

Ambient Groundwater Monitoring Program and Data Quality Management Plan for the WRIA 16 Planning Area

Prepared for the
WRIA 16 Planning Area
Jefferson and Mason County, Washington

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Approval Page for the

**Ambient Groundwater Monitoring Program
and Data Quality Management Plan for
The WRIA 16 Planning Area**

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1 About This Plan

This plan has been prepared using Appendix B of *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, a publication of the Washington State Department of Ecology (DOE, 2004), and it is intended to be used as the quality assurance project plan (QAPP) for the groundwater monitoring program that this plan describes. The DOE guidelines follow a systematic planning process described by the U.S. Environmental Protection Agency (EPA).

This Plan only includes the pertinent elements specified in DOE's guidelines, which are designed to address a range of environmental studies. It does not include the rigorous, detailed elements required for contamination studies because we propose monitoring only constituents that occur naturally, at measurable concentrations, under both unimpacted and impacted conditions.

2 Distribution

Twenty-five copies of this monitoring plan have been distributed to the members of the WRIA 16 Planning Unit.

3 Background

The Skokomish-Dosewallips Basin, WRIA 16, is located on the Olympic Peninsula on the west side of Hood Canal (**Figure 1**). The southern part of WRIA 16 lies in Mason County and the northern part lies in Jefferson County. The physiography ranges from the snow-capped mountains in the western part of WRIA 16 to the flatlands of the Skokomish River Valley in the southeastern part and to the hills and river valleys along the eastern shore of Hood Canal. The WRIA 16 Planning Area includes the south shore of Hood Canal, which is WRIA 14b. This is the portion of WRIA 14 (Kennedy / Goldsborough) that drains north into the lower Hood Canal.

The principal drainages in WRIA 16 are the Dosewallips, Duckabush, Hamma Hamma, and the Skokomish Rivers. Many smaller streams discharge into Hood Canal.

3.1 Hydrogeology

In general, the hydrogeology of the area is characterized by glacial deposits and basalt. Glacial deposits comprise permeable outwash, low-permeability till, fluvially reworked glacial deposits, and low-permeability glaciolacustrine silt and clay. Wells are completed in gravel units within the unconsolidated deposits or in fractured basalts. Uplands may be covered with a thin veneer of glacial deposits overlying basalt. River valleys have a relatively thick sequence of glacial deposits beneath alluvial deposits.

During 2002, the Planning Unit completed a draft *Phase 2 Level 1 Technical Assessment* which describes what is known about water issues. A key finding concludes that although much less than 1 percent of the total amount of available water is actually used, the watershed still faces serious availability problems during the low-flow summer months.

Development in the basin is primarily concentrated along the shorelines of Hood Canal and Lake Cushman. Water supplies are needed for future development in the Brinnon area, most notably the Black Point area. Other “growth areas” include Union, Hoodsport, and Lilliwaup. Some wells near the shore have experienced seawater intrusion. A few are located inland in more remote parts of the basin; access to these wells may be difficult or require lengthy driving time.

3.2 Previous Work

Most of the water quality information available for the WRIA 16 Planning Area is for surface water (streams and marine areas). For streams, concerns include nutrients (primarily nitrate), pH, and coliform. For marine waters, low dissolved oxygen is the primary concern. Very little groundwater quality data has been collected for wells throughout the WRIA 16 Planning Area. Some data indicate that chloride is a constituent of concern in a few wells and may be a result of seawater intrusion. *Hydrogeologic Study of the Lower Dosewallips / Brinnon Area* reports that the chloride source is uncertain. The report recommends additional sampling to identify whether the chloride originates from seawater intrusion or from connate groundwater.

A water supply and groundwater impact analysis was prepared as part of the Draft Environmental Impact Statement prepared for the Pleasant Harbor Marina and Golf Resort. This analysis includes subsurface sections through the Black Point peninsula in the Brinnon area (Subsurface Group, 2008).

The U.S. Geological Survey (USGS) has monitored shallow groundwater quality for nutrients along the South Shore of Hood Canal (Turney and Simonds, 2006; Simonds et al, 2008). Most of the USGS samples were collected from



temporary shallow piezometers that were installed for the study. However, neither the USGS nor any other agency has monitored ambient groundwater levels or water quality in the WRIA 16 Planning Area; consequently, we have no reasonable means to determine whether future groundwater development will cause unacceptable impacts on streamflow, aquifer levels, and water quality.

4 Monitoring Program Description

4.1 Objectives

The goal of this Plan is to provide a framework for implementing an ambient monitoring program in WRIA 16 Planning Area. Designed to address water levels and groundwater quality, this program uses a wide array of wells to cover a large geographic expanse that includes areas where future development is expected to occur. The monitoring data will not only serve as a basis for characterizing the regional hydrogeology, but it will also help fill gaps that were identified during earlier studies. Most importantly, it will provide a basis for predicting the impacts of future proposed groundwater development and provide data for early detection of water quality and water quantity problems. Planners can then make decisions that sustain adequate streamflow, aquifer levels, and water quality. This plan specifies procedures and protocols for achieving several key objectives, as noted below.

Objective	Approach
Represent the range of hydrogeologic conditions in the basin	Select a set of monitoring wells in optimum locations
Identify seasonal water level trends	Monitor quarterly at selected wells for at least 2 years
Identify trends in concentrations of key constituents	Select an optimum suite of analytes for regular water sampling
Provide data for evaluating possible seawater intrusion	Monitor chloride continuously at selected wells
Collect data on a regular schedule from private and water supply wells	Develop cooperative relationships with well owners that respect their time and property
Ensure greatest possible data accuracy	Collect samples and review lab results using consistent protocols; maintain data in a format consistent with DOE's Environmental Information Management System (EIMS) database

4.2 Data Sources

This Plan uses information from many sources:

- DOE well log database (1,712 wells within the WRIA 16 Planning Area)
- Washington State Department of Health (DOH) database (116 Group A wells and 137 Group B wells in the WRIA 16 Planning Area, in the form of shapefiles)
- Brinnon area hydrogeologic study (Aspect, 2005)
- USGS nitrate study in South Hood Canal (Simonds et al, 2008)
- Mason County PUD#1 wells

4.3 Method

4.3.1 Database

Well data was imported into an Access database after establishing project coordinates using GIS methods. Logs for the deepest wells in each section were printed, summarized, and entered into Access. The database was then integrated with ViewLog, which allowed us to map the wells, create a set of cross-sections, and view the wells and well logs in a three-dimensional system.

4.3.2 Well Selection

Wells were selected based on location and depth to represent groundwater conditions throughout the WRIA 16 Planning Area. The data set includes shallow and deep wells, wells completed in the basalt and unconsolidated deposits, wells located on uplands and lowland areas, wells located near the shore, and inland wells. Our selection criteria also emphasized “growth areas”—Brinnon, Black Point, Triton, Lilliwaup, Hoodspout, the Lower Skokomish River valley, Union, and the Sunset Beach area—where future groundwater development is likely. A few remote wells were also selected for background conditions. To be selected for continuous monitoring, a well had to meet one of two criteria: It must lie within a growth area that is subject to seawater intrusion or it must lie within an area where groundwater decline is an issue.

In general, shallow wells near streams were not considered because these wells are likely already being monitored under DOH’s GWI program (groundwater under the influence of surface water) and these wells are not as pertinent to the issue of future groundwater development.

In general, the majority of the population and areas of anticipated growth occurs near the Hood Canal coastline. For these cases, potential for seawater intrusion is an important concern due to proximity to marine waters of Hood Ca-

nal. Therefore, while domestic wells occur within a broader part of the WRIA 16 Planning Area, most of the recommended wells occur near the canal's coastline.

4.4 Implementing the Monitoring Program

The tasks required to implement the Plan are summarized below. These tasks would be conducted on a quarterly basis, unless stated otherwise. Detailed monitoring procedures are given in Section 8, "Sampling & Measurement Procedures."

For Startup:

- Conduct a site visit to each well.
- If it has not already been obtained, obtain a signed written agreement.
- Locate well on a map using local streets or use a hand-held GPS unit to identify spatial coordinates of the well. Update the land-surface and well-bottom elevation data in the database, using GPS elevation data or digital elevation data with mapping software (GIS or ViewLog)
- Confirm the ability to place a sounder down the well.
- Identify and mark the measuring point on the well. Identify and describe the sampling port.
- Prepare a local map for each well and include any detailed descriptions needed to describe clearly and concisely how to find and access the well, the measuring point, and the sampling port.
- Place the map in the field notebook.

For Quarterly Monitoring:

Step 1: Confirm the time and date of the site visit by telephone. If only water level measurements will be made, request that the pump be shut off when you arrive.

Step 2: Visit each well.

- For wells with continuous monitoring, download data from the datalogger.
- If applicable, collect a water sample from a spigot as close to the wellhead as possible. Avoid sampling from garden hoses or from plumbing that receives water from a holding tank. Use the quality assurance protocols described in Section 8.2, "Collecting Water Samples."

- Shut the pump off, if necessary, and measure the depth to water. Keep measuring until the water level stabilizes. Record this measurement using the quality assurance protocols described in Section 8.3, “Measuring Water Levels.”

Step 3: Store samples in an ice chest and bring them to the lab within the shortest holding time of all the analytes. Alternatively, have the lab pick up the samples.

Step 4: At the office, enter data into a spreadsheet or database.

Step 5: Review the quality control parameters to evaluate the data’s validity and usability.

Step 6: Copy any continuous digital data to an Excel spreadsheet and update the hydrograph for each well.

4.5 Duration of the Monitoring Program

The monitoring program should proceed according to this plan for at least two years. After two years, the data should be evaluated to determine if the program should continued unchanged or be modified. The data should be reviewed to identify wells that could be eliminated from the program due to redundancy, wells that should be added due to new needs or information, and to modify the analyte suite if needed. Similarly, water quality sampling frequency may be reduced if appropriate.

5 Organization, Schedule, & Budget

This section describes the project organization, schedule, and specific responsibilities. At this time, the Planning Unit has not identified who will conduct and pay for the monitoring, or when the program would begin; therefore, this Plan does not specify a start date or schedule. This section offers generic guidelines but does not name individuals, institutions, or dates.

5.1 Organization

The Planning Unit will identify an individual within one of its participating agencies (for example, Mason County) or hire a consultant to conduct the monitoring. This individual(s) will answer to the Planning Unit and will be responsible for measuring water levels, collecting water quality samples, implementing quality control procedures, managing data, and reporting. We recom-

mend that the Planning Unit designate one of its members to directly manage the individual who manages the work described above.

5.2 Schedule

This monitoring plan describes a quarterly schedule for sampling, data review, and data management activities. The final schedule will be determined by the Planning Unit based on the available budget and/or other criteria. Quarterly monitoring will be scheduled to optimize the recording of maximum seasonal change.

5.3 Budget

At the request of the WRIA 16 Planning Unit, the budget for the monitoring program has been prepared in three tiers.

- **Tier 1**, the least expensive, attempts to minimize cost while maximizing data collection.
- **Tier 3**, the most expensive, is designed to obtain the best data for understanding ambient groundwater quality and quantity conditions, for tracking trends in water level and conductivity at selected wells, and for documenting spatial variability.
- **Tier 2** offers an alternative that lies between the bare minimum of Tier 1 and the completeness of Tier 3.

Table 2 summarizes the tasks and costs to implement the monitoring program for each tier. Startup costs are separate from annual costs for quarterly monitoring. The budgets allow the Planning Unit to modify the number of wells that would be subject to quarterly water level measurements, water quality sampling, and continuous monitoring. In this way, the details of the monitoring program can be adjusted to meet constraints based on budget or specific information needs.

Table 2 shows **Tier 1** has 35 wells monitored for water level and 25 wells monitored for water quality, while **Tier 3** has 50 and 40 wells, respectively. Because of the expense of laboratory analyses, fewer wells are monitored for water quality than water level to reduce costs. The exact number of wells monitored for water level and water quality can be modified as needed. More wells would provide a greater range of spatial variability. Fewer wells, such as 30, would still provide a useful set of data. Fewer than 25 to 30 wells would likely not provide an adequate representation of the hydrogeologic conditions.

Startup costs reflect equipment and field hours needed to confirm location and well access, identify the sampling port, and the office work needed to prepare the field map and data sheets for each site. Annual costs reflect the field and office hours needed to collect and manage the data and analytical laboratory costs. Equipment costs include sales tax of 8.5% but do not include any handling fees.

Cost estimates were obtained from four labs in the area that are accredited with DOE. Costs are shown on **Table 2** and assume the cost for the low end of the cost range. Analytical laboratory costs could increase by as much as several thousand dollars per year if a more expensive laboratory is used. Laboratory cost estimates do not include sales tax or handling fees. No sample transport costs are included in the budget. Transport costs would need to be included if a non-local lab is used.

Field and office hours assume a rate of \$120/hr.

Additional budget should be considered to pay for the analytical laboratory costs for the Skokomish Indian Tribe water supply wells so that they use the same analytical methods and meet the same data review criteria as the data collected specifically for this project. These costs are included in the budget given in **Table 2**. Therefore, for each tier, the number of wells associated with laboratory costs is increased by two more than the number of wells sampled.

6 Data Quality Objectives

The data collected under this plan will be useful for guiding future groundwater development but not for decision processes that outline critical, specific actions depending on the analytical results. Therefore, this section presents *measurement quality objectives (MQOs)*, which describe how good the data must be to meet the objectives of the project. It does not include *decision quality objectives (DQOs)*. Data that meet the objectives will be considered accurate and valid. Several types of errors will affect the quality of the data for this monitoring program:

- Errors in water level measurement
- Errors in sampling (during collection of water samples)
- Analyst errors during the measurement of field parameters
- Equipment errors during the measurement of field parameters
- Analyst and equipment errors during laboratory analysis of water samples
- Data-entry errors during the data management process

The detailed sampling and measurement procedures described in Section 8, “Sampling & Measurement Procedures,” address potential errors from sources

that are not related to labs or equipment. The MQOs described below, on the other hand, are designed to identify whether the results reflect lab- or equipment-related errors; Section 9, “Quality Control,” offers procedures for reducing such errors.

In general, MQOs are used to evaluate quality control (QC) results; if the QC results meet the MQOs, they are considered valid and it is inferred that the sample results are also valid. However, the ion-balance error, which can be calculated, provides a direct means to evaluate whether the major ion data is valid for each sample. This section addresses the MQOs and ion balance separately.

6.1 MQOs

The MQOs are based on quality assurance criteria for method blanks, analytical duplicates, matrix spikes, and standard checking for each batch of samples. MQOs are given in **Table 3**. While the quality control procedures (Section 10) describe the required tests and their frequency, the control criteria establish the acceptable results from these tests.

To evaluate bias, results for matrix spikes will be reviewed. To evaluate precision, results for analytical duplicates will be reviewed (DOE, 2004).

6.2 Ion-Balance Error

In water the charge of the anions (which is negative) must equal the charge of the cations (which is positive). The accuracy of major dissolved-constituent values can be checked using a cation-anion balance (Hem, 1985). The ion-balance error will be calculated for annual samples that have been analyzed for a complete suite of routine ions (sodium, potassium, magnesium, calcium, chloride, sulfate, carbonate and bicarbonate). It should not exceed 10 percent.

6.3 Completeness

Completeness is a measure of the amount of valid data needed to be obtained from the measurement system. The goal for this monitoring program is to sample at least 95% of the wells identified to be included. Ideally, 100% of the wells identified for the program would be monitored each quarter.

6.4 Comparability

Comparability is the ability to compare the data with data from other studies. Comparability is ensured by selecting and documenting standardized procedures for sampling and analysis. This plan strives to use consistent field and analytical methods over the course of the groundwater monitoring program.

7 Sampling Process Overview

Wells will be sampled quarterly. If access allows, water levels will be measured in all wells, and water samples will be collected at selected wells. Several parameters will be measured in the field at the time of sampling—specific conductivity, pH, temperature, and dissolved oxygen (DO). In addition to these field parameters, water samples will be analyzed by a laboratory for chloride, nitrate, dissolved oxygen, and total dissolved solids (TDS). Annually, samples will be also be analyzed for sodium, potassium, calcium, magnesium, sulfate, and alkalinity. **Table 4** summarizes the recommended analyte list and schedule for the monitoring program. This table may be modified at the request of the Planning Unit based on budget constraints or other criteria. Once finalized, the list should be incorporated into both this Plan and the field notebook.

Selected wells may be instrumented with a datalogger and a sensor to record frequent measurements of electrical conductivity and water level. Some wells will be instrumented with a datalogger and sensor to record only water level in wells where water level decline is the only significant concern. Recommended data collection frequency should be about every half-hour. This would provide sufficient data to identify tidal effects but not so much data that the data volume is unwieldy. Data from these wells will be downloaded quarterly, on the same schedule as the other wells. Before setting the data collection frequency, confirm that the datalogger memory can hold the number of records indicated by the selected frequency. Manual water level measurements will be made at each well before digital data are downloaded.

7.1 Recommended Monitoring Wells

Table 1 lists wells that should be considered for the monitoring program. A final set of monitoring wells will be selected from this table based not only on budget constraints but also on the feasibility of negotiating an access agreement and measuring water levels using a sounder. Tier 1 would include the minimum number of wells and would provide good spatial distribution of wells within the populated area of the WRAI 16 Planning Area. Tier 3 would include a larger number of wells, would provide a good spatial distribution of

wells, but would monitor more wells in the highest growth areas and would have more shallow deep pairs.

Wells in **Table 1** are grouped by nearest town and listed in order from the northern part of the WRIA 16 Planning Area at Seal Point to the southern part at Union and then east along the south shore of Hood Canal toward Belfair. Each well is assigned a priority number of 1, 2, or 3 for water level and water quality monitoring. Due to costs, fewer wells will be monitored for water quality than for water level. A priority of “1” indicates that the well should be considered for Tier 1. Since Tier 3 is more comprehensive than Tier 1, all wells in Tier 1 would be included in Tiers 2 and 3. A priority of more than “1” indicates that the well’s inclusion will depend on which tier the Planning Unit selects and how many wells can be monitored. Wells with a “Y” in the “Definite” column should definitely be considered in Tiers 1, 2, and 3; verbal agreement to monitor has already been made with the well owner or operator for these wells.

Figure 1 shows the well location for the wells included on **Table 1**. Wells designated as definite are indicated with a different symbol than the rest of the wells. The well numbers shown on **Figure 1** are given in **Table 1**. **Figure 1** illustrates that in areas where many wells are available, like Hoodspout and Union, the list includes more wells than needed, to provide plenty of options in case access is a problem. Similarly, in Ayock, Hamma Hamma, and west of Forest Beach. More wells than needed are provided in **Table 1** in case the well is not accessible or permission from the well owner is not provided. Therefore, there are more wells with a priority of 1 than would be included in a Tier 1 program. The final list should include at least one well in each of these areas for Tier 1. The final list could also include a well that is not currently on **Figure 1** if it is deemed important by the Planning Unit.

Table 1 summarizes hydrogeologic information, the reason for the well’s inclusion, the status of verbal approval from the owner, and contact information. In some cases, we have not yet successfully contacted well owners and we therefore recommend a site visit to obtain approval. Site visits should be conducted for each well that is selected for monitoring to confirm adequate access. Well owners must sign a formal statement of agreement to monitor; **Appendix A** contains sample agreements.

7.2 Parameters of Investigation

Field parameters—pH, specific conductivity, temperature, and dissolved oxygen (DO)—will be measured at wells sampled for water quality. Collected samples will be sent to the analytical laboratory for analysis of pH, TDS, nitrate, chloride, and dissolved oxygen. Annually, the samples will also be analyzed for calcium, magnesium, potassium, sodium, sulfate, and total alkalinity.

If the pump has been shut down for more than a few hours, the pumping rate will be estimated and the pumping duration prior to sampling will be recorded. For consistency and comparability, all wells will be sampled within a 2-week period during each quarterly sampling event.

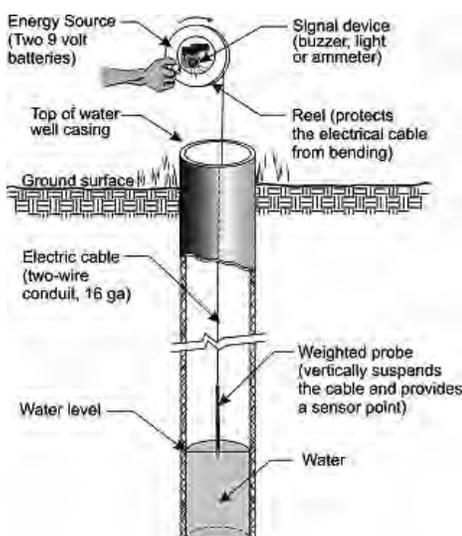
7.3 Other Available Data

The Skokomish Tribe currently monitors groundwater beneath the Skokomish Reservation from about nine shallow monitoring wells. In addition, supply wells are monitored regularly for water quality. Although these wells will not be part of the monitoring program, the Tribe will provide historical and future monitoring data to the Planning Unit. These data should be included in the data management aspect of the monitoring program so that data from the Skokomish River valley are included. Similar analytical methods should be used to ensure comparability.

Mason County currently monitors two wells that are near to Webb Hill. Mason County will continue to monitor these wells and provide the data to the project manager of the monitoring program to be included in the data management procedures. Mason County will conduct the quality assurance and quality control review of the data before providing the data to the project manager.

8 Sampling & Measurement Procedures

8.1 Measuring Water Levels



Step 1: Prepare

Before going out in the field, turn on the sounder and use the battery test to make sure it is working properly. Always carry spare batteries for the sounder.

Step 2: Measure

Measure the water level. If possible, use the same sounder that has been used for previous measurements. Turn the sounder on.

- *If the well has a sounder access tube, hold the sounder tape between your thumb and index finger and lower it into the tube until the probe tip completes the circuit by touching the water surface. You may need*

to raise and lower the tape to find the surface. Read the measurement at the top of the tube on the sounder tape.

- *If the well does not have a sounder access tube*, lower the probe into the well until it touches the water surface and completes the electrical circuit. Be sure to lower it *slowly and carefully* to prevent the sounder from swinging and getting caught on something such as the riser pipe. Measure the depth to water while holding the measuring tape at the top of the well casing or some other stationary location.

Take several measurements a few minutes apart to ensure that the water level in the well is stable. Compare the measurement to the previous one to verify that it makes sense. If not, measure again.

Step 3: Record

Record the date and time on the field data sheet for the well. Only record measurements when water level stability is indicated. Record the final measurement as the depth to water.

Mark the spot on the casing (or other object) where you measured the water level (for example, a particular location on the top of casing). Describe this location on the field data sheet and use your mark each time you measure that well.

Step 4: Clean and decontaminate the sounder

The sounder will be cleaned as it is removed from the well, before being wound onto the reel. The sounder tape will be wiped with a clean cloth using either isopropyl alcohol or a weak bleach solution. To make a 0.5% solution using standard household bleach (3.5%) use 1 part chlorine to 6 parts water. The probe tip will be sprayed with the bleach solution before and after each use. If at any time, after removing a sounder probe from a well, the probe shows evidence of iron bacteria in the form of brown slime, with wire tape and probe tip should be washed in soap to remove the visible slime and then rinsed or wiped down with alcohol or bleach solution.

8.2 Collecting Water Samples

Step 1: Purge

If the pump has been off for a while and you (or the owner) just turned it on for sampling, pump the well until at least three borehole volumes have been purged.

To verify that the well has effectively been purged, monitor pH, temperature, and conductivity. When these parameters stabilize (successive measurements change by less than 10 percent), you can assume that formation water has entered the well. Measure the three parameters at 5-minute intervals, or less, and document times and values on the field data collection sheet, which should reside in the field notebook with previous sheets for the well.

See Section 8.3, “Measuring Water Quality,” for details about equipment and procedures. See Section 8.5, “Recordkeeping,” for information on calculating borehole volumes. Section 9.1 “Quality Control, Field” provides guidelines for obtaining bottles from the analytical lab.

Step 2: Sample

Collect the sample *only* after the field parameters stabilize—even if three borehole volumes have already been purged. Document the time of sampling.

- Collect samples from a spigot as close to the wellhead as possible.
- Avoid sampling from a garden hose or from a point after the water has moved into a holding tank.
- Place samples directly into bottles provided by the analytical laboratory and cap them immediately.
- Take care to prevent overflow in bottles that contain a preservative.
- When holding the sample bottle, keep your hands away from the opening to prevent contamination. Do not touch the open edge of the sample bottle with the spigot or anything else.

Step 3: Label

Label the samples clearly with the well name, date, time, and your name or initials.

Step 4: Preserve

Keep samples in a cooler with ice at 4 degrees centigrade or less from the time of collection until delivery to the lab.

8.3 Measuring Water Quality Parameters in the Field

8.3.1 Specific Conductivity, pH, and Temperature

Specific conductivity, pH, and temperature should be measured using a field instrument purchased specifically for this project. We recommend the portable and waterproof Hanna HI 98129, which is reliable, easy to use, and relatively inexpensive. The instrument should be calibrated according to the manufac-

turer's instructions at the beginning of each day. Clean the probe after each measurement by spraying it with distilled water, which you can buy at grocery stores. Be sure to purchase distilled water—not purified water, which contains dissolved constituents.

8.3.2 Dissolved Oxygen

Use CHEMets[®]—self-filling ampoules for visual colorimetric analysis—to measure DO. These easy-to-use kits (and refills) are available online at www.chemetrics.com/visprods/Oxygen.htm. Be sure to purchase separate kits to cover the ranges from 0–1 ppm and 1–12 ppm. One set of refills should always be available in the field.

To use the CHEMets, immerse the ampoule in the sample and snap the tip. The correct volume is drawn in by vacuum, leaving a small, inert gas bubble. To mix the sample and reagent, tilt the ampoule so the bubble travels from end to end. In 2 minutes or less, compare the resulting color to the standards that come with the kit to quantify the result. Test first using the 1–12 ppm kit. If concentrations are less than 1 ppm, test again using the 0–1 ppm kit.

8.4 Continuous Monitoring

Water levels and/or conductivity can be monitored continuously using a down-hole sensor and a datalogger. Electrical conductivity is of particular interest because it can be used as an indicator of seawater intrusion. Work by USGS indicates that conductivity can range widely within a single well over a relatively short period and that values can vary with the tide. Occasional single measurements provide limited information about seawater intrusion. Therefore, it is important to observe trends over a relatively long period. Continuous monitoring for at least 1 month will indicate the general range in conductivity.

To optimize resources, a single transducer can be moved to different wells at different times during the study. The monitoring results, however, may reveal one or more wells that would be good candidates for a dedicated transducer; likewise, they may also show that “sharing” a transducer is the best approach. It may be useful to monitor a single well for one quarter and then switch to a different well for the next quarter. In this way, one conductivity sensor and datalogger could be used to monitor several wells.

Step 1: Record a baseline measurement.

Before installing a sensor and datalogger, measure the water level with a sounder. Record the time and water level on the field data sheet. This measurement will be used to calibrate the digital data.

Step 2: Install the equipment and set the measurement interval.

Install the datalogger and sensor according to manufacturers' instructions. Include a copy of the calibration data sheet in the field notebook. After installation, set the reading frequency to every minute. Collect data for a few minutes and then download the data to verify that the datalogger is recording and downloading properly. Once you establish that the equipment is functioning properly, set the data measurement interval to 30 minutes to record 48 measurements per day.

8.5 Recordkeeping

Maintain a field notebook, either bound or loose leaf, for the monitoring program. The notebook should feature a separate section divider labeled for each well. Each divider should contain a field data collection sheet for water level and water quality monitoring. Example field data collection sheets are included in **Appendix B**.

The water level sheet should document the name of field technician, monitoring well, date, and time; water level measurements will be recorded for each well so they can be compared.

The water quality sheet should document the flow rate, purge time, and date / time of sampling for each sampling event. It should also include the well depth, diameter, and borehole volume calculations. The well depth and diameter are typically available on the well log, which should be incorporated into the field notebook.

8.5.1 Calculating Purge Volumes

Use the following equation to calculate three borehole volumes of water:

$$\text{Purge time} = (3 \times \text{borehole volume}) / \text{flow rate}$$

$$\text{Borehole volume} = 3.1416(\text{inner diameter of well}) \times (\text{well depth} - \text{water depth})$$

8.5.2 Initiating the Chain of Custody

Fill out chain of custody (COC) forms and keep a copy in the notebook. The COC forms must accompany the samples to the lab. Take care to ensure that you are the only person to handle the samples until they are delivered to the lab. Both you and the lab personnel will sign the form at the time of delivery.

9 Quality Control

9.1 Procedures

9.1.1 Field

The pH/conductivity meter should be calibrated each day using fresh standards. Calibration results should be recorded in the field notebook.

9.1.2 Laboratory

The selected laboratory will be accredited by DOE. The quality control procedures in this plan rely heavily on this lab's quality assurance program (See Section 6, "Data Quality Objectives"). **Table 5** summarizes these procedures and the frequency at which the lab must conduct them. In general, standards are checked daily and other quality control measures such as method blanks, analytical duplicates, matrix spikes, and matrix spike duplicates are performed once per batch. A batch of samples comprises no more than a set number of samples—most commonly, ten.

The lab includes the results of its quality control procedures with each quarterly report of analytical results for the samples submitted. This report should be reviewed by a designated individual to verify that they meet the MQOs for the monitoring program.

Samples collected for specific analyses may require a minimum volume, or the bottle may require special treatment. To minimize errors related to insufficient sample size or preservation, the lab should provide the bottles. The field sampler will contact the lab and request a bottle order for the number of wells being sampled and for any field duplicates that are to be collected. The lab will provide the correct bottles, along with any required preservatives for the requested analytes. **Table 6** summarizes the sample bottles, preservation, and holding times for the analytes being considered for this project. **Table 4** shows the analytical methods and reporting limits that should be used for the program. These analytical methods are approved by DOE. Methods different from those shown on **Table 4** should be approved by the quality assurance officer at DOE.

9.1.3 Ion-Balance Error

Ion-balance errors will be calculated for each sample with major ion analyses. The calculation should be automated using software features in Access or Excel, whichever is used for data management, using the following formula:

$$\text{Percent ion balance error} = [(cations - anions)/(cations + anions)] \times 100$$

Cations and anions are expressed in concentration units of milliequivalents per liter.

9.1.4 Compare Field and Laboratory Results for TDS and DO

Field and lab measurements of TDS and DO will be compared using the following equation:

$$\text{Percent error for field parameter} = [(Field-Lab)/Lab] \times 100$$

If the difference is less than 5 percent of the laboratory results, then the frequency of laboratory measurements may be considered to reduce long-term lab costs.

The DO is measured in the field as an inexpensive, semi-quantitative method to identify low, moderate, or high concentration of dissolved oxygen. Since low DO in marine waters of Hood Canal is a concern, approximate concentration for DO in groundwater in the WRIA 16 Planning Area is useful to better understand the role of groundwater with regards to the low DO in Hood Canal. Field measurements for DO will be compared to laboratory results to identify if the field method is reliable for long-term use in this study in lieu of more expensive laboratory analysis.

9.2 Corrective Action

If the results for the laboratory quality control procedures are outside the quality control criteria, the lab's project manager should be contacted and the results should be reviewed to identify the source of the problem. The lab must follow prescribed procedures to resolve the problems. Such procedures may include retrieving missing information, recalibrating the measurement system, and/or reanalyzing the sample if the holding time has not been exceeded and if the volume is sufficient.

If the ion balance error is greater than 10 percent and the results for the quality control procedures meet the MQOs, consider adding other ions in the analysis to account for the observed error. Note any pattern in the error and note whether the error exceeds than 10 percent in more than one sample. If all the errors are of the same charge (positive or negative), it is likely that a significant ion has not been included in the analysis. If the errors are of different charges, they are more likely analytical.

10 Data Management Procedures

This section addresses both field water level measurements and field and laboratory water quality data. All data will be maintained electronically; therefore, field data must be converted to a digital format from the notebooks.

Water quality data should be maintained in a Microsoft Access database. Field headers should be consistent with DOE's EIMS database. Data entered using these field names can then be easily uploaded into the DOE EIMS. Similarly, data from the EIM could be easily incorporated into the project database. The location data needs to be entered only once for each well. The results data needs to be entered each time data is collected. These two tables are cross-reference using the field (User_Location_ID).

Tables 7a and 7b summarize the headers that should be used for the location and results data, respectively. To be consistent with the EIM requirements, all the wells should have a DOE well tag identifier. Because some wells that we recommend for monitoring (**Table 1**) are not included in the DOE database, they do not currently have a well tag ID; DOE will need to provide a well tag ID for these wells that are included in the program. In addition to using the field headers provided in **Tables 7a and 7b**, it is important to use the information provided in these tables to fill these fields in correctly.

If data is uploaded to the EIMS, field results for dissolved oxygen and pH should not be included since the analytical methods are different than recommended and would thus not provide adequate comparability.

11 Audits & Reports

The data will be made available electronically to anyone within the Planning Unit who requests it, either as Excel workbooks or as an Access database. Hydrographs and water-quality trend plots will be produced annually.

12 Data Verification & Validation

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. The analytical laboratory is responsible for performing the following functions:

- Reviewing and reporting QC checks on instrument performance such as initial and continuing calibrations.

- Reviewing and reporting case narratives. This includes comparison of QC results with method acceptance criteria such as precision data, surrogate and spike recoveries, laboratory control sample analysis, and procedural blanks.
- Explaining flags or qualifiers assigned to sample results.
- Reviewing and assessing the lab's performance in meeting the conditions and requirements set forth in this sampling plan.
- Reporting the above information to the project manager or lead.

After measurement results have been recorded, the results are verified by the office lead to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions.
- Results of QC samples accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers are properly assigned where necessary.
- Data specified in the Sampling Process Design were obtained.
- Methods and protocols specified in the Quality Assurance Project Plan were followed.

