samples from all Tasks in Table 3.1-1. |
| DM15 | Can we use the word "Task" instead? (referring to the term used in the contract that identifies goals of the Watershed Planning Unit) | The term "Goal" has been changed to "Task" throughout the document. This term is more commonly used when technical studies are describing implementation elements. |
| DM16 | You might cover this later but how will an acceptable storm be defined in terms of antecendent dry period, etc. What part of the storm are you targeting? These things are really tricky and much thought needs to be given to site selection, target storms, and false starts. Not to mention sampling stormwater is incredibly difficult anyway. | We inserted a reference to additional information describing storm events and sampling strategies. This information was acquired from Ecology's Stormwater Manual. |
| DM17 | More current study is Publication 04-03-006. (refers to the most recent TMDL publication) | We included the most recent (2004) Ecology publication detailing the TMDL model. The citation for use of the updated model and data is reported in Section 1.3 of this QAPP. |
| JR | Rational for extrapolating internal phosphorus loads from the upper reaches to the entire reservoir is not adequately supported. | The sediment coring as part of Task 4 specifies sediment core collection on the middle of each transect that directly characterizes a longitudinal profile of the reservoir. |

# Appendix D
## Field and Laboratory Forms

**Aquatic Research Inc.**
3927 Aurora Avenue N, Seattle, WA 98103
P 206.632.2715 | F 206.632.2417
www.aquaticresearchinc.com

SHEET _____ OF _____

**CHAIN-OF-CUSTODY RECORD**

CLIENT: _____ PROJECT ID: _____
SAMPLING DATE: _____ CASE FILE NO.: _____
SAMPLERS: _____ DATA RECORDED BY: _____

**SAMPLE INFORMATION**

| SAMPLE ID | DATE/TIME COLLECTED | PARAMETERS | BOTT # | NOTES |
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| | Relinquished By | Date/Time | Received By | Date/Time |
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| Printed Name | | | | |
| Signature | | | | |
| Affiliation | | | | |

| | Relinquished By | Date/Time | Received By | Date/Time |
|---|---|---|---|---|
| Printed Name | | | | |
| Signature | | | | |
| Affiliation | | | | |

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): _____

3927 Aurora Ave. N | Seattle, WA 98103 | 206.632.2715

TETRA TECH

# FIELD DATA REPORT FORM

Y M M D D
0

SURVEY ..... SAMPLER ..... PAGE ..... OF .....

| STATION NO. | STATION NAME | TIME | TEMP ºC | DO mg/L | DO # | pH | TRUE pH / METER | COND. µMHOS/CM | REDOX POTENTIAL | *L/M/R | DEPTH (meters) | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
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WEATHER:

ADDITIONAL COMMENTS:

Tt (Rev. 11/07)

* L = Left Bank; M = Middle Bank; R = Right Bank

Run: _____ Date: _____

# Meter Calibration Log Form

Cond Meter# _____ Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

pH Meter # _____ pH Probe # _____

Thermistor # _____ Thermistor _____ °C Thermometer _____ °C Correction _____

**DAY 1**

Low Ionic Strength pH Value vs. Temp. °C

| | 7 | 10 |
|---|---|---|
| **10** | 7.01 | 9.27 |
| **15** | 6.99/7.00 | 9.23 |
| **20** | 6.98 | 9.19 |

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

| | true pH | meter | time of day | | |
|---|---|---|---|---|---|
| QA Check #1 | _____ | _____ | _____ | Recalibrated | Y / N |
| QA Check #2 | _____ | _____ | _____ | Recalibrated | Y / N |
| QA Check #3 | _____ | _____ | _____ | Recalibrated | Y / N |

*If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.*

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

**DAY 2**

Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

| | true pH | meter | time of day | | |
|---|---|---|---|---|---|
| QA Check #1 | _____ | _____ | _____ | Recalibrated | Y / N |
| QA Check #2 | _____ | _____ | _____ | Recalibrated | Y / N |
| QA Check #3 | _____ | _____ | _____ | Recalibrated | Y / N |

*If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.*

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

**DAY 3**

Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

| | true pH | meter | time of day | | |
|---|---|---|---|---|---|
| QA Check #1 | _____ | _____ | _____ | Recalibrated | Y / N |
| QA Check #2 | _____ | _____ | _____ | Recalibrated | Y / N |
| QA Check #3 | _____ | _____ | _____ | Recalibrated | Y / N |

*If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.*

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm