



DEPARTMENT OF
ECOLOGY
State of Washington

Quality Assurance Project Plan

Hangman Hills Sewage Treatment Plant Nutrient Loading and Groundwater Study

September 2010

Publication No. 10-03-116

Publication Information

This plan is available on the Department of Ecology's website at www.ecy.wa.gov/biblio/1003116.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, MRED0002.

Ecology's Activity Tracker Code for this study is 10-140.

Waterbody Number: WA-56-1010

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Quality Assurance Project Plan

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September 2010

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ERO - Eastern Regional Office.
EAP - Environmental Assessment Program.
EIM - Environmental Information Management database.

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Abstract

Hangman Creek is the subject of a Total Maximum Daily Load evaluation for pH and dissolved oxygen with an emphasis on nutrients. Excessive nutrient loading from wastewater discharges, on-site sewage systems, agriculture, fertilizer use, golf courses, and animal operations can cause dissolved oxygen and pH problems. Hangman Creek, also known as Latah Creek, is located in the Hangman Creek watershed, south of Spokane, Washington.

The goal of this project is to determine which sources of nitrogen and phosphorus are infiltrating to groundwater and migrating into Hangman Creek. The primary focus of this study is to quantify the nutrient load from the Hangman Hills Sewage Treatment Plant into the creek. Secondly, this project will attempt to identify gaining and losing reaches of the lower creek where there are transitions in land use. This project will also attempt to quantify the nutrient load from the golf course and agricultural sources.

The Washington State Department of Ecology (Ecology) will collect water quality samples from existing groundwater wells, groundwater seeps, and surface water sites. Samples will be collected during the low-flow period in the summer of 2010. Results from this study will support numerical modeling of water quality conditions for the Hangman Creek watershed.

Each study conducted by Ecology must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

Background

The Hangman Creek watershed (WRIA 56) is the subject of a Total Maximum Daily Load (TMDL) to address fecal coliform bacteria, temperature, and turbidity. The Washington State Department of Ecology (Ecology) is currently conducting modeling work to address the dissolved oxygen and pH violations thought to result from inadequate shade, low streamflows, and excessive nitrogen and phosphorus loads. (Joy, 2008). This study is designed to assess nutrient loading from groundwater in the lower reaches of Hangman Creek.

Hangman Creek, also known as Latah Creek, originates in the foothills of the Rocky Mountains in Idaho and flows northwest into Washington until it reaches the confluence with the Spokane River (Figure 1). Streamflow peaks during the winter and spring when flows typically range from 4,000 to 10,000 cubic feet per second (cfs). During the summer months the flow decreases dramatically, with creek flows relying on groundwater discharge. (Joy, 2008)

Nitrogen loading increases in the lower reaches of Hangman Creek during the low-flow season. This increase is thought to originate from groundwater. (Joy, 2008)

This study will evaluate contributions from a variety of potential sources which discharge to groundwater. These potential sources include the Hangman Hills Sewage Treatment Plant (STP), the county golf course, agriculture, and residential developments which use on-site sewage systems within the study area (Figure 2). Ecology will determine if any of these identified sources are impacting Hangman Creek in gaining reaches, mainly focusing on quantifying the nutrient load from the Hangman Hills STP.

With the results of this study, Ecology will examine the effects of nutrient loading from groundwater on the pH and dissolved oxygen violations occurring in the lower reaches of Hangman Creek.

Hydrogeologic Setting

There are two distinct aquifers in the area: the shallow, unconfined alluvial aquifer and the lower, confined water-bearing zones in the deeper basalt. The Hangman Valley is underlain primarily by glacio-alluvial deposits. These deposits are up to 200 feet thick and overlay the Columbia River Basalt Group. In the shallow alluvial aquifer, depth to water is about 10 to 20 feet below land surface.

The Latah formation is comprised of weakly cemented lacustrine silt and clay mixed with some sand and gravel. This confining layer separates the upper glacio-alluvial deposits from the lower Columbia River Basalt Group. GeoEngineers (2000) determined that significant hydraulic continuity between the upper and lower aquifers is unlikely.

Locally, the Columbia River Basalt Group is comprised of the Wanapum and Grand Ronde members. Depth to basalt varies but is estimated to be approximately 200 feet below land surface. The basalt group is interspersed with the Latah formation which is interbedded between

the basalt flows. It is comprised of weakly cemented lacustrine silt and clay with some sand and gravel. This group contains discontinuous confined water-bearing zones. Groundwater flow direction is estimated to be to the west-southwest. (GeoEngineers, 2000)

Hangman Hills Sewage Treatment Plant

The Hangman Hills STP is located approximately 5 miles south of the Spokane City Limits. This Spokane County facility was built to provide wastewater treatment for the residential development, Hangman Hills, directly north of the plant. Other newer developments across the river and further up in the watershed are not connected to this facility.

The facility includes a settling basin, a sludge waste-holding tank, an aerobic digester, one polishing pond, and two exfiltration (evaporation) ponds. The plant capacity is 86,000 gallons per day (gpd), and the current average monthly flow is approximately 50,000 gpd. (Ecology, 2007). The facility was constructed in 1972 and upgraded in 1977 and 2001. (GeoEngineers, 2000; Ecology, 2007)

There are four monitor wells, completed in the upper alluvial aquifer, at the Hangman Hills STP (Figure 3). Three wells are on the lower terrace and one recently constructed well is on the upper terrace directly up-gradient of the treatment plant. The lower terrace is approximately 25 to 30 feet lower in elevation than the upper terrace.

Groundwater quality sampling is required once per year for nitrate, total dissolved solids, chloride, and fecal and total coliform bacteria. Groundwater flow varies seasonally, with the predominant flow northwest beneath the site towards the creek. Groundwater is hydraulically connected to Hangman Creek (Ecology, 2007).

Ecology issued a state waste discharge permit (#ST-8045) on June 25, 2007.

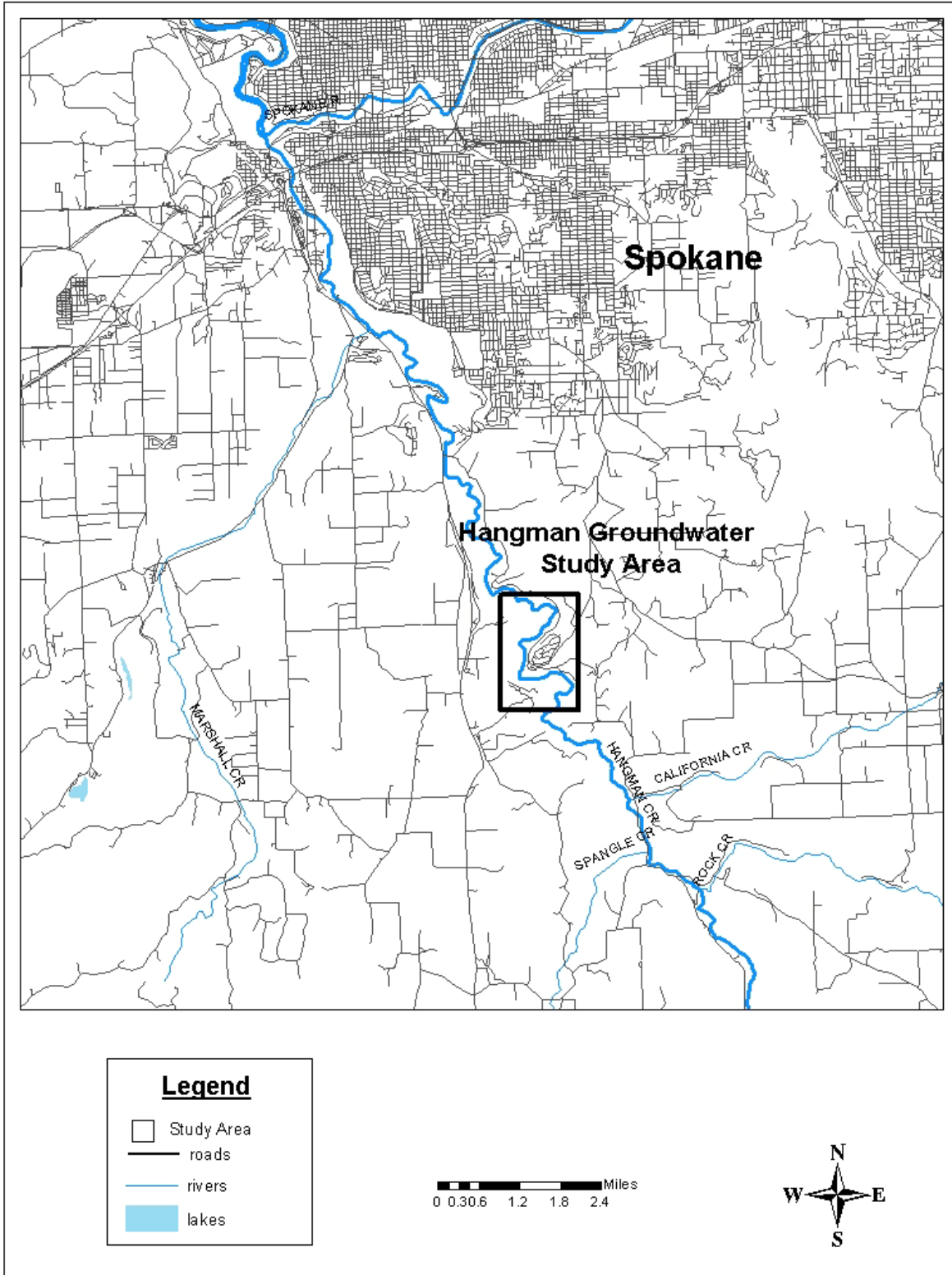


Figure 1. Project study area.

Project Description

This project focuses on quantifying the groundwater contribution of nutrients to Hangman Creek within the defined study area with particular emphasis on the Hangman Hills STP. Existing groundwater wells will be identified for a one-time summer sampling in the area of the STP, as well as the Spokane County golf course and agricultural areas located directly up-gradient of the STP.

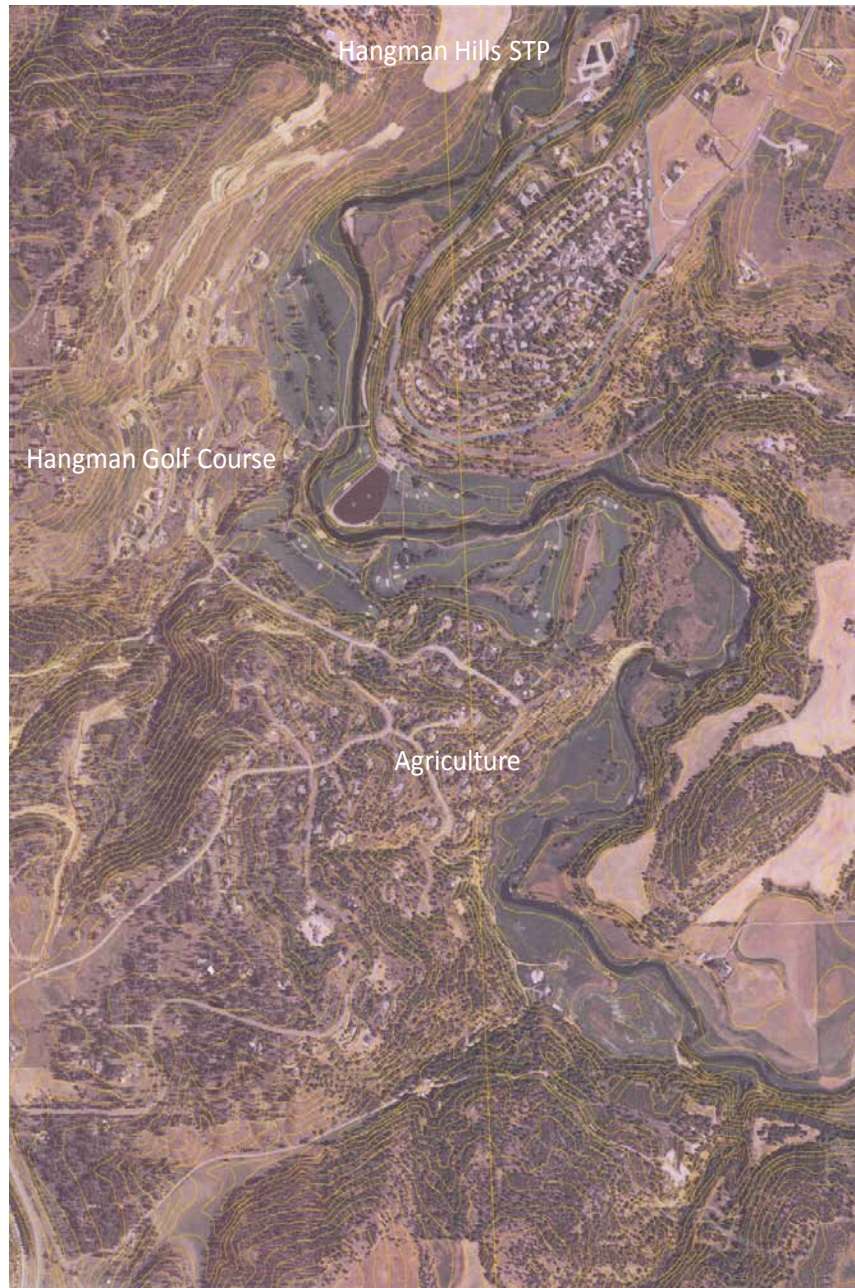


Figure 2. Land use in the lower Hangman Creek watershed.

A reconnaissance survey will be conducted to identify gaining and losing reaches within the study area, groundwater seeps, and surface water sample sites. Gaining and losing reaches will be determined by (1) collecting continuous thermal data in the creek through the study area, and (2) creating a thermal profile of the hyporheic zone within the study area.

Water quality samples will be analyzed for nutrients and inorganic constituents. A list of these parameters is contained in Table 3. Static water level measurements will be taken from wells to determine groundwater flow direction, and field measurements will be made for temperature, specific conductance, dissolved oxygen, pH, and oxidation-reduction potential (ORP).

A thermal profile of the hyporheic zone will be conducted using a thermal probe and measuring at specific intervals along the zones of interest.



Figure 3. Monitor well locations at the Hangman Hills Sewage Treatment Plant.

Organization and Schedule

The following people are involved in this project. All are employees of the Washington State Department of Ecology.

Table 1. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Elaine Snouwaert Water Quality Program Eastern Regional Office Phone: (509) 329-3503	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Melanie Redding Eastern Operations Section Phone: (360) 407-6524	Project Manager/ Principal Investigator	Writes the QAPP. Oversees field sampling and transport of samples to the laboratory. Conducts QA review of data, analyzes and interprets data. Writes the draft report and final report.
Wayne Peterson Water Quality Program Eastern Regional Office Phone: (509) 329-3518	Field Assistant	Helps collect samples and records field information.
Scott Tarbutton Eastern Operations Section Phone: (509) 329-3452	EIM Data Engineer	Enters data into EIM.
Gary Arnold Eastern Operations Section Phone: (509) 454-4244	Section Manager for the Project Manager and Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory Phone: (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: (360) 407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP – Environmental Assessment Program.

EIM – Environmental Information Management system.

QAPP – Quality Assurance Project Plan.

Table 2. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	August 2010	Melanie Redding
Laboratory analyses completed	October 2010	
Environmental Information System (EIM) database		
EIM user study ID	MRED0002	
Product	Due date	Lead staff
EIM data loaded	May 2011	Scott Tarbutton
EIM quality assurance	July 2011	Joe Joy
EIM complete	September 2011	Scott Tarbutton
Groundwater report		
Activity Tracker code	10-140	
Author lead	Melanie Redding	
Schedule		
Draft due to supervisor	February 2011	
Draft due to client/peer reviewer	April 2011	
Draft due to external reviewer(s)	May 2011	
Final (all reviews done) due to publications coordinator	July 2011	
Final report due on web	September 2011	

Quality Objectives

Field sampling procedures and laboratory analysis inherently have a level of error associated with them. Measurement quality objectives (MQOs) are the allowable error level determined acceptable for a project. Precision and bias are data quality criteria used to indicate agreement with MQOs.

The primary objective of this study is to characterize the nutrient contributions from groundwater infiltrating into Hangman Creek. The data from this monitoring program will provide the nutrient loading for the TMDL modeling currently in progress.

Table 3 shows the MQOs for this project. All water quality data referenced in the final report will be evaluated against the project MQOs. Providing pre-established criteria for data quality in the MQOs allows the determination of potential sources of error when evaluating precision and bias for the analytical method. Field replicates will be collected at 10% of the wells sampled. Laboratory quality assurance will include matrix spikes and matrix spike duplicates for metals and also duplicates and matrix spikes for nutrients and other inorganic parameters

Table 3. Measurement quality objectives.

Parameter		Field Replicates	Laboratory Control Standard (LCS)	Duplicate Samples	Matrix Spikes	Matrix Spike Duplicates
		% RPD	% Recovery Limits	% RPD	% Recovery Limits	% RPD
Nitrate+Nitrite-N	dissolved	20	80 – 120	20	75 – 125	
Ammonia-N	dissolved	20	80 – 120	20	75 – 125	
Total Dissolved Phosphorus	dissolved	20	80 – 120	20	75 – 125	
Orthophosphate-P	dissolved	20	80 – 120	20	75 – 125	
Dissolved Organic Carbon	dissolved	20	80 – 120	20	75 – 125	
Total Dissolved Solids	dissolved	20	80 – 120	20	75 – 125	
Chloride	dissolved	20	90 – 110	20	75 – 125	
Bromide	dissolved	20	90 – 110	20	75 – 125	
Boron	dissolved	20	85 – 115		75 – 125	20
Iron	dissolved	20	85 – 115		75 – 125	20
Manganese	dissolved	20	85 – 115		75 – 125	20
Calcium	dissolved	20	85 – 115		75 – 125	20
Magnesium	dissolved	20	85 – 115		75 – 125	20
Potassium	dissolved	20	85 – 115		75 – 125	20
Sodium	dissolved	20	85 – 115		75 – 125	20
Sulfate	dissolved	20	90 – 110	20	75 – 125	
Bicarbonate	total	20	80 – 120	20	75 – 125	
Alkalinity	total	20	80 – 120	20	75 – 125	

Sampling Process Design (Experimental Design)

The primary focus of this study is to characterize the nutrient load along sections of Hangman Creek and determine which sources in the area are impacting water quality. Staff will sample surface and groundwater for the chemicals listed in Table 7 and will send the samples to Manchester Environmental Laboratory (MEL) for laboratory analysis. Staff will measure field parameters in the field.

During this project, staff will tag all wells which do not have a unique Ecology well tag.

Sampling Considerations

To minimize the effects of altering the water chemistry of groundwater samples, staff will follow these procedures:

- Obtain samples from as close to the wellhead as possible.
- Obtain samples prior to any water treatment device.
- Avoid sampling wells that do not have adequate surface seals or may be contaminated by surface runoff.
- Purge wells until the field parameters have stabilized.
- Obtain samples when the pump is running to minimize the contribution from storage tanks.

Samples will be field filtered (depending upon the parameter) to distinguish the dissolved phase concentrations, which are the mobile fraction in the subsurface.

Staff will conduct a thermal profile of the hyporheic zone by inserting a thermal probe in the stream banks along the areas where groundwater contributions are of interest. Staff will measure every 10 meters with a long shaft K-type temperature probe. Variations in thermal readings should indicate zones where groundwater recharges to Hangman Creek.

Sampling Procedures

Staff will purge and sample groundwater wells with a peristaltic pump, using low-flow sampling procedures. They will use a flow-through-cell to measure temperature, pH, electrical conductivity, dissolved oxygen, and oxidation-reduction potential prior to the water being exposed to the atmosphere. Purging will continue until these parameters have stabilized, with measurements taken at five minute intervals. Stability criteria are listed in Table 4. Purging will be considered complete when two consecutive sets of parameter readings show changes less than the criteria listed below.

Table 4. Stability criteria for sampling groundwater.

Field Parameter	Criteria	Typical Change
Temperature	0.2°C	2%
pH	0.2 SU	3%
Electrical Conductivity	10 µmhos/cm	7%
Dissolved Oxygen	0.3 mg/l	10%
Oxidation-Reduction Potential	20 mV	20%

All samples which require field filtration will use an inline 0.45 micron filter, except for dissolved organic carbon and orthophosphate, where a syringe filter will be used. Staff will place samples in bottles obtained from MEL and samples will be collected using the parameter specific criteria listed below in Table 5.

Staff will place samples in coolers with ice while in transit. At the completion of the sampling event, the coolers will be transported to the Ecology Operations Center walk-in cooler, where a MEL courier will pick up the coolers and transport the samples to the MEL in Manchester, Washington.

Table 5. Collection and preservation requirements.

Parameter	Container	Preservative	Holding Time
Nitrate+Nitrite-N	125 ml, wide-mouth polyethylene	Filter, Sulfuric acid to pH<2, cool to 4°C	28 days
Ammonia-N	125 ml, wide-mouth polyethylene	Filter, Sulfuric acid to pH<2, cool to 4°C	28 days
Total Dissolved Phosphorus	125 ml, wide-mouth polyethylene	Filter, HCl to pH<2, cool to 4°C	28 days
Orthophosphate-P	125 ml amber Nalgene	Filter, cool to 4°C	48 hours
Dissolved Organic Carbon	125 ml, wide-mouth polyethylene	Filter, HCl to pH<2, cool to 4°C	28 days
Total Dissolved Solids	500 ml, wide-mouth polyethylene	Filter, cool to 4°C	7 days
Chloride	500 ml, wide-mouth polyethylene	Filter, cool to 4°C	28 days
Bromide	500 ml, wide-mouth polyethylene	Filter, cool to 4°C	28 days
Boron	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Iron	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Manganese	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Calcium	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Magnesium	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Potassium	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Sodium	500 ml, wide-mouth polyethylene	Filter, nitric acid, cool to 4°C	28 days
Sulfate	500 ml, wide-mouth polyethylene	Filter, cool to 4°C	28 days
Bicarbonate	500 ml, wide-mouth polyethylene	Cool to 4°C	28 days
Alkalinity	500 ml, wide-mouth polyethylene	Cool to 4°C	14 days

Measurement Procedures

This study will employ both field- and laboratory-based measurements. Table 6 lists the method, reporting limit, and the expected concentration ranges.

Table 6. Summary of field and laboratory measurements, methods, reporting limits, and expected ranges for groundwater samples.

Parameter	Method	Reporting Limit	Expected Range	Laboratory Costs ¹
Field Measurements				
pH	EPA 150.1	+/- 0.1 SU	5.5 – 7.5 SU	N/A
Conductivity	EPA 120.1	+/- 1 μ S/cm	100 – 1000 μ S/cm	N/A
Temperature		+/- 0.2 °C	7 -15 °C	N/A
Dissolved Oxygen	EPA 360.1	+/- 0.2 mg/L	0.1 – 10 mg/L	N/A
ORP	SM 2580B	10 mV		N/A
Laboratory Parameters				
Nitrate+Nitrite-N	4500 NO3 I	0.01 mg/L	0.01 – 50 mg/L	\$13
Ammonia-N	SM 4500-NH ₃ H	0.01 mg/L	0.01 – 5 mg/L	\$13
Total Dissolved Phosphorus	SM 4500-P F	0.005 mg/L	0.005 – 2 mg/L	\$18
Orthophosphate-P	SM 4500-P G	0.003 mg/L	0.003 – 2 mg/L	\$15
Dissolved Organic Carbon	SM 5310 B	1 mg/L	1 - 15	\$35
Total Dissolved Solids	2540 C	1 mg/L	10 – 500 mg/L	\$11
Chloride	EPA 300.0	0.1 mg/L	0.5 – 250 mg/L	\$13
Bromide	EPA 300.0	0.2 mg/L	0.003 – 0.1 mg/L	\$13
Boron	EPA 200.7	0.05 mg/L	0.3 – 1.5 mg/L	\$10
Iron	EPA 200.7	0.05 mg/L	0.05 – 2 mg/L	\$10
Manganese	EPA 200.7	0.05 mg/L	0.05 – 20 mg/L	\$10
Calcium	EPA 200.7	0.05 mg/L	0.05 – 20 mg/L	\$10
Magnesium	EPA 200.7	0.05 mg/L	0.05 – 20 mg/L	\$10
Potassium	EPA 200.7	0.5 mg/L	0.05 – 20 mg/L	\$10
Sodium	EPA 200.7	0.05 mg/L	0.05 – 20 mg/L	\$10
Sulfate	EPA 300.0	0.3 mg/L	1 – 250 mg/L	\$13
Bicarbonate	EPA 310.2	5 mg/L	5 – 20 mg/L	\$17
Alkalinity	EPA 310.2	5 mg/L	5 – 20 mg/L	\$17

(MEL, 2008), (Standard Methods (20th Edition)).

Dissolved fraction samples will be field filtered.

¹The laboratory costs include a 50% discount for Manchester Laboratory.

The total suite of laboratory analyses = \$248 per sample.

It is anticipated that 4 groundwater samples, 4 groundwater seeps, 4 surface water sites, 3 duplicates, and 1 blank will be collected.

The total analytical budget for this project is estimated at \$3,968.

Quality Control Procedures

Field

A field duplicate water quality sample will be collected for 10% of the wells, seeps, and surface water sites sampled, and will be submitted to the laboratory as a blind sample. At least one duplicate will be collected from each different media. A field duplicate is a second sample from the same well using identical sampling procedures. Duplicate sample results will provide an estimate of overall sampling and analytical precision.

Field equipment (filter) blanks will be collected to determine bias introduced by the sample collection procedures or the field equipment. This blank will be collected by running laboratory-grade de-ionized water through the sampling equipment and filtration process and then submitting samples to MEL for analysis.

All equipment will be decontaminated between sample sites and pre-rinsed with sample water prior to collecting a sample for analysis.

Field meters will be calibrated in accordance with the manufacturer's instructions.

Laboratory

Routine laboratory quality control procedures will be adequate to estimate laboratory precision and accuracy for this project. Laboratory quality control samples consist of filter blanks, duplicates, matrix spikes, and laboratory control standards (MEL, 2006).

Duplicates will be used to assess analytical precision. Matrix spikes will be used to indicate bias due to matrix interferences. Check standards will be used to estimate bias due to calibration. Laboratory blanks will be used to measure the response of the analytical system at a theoretical concentration of zero.

Data Management Procedures

All field observations and monitoring results will be recorded on individual well sampling sheets that will be maintained throughout the length of the project and eventually archived in project files. Staff will check field observations and data for legibility and completeness before leaving the site locations. They will enter field data in spreadsheets and in the Ecology Environmental Information Management (EIM) database.

Analytical data from MEL will be stored in electronic format in the data management system (LIMS). After the data are verified, they will be summarized in case narratives and provided to the project manager.

After completing the sampling, staff will compile and evaluate all field and laboratory analytical data against the project MQOs listed in Table 3. Data reduction, review, and reporting will follow the procedures outlined in MEL's *Lab Users Manual* (MEL, 2008).

All laboratory data will be entered into the EIM database. Data will also be entered into spreadsheets for evaluation and presentation in graphical formats.

Audits and Reports

MEL participates in performance and system audits of their routine procedures. Reported results of these audits are available upon request. Ecology's Laboratory Accreditation Program establishes whether the laboratory has the capability to provide accurate and defensible data. The accreditation involves an evaluation of the laboratory's quality system, staff, facilities, equipment, test methods, records, and reports.

The final report will include a quality assurance section describing data quality. These reports will undergo scientific peer review by staff who have appropriate expertise and who are not directly connected with this project.

After the data are reviewed for each sampling event, the results will be sent to each well owner, along with an explanation of the water quality analyses.

Data Verification

Data verification is a quality assurance review process to determine the quality and the completeness of the field and analytical data. This is done by determining that all quality control samples meet the acceptance criteria as specified in the standard operating procedure for that method.

MEL staff will review all laboratory analysis for the project to verify that the methods and protocols specified in the Quality Assurance Project Plan were followed; that all instrument calibrations, quality control checks, and intermediate calculations were performed appropriately; and that the final reported data are consistent, correct, and complete with no omissions or errors, (MEL, 2008). Evaluation criteria will include the acceptability of instrument calibrations, procedural blanks, spike sample analysis, precision data, laboratory control sample analysis, and the appropriateness of assigned data qualifiers. The MEL staff will prepare a written case narrative describing the results of their data review.

Precision will be estimated by calculating the RPD for field duplicate results. Analytical bias will be assumed to be within acceptable limits if laboratory quality control limits are achieved for blanks, matrix spikes and check standards. Sampling bias will be assessed by verifying that the correct sampling and handling procedures were used. Goals for completeness will be evaluated and, if needed, replacement samples will be obtained and adjustments in subsequent sampling events will be made.

Field quality control procedures include reviewing field notes for completeness, errors, and consistency. Duplicate measurements and documentation of conditions in field notes will support verification of analytical measurements and field measurements.

The project lead will review the data package and case narrative to determine if the results meet the MQOs for accuracy, precision, and bias for that sampling episode. Field duplicate results will be evaluated and compared to the MQOs shown in Table 3. Based on these assessments, the data will be accepted, accepted with appropriate qualifications, or rejected.

After the laboratory and field data have been reviewed and verified by the project manager, they will be transitioned to the EIM system for access by the project client and others. The EIM data sets will be independently reviewed for errors by another staff person before finalizing and completing the project in EIM.

Data Quality (Usability) Assessment

Once the data have been reviewed and verified, the project lead will use her best professional judgment and statistical analysis to determine if the data can be used to meet the project goals and objectives. Data will be compared to the project MQOs for accuracy, precision, and bias. Additionally, the laboratory case narratives and duplicate sample analyses will be evaluated. Depending upon the ability to meet these goals, the data will be deemed acceptable for use.

Data that does not meet the project data quality criteria will be qualified or rejected as appropriate. The final report will discuss data quality and any limitations.

References

GeoEngineers, 2000. Hydrogeologic Study, Hangman Hills Sewage Treatment Plan, Spokane, County, Washington. Spokane, WA. 9 pgs plus tables, figures and appendices.

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen: A measure of the amount of oxygen dissolved in water.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Hyporheic: The area beneath and adjacent to a stream where surface water and groundwater intermix.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Reach: A specific portion or segment of a stream.

Streamflow: Discharge of water in a surface stream (river or creek).

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
ORP	Oxidation-reduction potential
QA	Quality assurance
RPD	Relative percent difference
RSD	Relative standard deviation
STP	Sewage treatment plant
TMDL	(See Glossary above)
WRIA	Water Resources Inventory Area

Units of Measurement

gpd	gallons per day
mgd	million gallons per day
mg/L	milligrams per liter (parts per million)
mV	millivolts
µg/L	micrograms per liter (parts per billion)
µmhos/cm	micromhos per centimeter
µS	microsiemens per centimeter
µS/cm	microsiemens per centimeter, a unit of conductivity