The analytical laboratory is responsible for verifying all analytical results. Reports of results and case summaries provide adequate documentation of the verification process. Laboratory analytical data will be reviewed and verified by comparison with acceptance criteria according to the laboratory's established data review protocol. Appropriate qualifiers will be used to label results that do not meet quality assurance requirements. An explanation for data qualifiers is provided.

The analytical laboratory will include in its report a comparison of the results of quality control tests (described in Section 10) to the MQOs established in Section 6. The laboratory data is considered valid if:

- These tests meet the MQOs.
- Ion-balance error is less than 10 percent. Under this condition, it can also be assumed that all significant ions have been analyzed.

Comparing the field data to the laboratory data:

- If after 1 year, the field measurements for TDS and dissolved oxygen are within than 5 percent of the lab measurements, then the field measurements could be considered valid and the lab measurements can be discontinued to save costs.

Field results will also be verified by field staff before leaving the site after measurements are made. As described in Section 8.5 Recordkeeping, detailed field notes will be taken to meet the requirements for documentation of field measurements. The field lead is responsible for checking that field data entries are complete and error free. The field lead should check for consistency within an expected range of values, verify measurements, ensure measurements are made within the acceptable instrumentation error limits, and record anomalous observations.

13 Data Usability Assessment

Data usability assessment follows verification. To analyze data for its usability, the project lead will consider precision, bias, completeness, comparability, and documentation of adherence to protocols. This involves a detailed examination of the data package using professional judgment to determine whether the method quality objectives (MQOs) have been met. The project manager examines the complete data package to determine compliance with procedures outlined in this Plan. The project manager is also responsible for the data usability assessment by ensuring that the MQOs for precision, bias, and sensitivity are met.

Part of this process is an evaluation of precision. Precision will be assessed by calculating relative percent difference (RPDs) for field and laboratory duplicates. Laboratory duplicates will yield estimates of precision performance at the laboratory only. Field duplicates will indicate overall variability (environmental + sampling + laboratory). Acceptable precision performance is outlined in the MQOs (**Table 3**).

Completeness will be assessed by examining:

- number of samples collected compared to the sampling plan;
- number of samples shipped and received at the laboratory in good condition;
- the laboratory's ability to produce usable results for each sample; and
- sample results accepted by the project manager.

Data will also be examined for extremes (i.e., against historical records and against the distributions of these project data). Extreme values will require logical explanations. Identified sources of bias will be described. After the assessment described above, usability will be identified:

- If the MQOs are met and the RPDs are acceptable, documentation is thorough, the sample data will be identified as useable.
- If the ion balance error is acceptable, yet the MQOs and RPDs are unmet, the data will still be considered useable.
- All data submitted to DOH and included in its database will be considered useable.
- Data collected by the Skokomish Tribe will be considered useable if it meets tribal data quality objectives. All efforts should be made to encourage the analytical methods used by the Tribe are the same as those used as part of this program.

14 Cited References

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Table 1. Summary of Recommended Wells for WRIA 16 Monitoring Program

# on Figure 1	Well Owner	City	Verbal Agreement *	Definite	Water Level Priority	Water Quality Priority	Conductivity Transducer	WDOE Well Log ID	WDOE Well Tag	DOH Source ID	Depth, feet	LSE, feet msl	Well Bottom Elev, feet msl	x-coord State Plane NAD 27	y-coord State Plane NAD 27	Monitoring Reason	Geology	Contact Name or Agency	Contact Address	Contact Name	Phone	Comment	
1	JEFFERSON COUNTY PUD #1	Brinnon	yes	Y	1	1	Y	51013			485	92	-393	1403194	874545.9	monitor seawater intrusion, deep basalt	Basalt	Jefferson Cty PUD#1		Bill Graham	(360) 385-5800	may have some port access issues , swi? Bill woul	
2	JEFFERSON COUNTY PUD #1	Brinnon	if found		1	1	Y	48486			503	3	-500	1412387	875734.9	Deep Basalt nrt shore	Basalt	Jefferson Cty PUD#1		Bill Graham	(360) 385-5800	Call Bill Graham, they need to find it	
3	J. W. & ROSANNE OLSEN	Brinnon	yes	Y	1	1		277293			282	90	-192	1412470	878359	deep basalt	basalt			Abandoned		WQ, no WL, said well is sealed and inaccessible	
4	US OLYMPIC NATIONAL PARK	Brinnon	yes		1	1		333122	AFT796		125	321	196	1385552	866085	Inland, unimpacted source	basalt	US Forest Service		Kyle Nobel	360-956-2332		
5	AMERICAN CAMPGROUND	Brinnon	call		1	1	Y	43970	ACM513	18746	270	174	-96	1405037	854912	deep, Black Point well	unconsol		PO BOX 91597 Portland, OR	G PALMER BYRKIT	(503) 297-4180		
6	BRINNON SCHOOL DISTRICT	Brinnon	likely		2	2		341555	AFB551		56	30	-26	1408058	870532.9	monitored by Aspect	unconsol				360-796-4646	called twice, waiting for reply, call again	
7	PLEASANT HARBOUR MARINA PRIMARY WELL	Brinnon	call		2	2	Y			47629	88	72	-16	1405713	858742	Black Point, nest with American CG			308913 HWY 101 BRINNON	DIANE COLEMAN	(360) 796-4611	no log in WDOE database	
8	PLEASANT TIDES WATER CO OP	Brinnon	call		3	3		51352		3313	210	157	-53	1402493	857477	Black Point, nested with American CG	unconsol	PO BOX 91 Brinnon WA 9832	761 RHODODENDRON LN	DONALD HERRIN	(360) 796-4433		
9	TRITON COVE ESTATES	Triton	likely		1	1		53498			443	315	-128	1385800	840771	Basalt deep near shore	Basalt	Jefferson Cty PUD#1		Bill Graham	(360) 385-5800	Get confirmation approval from Bill Graham	
10	CAMP ROBINSWOLD GIRL SCOUT WELL #2	Triton/Eldon	yes	Y	1	1		301343	AFS634	1094502	280	30	-250	1383065	831726.9	deep basalt near shore	Basalt	Camp Robbinswold	N 39580 HWY 101	Jim Messmer	(360) 877-5455	jimm@girlscoutswa.o	
11	PARADISE COVE CLUB, INC. WTR SYS WELL #1	Duckabush/Triton	likey		1	1		51046		3368101	28	92	64	1393274	846348	shallow, nr shore same as 48482	unconsol	Paradise Cove Pres.	119 17TH AVE SW	David Bianchi	206-852-0828		
12	OLYMPIC CANAL TRACTS	Duckabush	site visit		1	2		337602	AGP368		562	3	-559	1399442	850736	deep well, Group A	basalt		3485 DOSEWALLIPS RD		(360) 796-4886	very deep well, try to get	
13	HUNGRY BEAR CAFE	Eldon	site visit		1	2		276285	AHB685		240	128	-112	1374523	819559.1	deep basalt nr shore swi	basalt			Rahn Redmon	360-765-3500	same locn as Norma Jean Jaspar, either one is fine	
14	CANAL VIEW, WELL #1	Eldon	call		3	2			AHB685	1364501		72		1374382	819314.2	location			41 N TEAL PL		(360) 877-9073		
15	NANCY HANSEN	Hamma	site visit		1	1			ABZ526		73	75	2	1371906	812832.1	location, select only one from Hamma							
16	HAMMA RIDGE WATER SYSTEM WELL #1	Hamma	call		1	1				586701				1367065	807656	location, select only one from Hamma			PO BOX 542		(360) 357-3277		
17	AYOCK BEACH IMPROVEMENT WS	Ayock	call		1	1				345001				1368262	802980.5	Ayock vicinity		H2O Mngmt. Services			(360) 427-0654		
18	EAGLE CREEK TAVERN WATER SYSTEM	Ayock	call		1	1			AHA962	1075601				1362043	795662.9	Ayock vicinity					(360) 337-5777		
19	COLONY SURF WATER SUPPLY	Ayock	call		1	1				1408001				1363388	799874.2	location, select only 1 or 2 from Ayock					(360) 877-5434		
20	GERALDINE ANDERSON	Ayock	site visit		1	1		54546	ABB199		282	279	-3	1368094	805701.2	Ayock vicinity	unconsol						
21	MASON COUNTY PUD #1	Lilliwaup	S. Taylor	Y	1	1	Y	499850	BAC353		420	430	10	1350271	781187.3	deep basalt	Basalt	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	a good well for continuous monitoring?	
22	CANAL MUTUAL WATER Well 1 North	Lilliwaup	S. Taylor	Y	1	1	Y		AHA959	1099901	76	10	-66	1352464	779559.3	seawater intrusion	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	Maybe can remain as a monitoring well, discuss wit	
23	CANAL MUTUAL WATER Upper	Lilliwaup	S. Taylor	Y	1	1		44919	AHA960		515	302	-213	1351599	781238.3	other Canal Mutual	basalt	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
24	CANAL MUTUAL WATER Well 2 South	Lilliwaup	S. Taylor		2	3				1099902	70	0	-70	1354982	778719.2	seawater intrusion	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
25	TAHJA II WS Well #1 AHA964 TAHJA II	Hoodsport/Lilli	yes	Y	1	1		305201			68	16	-52	1352421	779626.4	shallow, near water	unconsol	PO box 125 Hoodsport 98546	PO BOX 323	Don Misner	(360)-229-6844		
26	CANAL BEACH TRACTS MUTUAL WTR CO WELL #1	Hoodsport	S. Taylor	Y	1	2				668901	101	26	-75	1348918	771897.9	monitor w/ tribe, was Glen Ayr	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	may not be necessary cuz lots of wells in the area	
27	HOODSPORT SUNCREST WELL (85204)	Hoodsport	S. Taylor	Y	1	1	Y			3410004	167	279	112	1341857	765321.8	mon. with deeper Reeder well?	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	good nested pair	
28	MASON CO. PARKS	Hoodsport	Yes	Y	1	1		50222			518	515	-3	1339332	766567.3	Deep, upland	unconsol	Mason County Parks		John Keat	(360) 427-9670	get key from John, well near caretaker residence a	
29	LAUBER HOME TRACTS A	Hoodsport	site visit		2	2		49715			203	0	-203	1346785	764439.3	near shore, deep gravel	unconsol					(360) 877-5249	Maybe don't need cuz have so many wells here
30	HOODSPORT REEDER WELL	Hoodsport	S. Taylor	Y	1	1	Y			3410003	270	243	-27	1342848	764915.5	gravel, nr river, swi, deep	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
31	JOHN HUBEN	Hoodsport	site visit		2	3		49033			220	725	505	1343630	775761.3	upland, inland, basalt	unconsol						
32	BETTY GOODPASTER	Hoodsport	S. Taylor		3	3		55200	ABQ797		33	161	128	1347503	769174.3	very shallow, upland							maybe not necessary
33	THOMAS AND MARY CARR	Hoodsport	site visit		3	3		392945	AKA909		278	259	-19	1349011	775760.3	deep upland, shale, nr river							
34	KEITH HALLER	Hoodsport	site visit		3	3		412583	AKJ033		380	351	-29	1346339	775787.3	deep, shale, upland							only if other Hoodsport wells aren't available
35	ROGER MAHLENDORF	lower Cushman	site visit		1	2		52329			515	640	125	1336709	766657.3	upland, uncon, inland, deep	unconsol						site visit
36	POTLATCH BEACH MUTUAL WS WELL #2	Potlatch	S. Taylor	Y	1	2				6905002	99	121	22	1343125	757765.5	Location, availability	Gravel	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
37	SKOKOMISH INDIAN RESERVATION	Skokomish R. Va	data		1	1		249728	ABG515		92	20	-72	1341380	740088.4	River valley, gravel not right to nex					Frank Cousins	(360) 877-2110	
38	MIKE PETZ	Skokomish R. Va	yes	Y	1	1					40	43	3	1327075	735433	Skokomish River Valley		2360 Skokomish Valley Rd		Mike Petz	(360) 877-2345		
39	RON GOLD	Skokomish R. Va	yes	Y	1	1					42	118	76	1312402	739397.4	upper Skokomish River Valley	unconsol			Ron Gold			
40	MINERVA TERRACE Well #1	Brockdale/Union	yes	Y	1	1				5507001	450	66	-384	1340007	745263.2	far shore deep gravel	unconsol	NW Water Systems	PO BOX 123	Reg Hearn	(360) 876-0958	call to arrange with technician	
41	MOOREVIEW HEIGHTS WS Well #1	Brockdale/Union	yes	Y	1	1		49637		767701	305	400	95	1342846	727069.1	far shore deep gravel	unconsol	NW Water Systems	PO BOX 123	Reg Hearn	(360) 876-0958	call to arrange with technician	
42	MARK BISER	Webb Hill	data		Y	1		54377	AAW361		110	358	248	1347350	724137.5	offsite Webb Hill monitoring well							
43	GERALD WILLIAMS	Webb Hill	data		Y	1								1347300	726700	Webb Hill		Mason County DCD		Pam Bennett-Cummin	(360) 427-9670	Mason Cty to monitor and provide data	
44	ALDERBROOK WATER CO WELL #2	Union	S. Taylor	Y	1	1				105002	600	518	-82	1365035	740671.7	nested site; unconsol, upland	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
45	MADRONA BEACH SUPPLY WELL #1	Union	S. Taylor		2	2				4995001	200	0	-200	1360093	748111.6	location	NO LOG	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	No log from Mason PUD #1	
46	VUECREST Well #1	Union	yes		2	2				1863701	490	531	41	1356425	739832.3	deep, unconsol	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	may not be necessary cuz lots of wells in the area	
47	HOOD CANAL WATER COMPANY B WELL #1 ACO4	Union	S. Taylor	Y	1	1			ACO407	AA41801	222	164	-58	1359830	746408.6	spatial variability, nested with Well B	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
48	UNION WATER SYSTEM Well #2	Union	S. Taylor	Y	1	1	Y	51015		5192002	298	239	-59	1356856	746885.4	below sea level, location, available	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
49	UNION WATER SYSTEM Well #1	Union	S. Taylor	Y	1	1	Y	50234		5192001	166	210	44	1357727	746904.6	available, nested site with Union Well 1	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
50	HOOD CANAL WATER COMPANY A HOOD CANAL V	Union	S. Taylor	Y	1	2				3405001	242	52	-190	1361650	744348.7	location, availability, depth, nest with Well A	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
51	ALDERBROOK WATER CO WELL #1	Union	S. Taylor	Y	1	1				105001	292	469	177	1360825	739018.2	nested site; unconsol, upland	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
52	Don H. Knudsen Pole Co.	Union	S. Taylor		2	3		46186			376	246	-130	1356135	743865.4	avaialbe, deep	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	may not be necessary cuz lots of wells in the area	
53	ALDERBROOK WATER CO WELL #3	Union	S. Taylor		2	3				105003	262	374	112	1362072	737580.8	spatial variability	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249	PUD didn't provide log, available?	
54	HIGHLAND PARK Well #1	Union	S. Taylor		3	3		46061		3282001	393	544	151	1358115	741095.6	location, deep, upland, slight inland	unconsol	Mason County PUD 1	21971 N HWY 101	Tracy Colard or Roy	(360) 877-5249		
55	SCHMITZ WELL WELL	Union	yes		3	3				5701	115												

Table 2. Startup and Annual Budget for Tiers 1, 2, and 3

Task	Hours Per Well	Per Hour Rate	Individual Item Costs		Tier 1					
					Startup Costs	# of wells	Labor Cost	Other Costs	sample events per year	Annual Costs
Startup Tasks										
Equipment purchase										
pH/conductivity meter, Hanna combo				\$ 168	\$ 168					
sounder, Waterline 500 feet				\$ 502	\$ 502					
pressure transducer/datalogger, Geokon 200 feet cable				\$ 1,330	\$ 2,660	2				
conductivity and pressure sensor/datalogger 200 feet cable				\$ 3,033	\$ 3,033	1				
Field Work										
Visit site, confirm well access, refine location, ID sampling port	1.5	\$ 120			\$ 6,300	35				
Total Startup										
Annual Tasks										
Field Work										
Measure water level at well, record in field notebook	1	\$ 120				35	4200		4	\$ 16,800
Collect water sample at well, field wq measurements	0.75	\$ 120	Chemets	\$ 2		25	2250	\$ 50	4	\$ 9,200
Download data from water level datalogger	0.5	\$ 120				2	120	\$ -	4	\$ 480
Download data from conductivity datalogger	0.5	\$ 120				1	60	\$ -	4	\$ 240
Deliver samples to lab	1.5	\$ 120					180			\$ -
Lab analysis of routine constituents, DO, TDS, nitrate, pH			lab	\$ 200		27		\$ 5,400	1	\$ 5,400
Lab analysis of nitrate, DO, chloride, pH, TDS			lab	\$ 90		27		\$ 2,430	3	\$ 7,290
Office Work										
Enter quarterly data into spreadsheets/database	0.1	\$ 120				35	420		4	\$ 1,680
Manage water level data from water level datalogger	1.5	\$ 120				2	360		4	\$ 1,440
Prepare hydrographs	0.5	\$ 120				35	2100		4	\$ 8,400
QA water quality data	0.25	\$ 120				25	750		4	\$ 3,000
Manage conductivity data from conductivity datalogger	1	\$ 120				1	120		4	\$ 480
Enter water quality data into database (includes data for Skokomish Tribe wells and Mason County Webb Hill monitoring wells)	0.2	\$ 120				29	696		4	\$ 2,784
Total for Office and Field					\$ 12,663					\$ 57,194
					First Year: Startup + Annual Costs =					\$ 69,857

Table 2. Startup and Annual Budget for Tiers 1, 2, and 3

Task	Hours Per Well	Per Hour Rate	Individual Item Costs		Tier 2					
					Startup Costs	# of wells	Labor Cost	Other Costs	sample events per year	Annual Costs
Startup Tasks										
Equipment purchase										
pH/conductivity meter, Hanna combo				\$ 168	\$ 168					
sounder, Waterline 500 feet				\$ 502	\$ 502					
pressure transducer/datalogger, Geokon 200 feet cable				\$ 1,330	\$ 3,990	3				
conductivity and pressure sensor/datalogger 200 feet cable				\$ 3,033	\$ 3,033	1				
Field Work										
Visit site, confirm well access, refine location, ID sampling port	1.5	\$ 120			\$ 7,200	40				
Total Startup										
Annual Tasks										
Field Work										
Measure water level at well, record in field notebook	1	\$ 120				40	\$ 4,800		4	19,200
Collect water sample at well, field wq measurements	0.75	\$ 120	Chemets	\$ 2		30	\$ 2,700	\$ 60	4	11,040
Download data from water level datalogger	0.5	\$ 120				3	\$ 180		4	720
Download data from conductivity datalogger	0.5	\$ 120				1	\$ 60		4	240
Deliver samples to lab	1.5	\$ 120					\$ 180			0
Lab analysis of routine constituents, DO, TDS, nitrate, pH			lab	\$ 200		32		\$ 6,400	1	6,400
Lab analysis of nitrate, DO, chloride, pH, TDS			lab	\$ 90		32		\$ 2,880	3	8,640
Office Work										
Enter quarterly data into spreadsheets/database	0.1	\$ 120				40	\$ 480		4	1920
Manage water level data from water level datalogger	1.5	\$ 120				3	\$ 540		4	2160
Prepare hydrographs	0.5	\$ 120				40	\$ 2,400		4	9600
QA water quality data	0.25	\$ 120				30	\$ 900		4	3600
Manage conductivity data from conductivity datalogger	1	\$ 120				1	\$ 120		4	480
Enter water quality data into database (includes data for Skokomish Tribe wells and Mason County Webb Hill monitoring wells)	0.2	\$ 120				34	\$ 816		4	3264
Total for Office and Field										
					\$ 14,893					\$ 67,264
					First Year: Startup + Annual Costs =					\$ 82,157

Table 2. Startup and Annual Budget for Tiers 1, 2, and 3

Task	Hours Per Well	Per Hour Rate	Individual Item Costs		Tier 3					
					Startup Costs	# of wells	Labor Cost	Other Costs	sample events per year	Annual Costs
Startup Tasks										
Equipment purchase										
pH/conductivity meter, Hanna combo				\$ 168	\$ 168					
sounder, Waterline 500 feet				\$ 502	\$ 502					
pressure transducer/datalogger, Geokon 200 feet cable				\$ 1,330	\$ 5,319	4				
conductivity and pressure sensor/datalogger 200 feet cable				\$ 3,033	\$ 6,065	2				
Field Work										
Visit site, confirm well access, refine location, ID sampling port	1.5	\$ 120			\$ 9,000	50				
Total Startup										
Annual Tasks										
Field Work										
Measure water level at well, record in field notebook	1	\$ 120				50	\$ 6,000		4	24,000
Collect water sample at well, field wq measurements	0.75	\$ 120	Chemets	\$ 2		40	\$ 3,600	\$ 80	4	14,720
Download data from water level datalogger	0.5	\$ 120				4	\$ 240		4	960
Download data from conductivity datalogger	0.5	\$ 120				2	\$ 120		4	960
Deliver samples to lab	1.5	\$ 120					\$ 180			0
Lab analysis of routine constituents, DO, TDS, nitrate, pH			lab	\$ 200		42		\$ 8,400	1	8,400
Lab analysis of nitrate, DO, chloride, pH, TDS			lab	\$ 90		42		\$ 3,780	3	11,340
Office Work										
Enter quarterly data into spreadsheets/database	0.1	\$ 120				50	\$ 600		4	2400
Manage water level data from water level datalogger	1.5	\$ 120				4	\$ 720		4	2880
Prepare hydrographs	0.5	\$ 120				50	\$ 3,000		4	12000
		\$ 120								
QA water quality data	0.25	\$ 120				40	\$ 1,200		4	4800
Manage conductivity data from conductivity datalogger	1	\$ 120				2	\$ 240		4	960
Enter water quality data into database (includes data for Skokomish Tribe wells and Mason County Webb Hill monitoring wells)	0.2	\$ 120				44	\$ 1,056		4	4224
Total for Office and Field										
					\$ 21,055					\$ 87,644
					First Year: Startup + Annual Costs =					\$ 108,699

Table 3. Example Measurement Quality Objectives

Parameter	Check Standard (LCS) % recovery limits	Duplicate samples RPD	Matrix spikes % recovery limits	Matrix spike duplicates RPD	Surrogate standards % recovery limits	Lowest concentrations of interest units of concentration
pH	90-110	10	N/A	N/A	N/A	pH units
dissolved oxygen	N/A	10	N/A	N/A	N/A	mg/L
nitrate	80-120	15	70-130	20	N/A	mg/L
Calcium	80-120	15	70-130	20	N/A	mg/L
magnesium	80-120	15	70-130	20	N/A	mg/L
potassium	80-120	15	70-130	20	N/A	mg/L
sodium	80-120	15	70-130	20	N/A	mg/L
chloride	80-120	15	70-130	20	N/A	mg/L
sulfate	80-120	15	70-130	20	N/A	mg/L
alkalinity	80-120	20	N/A	N/A	N/A	mg/L
total dissolved solids	N/A	10	N/A	N/A	N/A	mg/L

Table 4. Analyte List, Analysis Frequency, and Method of Analysis

Example of completed table, all are for a sample matrix of groundwater

Analyte	frequency	reporting limit	sample preparation method	Analytical method	CAS number
pH	quarterly	N/A	per method	SM 4500-H+	
dissolved oxygen	quarterly	0.05 mg/l	per method	SM 4500G	7782-44-7
nitrate	quarterly	0.25 mg/l	per method	EPA Method 300.0 or 300.1 or SM 4500-NO3-F	84145-82-4
chloride	quarterly	0.25 mg/l	per method	EPA Method 300.0 or 300.1 or SM 4500-Cl-D	16887-00-6
TDS	quarterly	10 mg/l	per method	SM 2540C	
calcium	annually	0.1 mg/l	per method	EPA 200.7 or SM 3120 (ICP)	8047-59-4
magnesium	annually	0.1 mg/l	per method	EPA 200.7 or SM 3120 (ICP)	7439-95-4
potassium	annually	0.5 mg/l	per method	EPA 200.7 or SM 3120 (ICP)	24203-36-9
sodium	annually	0.1 mg/l	per method	EPA 200.7 or SM 3120 (ICP)	17341-25-2
sulfate	annually	5 mg/l	per method	EPA Method 300.0 or 300.1 or SM 4500-SO4-E	14808-79-8
total alkalinity	annually	1 mg/l	per method	SM 2320 B	71-52-3

Table 5. Quality Control Procedures and Frequency

Example of completed table.

All are for a sample matrix of groundwater

Parameter	field			laboratory					
	Check standards	Blanks	Replicates	Check standards	Method blanks	Analytical duplicates	Matrix Spikes	Matrix Spike Duplicate	Lab Control Sample
pH	1/day*	N/A	until stable						
conductivity	1/day*	N/A	until stable						
dissolved oxygen	N/A	N/A	1/day						
nitrate				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
calcium				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
magnesium				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
potassium				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
sodium				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
chloride				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
sulfate				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
alkalinity				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20
TDS				per method **	1/batch of 20	1/batch of 10	1/batch of 20	1/batch of 20	1/batch of 20

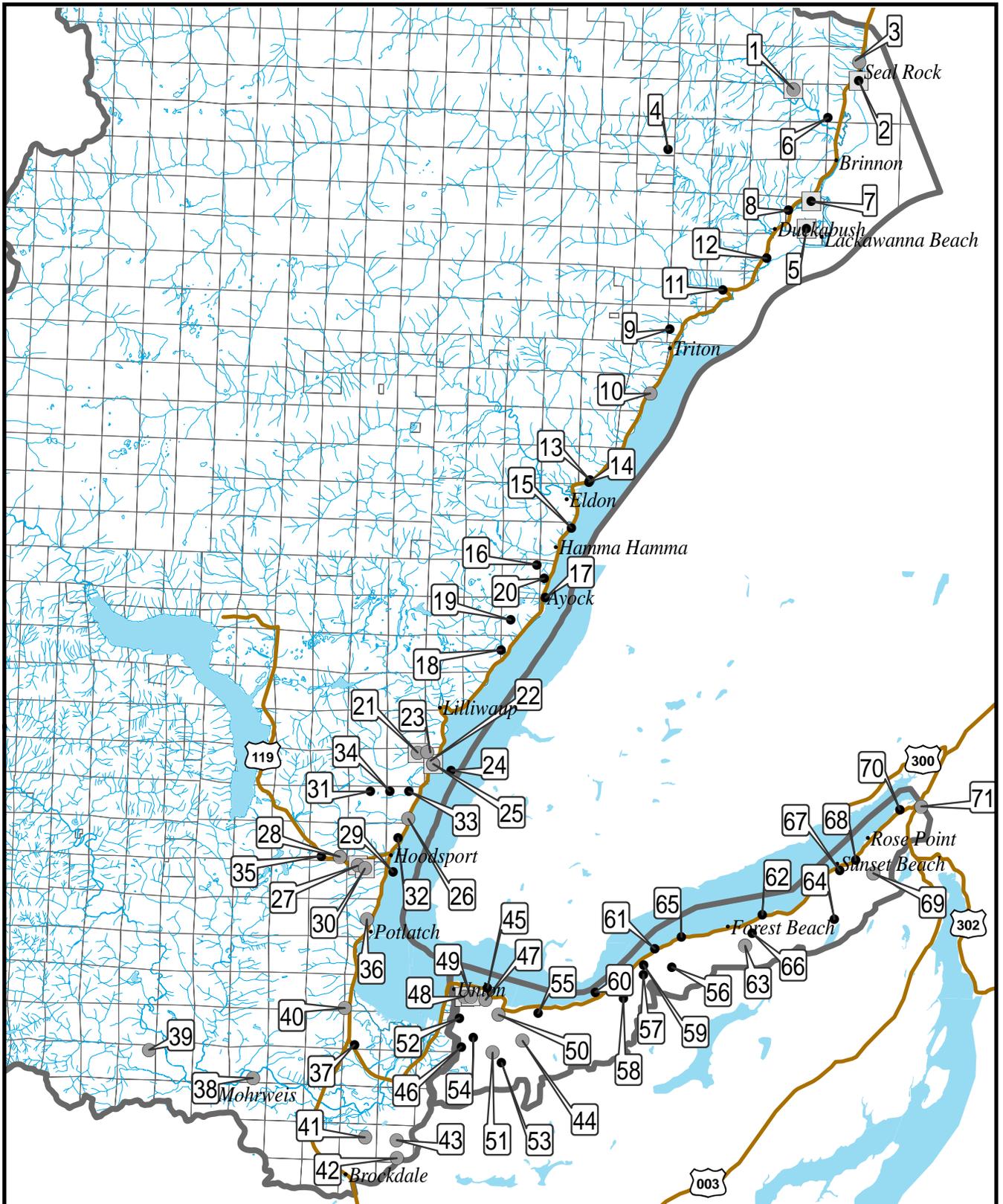
* calibrate meter using standards at the beginning of the day, before using the meter on samples

** on opening and closing and as needed based on number of samples analyzed and the method requirements

Table 6. Sample Containers, Preservation, and Holding Times

Example of completed table

Parameter	matrix	Minimum quantity required	Container	Preservative	Holding Time
pH	Water	250mL	Poly	Cool to 4 C	24 Hours
dissolved oxygen	Water	500 mL	Poly	Cool to 4 C	24 Hours
nitrate	Water	250mL	Poly	Cool to 4 C	48 Hours
calcium	Water	250mL	Poly	None	28 Days
magnesium	Water	250mL	Poly	HNO3-Cool 4C 6 months	
potassium	Water	250mL	Poly	HNO3-Cool 4C 6 months	
sodium	Water	250mL	Poly	None 14 Days	28 Days
chloride	Water	250mL	Poly	None	28 Days
sulfate	Water	250mL	Poly	None	28 Days
alkalinity	Water	250mL	Poly	Cool to 4 C	14 Days
TDS	Water	250mL	Poly	Cool to 4 C	7 Days



Explanation

- Definite Wells to be included in all Tiers
- Other Available Wells
- Candidate wells for conductivity monitoring
- Sections
- ▭ WRIA 16 Planning Area
- Highways

Refer to Table 1 for well number/name association and other information details



Figure 1.
Recommended Wells For
Water Level and Water Quality Monitoring

WRIA 16 Planning Area
 Ambient Groundwater Monitoring Plan



Appendix A: Example Written Agreements to Monitor Individual Wells

WELL ACCESS AGREEMENT

Purpose:

This Access Agreement is entered into between a representative of Mason and Jefferson counties, (hereafter referred to as the “representative”) and the well owner, (hereafter referred to as “the Owner”), for the purpose of obtaining access to, and groundwater level measurements in, water wells operated by the Owner. This agreement describes the nature of measurements to be collected by the representative and, by signature of the Owner, provides permission to the representative for temporary access to the Owner’s well(s). This Access Agreement also serves to indemnify the representative for all damages that may occur to the Owner’s well(s) during the measurement of water levels by the representative.

Introduction:

As part of ongoing watershed planning efforts, Mason and Jefferson Counties have contracted a representative to measure groundwater levels in wells within selected areas of Water Resource Inventory Area (“WRIA”) 16, which includes parts of Mason and Jefferson Counties. These measurements will be used to develop water-table maps for the area. Wells of interest include those used for drinking water supplies (private-residential and public-community), irrigation, industrial supplies, dewatering, testing, and environmental monitoring. Mason and Jefferson Counties, and the WRIA 16 Planning Unit encourage all water well owners and operators to assist the field staff in locating and accessing these wells.

Data Collection:

The representative will measure groundwater levels using an electric water-level sounder manufactured specifically for the water-well industry. All “downhole” components of sounder will be cleaned before and after use in each well. These components, which consist of a 1/4-inch-diameter probe attached to plastic-coated electrical wire, transmit signals to an indicator switch at the land surface. The sounder will be lowered into the well until it contacts the water surface and depth to water is recorded. After collecting the water level data, the sounder will be removed from the well. The Owner’s well cap will be reinstalled at the

WELL ACCESS AGREEMENT

completion of the representative's water level survey. The representative's work will be performed in accordance with standard accepted hydrogeologic practices.

The representative may also collect a water sample to analyze it for fundamental water quality parameters. If a sample is collected, the water sample will be collected from the nearest faucet or spigot. The sample bottle containers will not contact the faucet or the spigot. The representative will need to make sure that the well has pumped at least three borehole volumes before collecting a sample. The representative will calculate the pumping time required to do this based on the water level information and well information and the pumping rate. The representative will estimate the pumping rate using a stopwatch and a container of known volume.

Agreement:

The Owner agrees to provide the representative access to water wells for the purpose stated above. Although the chance of damage to the Owner's well is extremely small, the Owner agrees to indemnify the representative for all damages to the Owner's property that may occur while obtaining water level measurements. The representative will coordinate with the Owner in collecting all water level information at a time that is suitable to the Owner. The undersigned agree to the terms stated in this Access Agreement.

DATED this _____ day of _____, 2008.

OWNER OF WELL

(Printed Name)

(Signature)

Appendix B: Field Data Collection Sheets

WRIA 16 Ambient Groundwater Monitoring Program

Field Water Quality Data Sheet

Date: _____

Sampler: _____

Well Name: _____

Well Depth: _____ ft

Well Location: _____

Well Diameter: _____ inches

Description of Sampling Point Location: _____

(ie: spigot south of well head)

Time: DTW: _____

Calculated Height of Water (H): Well Depth - DTW = _____

Purge Volume (3 casings) = $((\text{Well Diam}/2)/12)^2 * (\text{Pi} * \text{H}) * 3 =$ _____ ft³, or x7.48 = _____ gal

To calculate pumping rate:

Pump start time: _____ Duration: _____ Volume (gal): _____

Q (pumping rate, in gpm) = volume in gal/duration in minutes = _____ gpm

Purge time: 3 casing volumes/Q:

<u>Time</u>	<u>pH</u>	<u>SC (us)</u>	<u>TDS</u>	<u>turbidity (N'</u>	<u>temp (deg C)</u>
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Sample time: _____

Comments: