Field Data Collection Plan
Quality Assurance / Quality Control Plan

Spokane Aquifer Joint Board Wellhead Protection Program

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Washington State Department of Ecology

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Section 1

Project Description

1.1 General Project Overview

The Spokane Aquifer Joint Board (SAAB) consists of nineteen Class A water purveyors in Spokane County who provide drinking water from the Spokane-Rathdrum Aquifer. This consortium provides water to over 110,000 residents from the Spokane-Rathdrum aquifer, which has been designated as a sole source aquifer by the U.S. Environmental Protection Agency (EPA). In general, the utility members of the SAJB operate over 170 wells located on over 90 parcels of land.

The field data collection program is being conducted as part of SAJB's planning process for implementation of a wellhead protection program. Under the 1986 Safe Drinking Water Act Amendments, most water purveyors using groundwater as their source are required to implement a wellhead protection program. As a result of this requirement, the Washington State Department of Health (DOH) recently adopted a Wellhead Protection Program which identifies the following six necessary components required for an acceptable program:

- A susceptibility assessment
- A delineated wellhead protection area for each well
- An inventory of potential contaminant sources
- A contingency plan to provide alternate water sources
- Public participation
- Adoption of a Wellhead Protection Program

The SAJB is currently collecting data in support of understanding and expanding the knowledge of the aquifer and its characteristics in support of the overall wellhead protection program. This Field Data Collection and QA/QC Plan supports the data collection efforts of the project by providing rationale for data collection activities, and methodologies for data collection and reduction.

The SAJB's Wellhead Protection Program is funded in part by a Washington State Department of Ecology Centennial Clean Water Fund Grant, by Spokane County, and by the Utilities.

1.2 Field Data Collection Program

The field data collection program consists of the following principal components:

- Installation of up to four monitoring wells
- Aquifer testing at four sites.
- Discrete water level monitoring (groundwater and surface water)
- Seismic reflection profiling
- Geochemical evaluation

1.3 Schedule

Well installation will begin in September of 1996. Aquifer testing, discrete water level monitoring, and seismic reflection profiling are expected to begin in early October 1996. The geochemical evaluation of the aquifer is scheduled to be performed during October.

Section 2

Project Organization

The project is being conducted by the SAJB which as water purveyors, is responsible for wellhead protection planning. Currently, Ty Wick, Manager of Spokane County Water District No.3, is the elected President of the SAJB.

The SAJB has contracted with CH2M HILL, Inc., to provide program assistance in the planning efforts. Brad Phelps, P.E. is CH2M HILL's project manager. CH2M Hill has also subcontracted Fogle Pump and Supply of Airway Heights for monitoring well drilling and installation. Other data collection activities as part of this project include non-intrusive bedrock determination using seismic reflection profiling or other methods to determine aquifer characteristics, the performing of aquifer tests, and also water level monitoring across the Washington-Idaho State Border.

Section 3

Data Quality Objectives and Data Collection Objectives

3.1 Data Quality Objectives

The principal data quality objectives for collecting the hydrogeologic data required for the SAJB's wellhead protection planning work are as follows:

- Collect sufficient hydrogeologic data to calibrate and refine a regional groundwater flow model. The model will be used to delineate wellhead protection areas for wells and wellfields operated by SAJB members and for proposed future well sites.

- Apply methods and procedures generally consistent with standard practices and applicable state regulations during drilling, well installation, and other hydrogeologic data collection activities.

The field program consists of the following eight principal tasks:

- Developing a monitoring well network
- Monitoring well installation
- Horizontal and vertical surveys
- Aquifer testing
- Discrete groundwater level observations
- Surface water data collection (water levels)
- Seismic reflection profiles
- Geochemical evaluation

Data collection objectives for each field task are discussed below.

3.2 Data Collection Objectives

3.2.1 Monitoring Well Network

A monitoring well network will be defined in order to collect data necessary for refinement of the existing Spokane Aquifer model to conduct simulation/calibration and wellhead delineation. The network will consist of existing wells and monitoring wells located within approximately five miles of the stateline, both in Washington and Idaho.

Wells identified for this monitoring network may be used to provide local groundwater information near SAJB members' pumping centers and to determine aquifer levels during the discrete groundwater monitoring event. These wells may include both production wells or inactive (idle) wells not in service. Water levels will be measured from production wells only during shut-down periods.

3.2.2 Monitoring Well Installation

Up to four monitoring wells will be installed for the following purposes:

- Characterize the geologic nature of the aquifer during drilling
- Provide access points for water level monitoring activities during aquifer testing and possible, future water quality monitoring by Spokane County

Three of the monitoring wells will be installed in the Spokane Valley and the fourth will be located in North Spokane. Tentative locations for the monitoring wells are listed in Table 3-1.

Each of these wells will be drilled and installed into the saturated zone to accommodate the range of expected seasonal water level fluctuations and accommodate depth-sampling requirements of the County. The target depth for these wells will be approximately 25 feet below the existing water level of the aquifer, which is approximately 5 feet above expected seasonal low water levels. Even under the lowest observed water level conditions, these completion depths should provide about 20 feet of saturated conditions. The screened length will be 30 feet, with the screen set such that the existing water level is approximately 5 feet below the top of the well screen.

Table 3-1
Anticipated Locations of New Monitoring Wells

Nearby SAJB Production Well	Target Depth of Well [a]
CID # 4 Wellfield (Mission and Barker)	120 ft.
CID # 5 Wellfield (Euclid and Barker)	105 ft.
CID # 11 Wellfield (Wellesley and Idaho Road)	165 ft.
N. Spokane Irrigation District. Wellfield (Francis and Regal)	240 ft

[a] Depths below ground surface in feet.
Seasonal water level fluctuations historically have ranged from 6 to 16 feet.

The exact locations of the four monitoring wells will be determined after discussions with current landowners and the securing of permanent easements to access the wells.

3.2.3 Horizontal and Vertical Surveys

Horizontal and vertical (elevation) surveys will be performed for each groundwater and surface water level monitoring station used for discrete monitoring. The vertical surveys will establish reference elevations for the measurement point of each monitoring station (wells, staff gages, and bridges). This information will be used to convert water level information (depth to water in wells, water level readings for staff gages) to water surface elevations. Vertical surveys will also be conducted for seismic reflection profile lines so that depth information can be converted to elevations.

3.2.4 Aquifer Testing

Aquifer testing will be conducted at a minimum of four SAJB wellsites where there is a large-capacity production well (greater than 2,000 gpm) and at least one or two observation wells (either inactive production wells or monitoring wells) nearby. Water level data will be collected from the pumping well and observation wells prior to pumping, during pumping, and after the pumping well has been shutdown. Analysis of water level data collected during aquifer testing will provide estimates of aquifer transmissivity and hydraulic conductivity to be used to refine modeling input.

3.2.5 Discrete Groundwater Level Observations

Manual water level measurements will be performed over a one to two-day period during October 1996 at each well in the water level monitoring network. At this time of the year, water levels in the aquifer should be near their seasonal low. The purpose of the water level measurement event is to provide a water table configuration for an expanded study area that extends approximately 5 miles into Idaho. This information will assist in calibration and refinement of the groundwater flow model.

It is anticipated that water level data will be collected from approximately 25 wells located in Washington and approximately 17 in Idaho.

3.2.6 Surface Water Data Collection

Water level data will be collected at approximately 10 locations during the discrete groundwater level measurement event. These locations will be located on a reach of the Spokane River between Lake Couer d' Alene and Sullivan Road in the Spokane Valley. These data will be evaluated together with available streamflow records (measured using previously-established river gauging stations) to identify losing and gaining reaches of the river and to accurately represent the river in the numerical groundwater flow model.

3.2.7 Seismic Reflection Profiles

Seismic reflection profiles will be conducted to evaluate the depth to bedrock, the depth to the water table, and variations in aquifer thickness. A profile will be conducted along approximately 5 miles of the Sullivan Road corridor. An additional profile may also be conducted in the North Spokane area to better determine aquifer thickness and bedrock configuration.

3.2.8 Geochemical Evaluation

Up to five groundwater samples will be collected from selected wells in the North Spokane area. The objective of this sampling is to characterize chemical distinctions between wells producing from shallower portions of the aquifer and those which are believed to produce from a deeper confined portion of the Spokane Aquifer. At a minimum the analytical suite will include major cations, ions, manganese, iron, cyanide, and radon. A laboratory accredited by the Washington State Department of Ecology (Ecology) will perform the analyses.

Section 4

Data Collection Procedures

4.1 Well Installation

The following sections discuss equipment and procedures used for siting, drilling, geologic logging, well design and construction, well development, and handling of drill cuttings and purge water. Additional procedures for maintaining construction quality during drilling and well installation are discussed in Section 6.1. Documentation procedures are discussed in Section 7.1.

4.1.1 Siting, Access, Utility Clearance

Specific locations for monitoring well installation will be determined by CH2M HILL staff based on locations of SAJB member production wells and the proximity of other wells that may be incorporated into the water level monitoring network. Access will be secured by representatives of the SAJB. Underground utilities that may be present will be clearly marked in the field by one-call utility locating local service and, if necessary, a private utility locator. Underground utility information will also be sought from individual property owners to supplement the field utility location work. Drilling will not begin at a given monitoring well site until field marking has been completed and/or utility clearances have been obtained. Start cards will be filed with the Ecology before drilling begins, as required by Washington Administrative Code (WAC) 173-160. The use of the wells will be identified as being for resource protection on each start card.

4.1.2 Borehole Drilling

Wells will be drilled with an air rotary drill rig. Each boring will be advanced with temporary steel casing using standard drill-and-drive techniques. It is anticipated that 6-inch inside diameter (ID) temporary casing will be used to advance boreholes and 2-inch ID casings will be used to construct monitoring wells. The air-rotary rig will be equipped with a pneumatic casing advancer and a bit appropriate for the materials to be penetrated. Filtration will be provided for compressed air prior to its introduction into the boring. Drilling methods will be performed in conformance with (WAC) 173-160. Downhole equipment will be steam-cleaned prior to drilling at each location.

4.1.3 Geologic Logging

A geologist will supervise the drilling and also geologically log the boring. Grab samples will be collected during drilling from cuttings discharged at the ground surface. Grab samples will be collected at minimum depth intervals of 5 feet or whenever a significant change is noted in cuttings or drilling conditions. Grab samples will be described in general conformance (due to materials & methods) with ASTM D-2488-90: *Standard Practice for Description and Identification of Soil (Visual-Manual Procedure).*

4.1.4 Well Design and Construction

Monitoring wells will be constructed in accordance with WAC 173-160. Attachment 1 illustrates typical monitoring well construction details. Final monitoring well designs (including screen depth, screen slot size, and size of filter pack materials) will be selected after drilling by the supervising geologist.

Two-inch diameter monitoring wells will be constructed at each location. The casing and screen materials will consist of PVC conforming to ASTM D-1785-93: *Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120* and ASTM F-480: *Standard Specification for Thermoplastic Water Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDRs).* Wells constructed to depths greater than 200 feet will be constructed with schedule 80 PVC. Wells constructed at shallower depths will be constructed with schedule 40 PVC.

The PVC well screen will be factory-fabricated and will consist of continuous slot screen or machine slotted screen. The screen length will be 30 feet, unless otherwise warranted based on conditions observed during drilling. The screen slot size will be compatible with the grain size of the filter pack.

The well screen, well casing, and sumps will have threaded couplings that meet ASTM F480 standards. No PVC solvents will be used to connect screen/casing lengths. Casing centralizers will be placed immediately above and below the well screen to center the well assembly in the borehole. Casing centralizers also will be attached to the well casing above the well screen at intervals of approximately 40 to 50 feet.

The filter pack will be placed by carefully pouring Colorado silica sand or equivalent down the annulus between the well casing and the temporary borehole casing. The temporary casing will be pulled back as the filter pack is being placed so that filter pack material is always inside the temporary casing. The well will then be developed by a combination of surging, bailing, and/or pumping to improve initial settlement of the filter pack and to reduce the possibility of creating a void space in the annulus between the filter pack and the overlying filter pack seal and annular seal during subsequent well development. The final filter pack level will be a minimum of three feet above the top of screen.

A minimum 3-foot thick filter pack seal consisting of bentonite chips or pellets will be placed above the filter pack. An annular seal will then be placed above the filter pack seal. The annular seal will consist of bentonite chips or pellets.

Each well will be completed with a protective casing and surface seal. The protective casing will consist of 0.250-inch walled steel casing at least 4 inches in diameter larger than the nominal diameter of the well casing. For above-grade completions, a concrete pad will be constructed around the well, and three steel guard posts will be installed around the wellhead. The protective casing will include a locking cap that fully encloses the casing collar. The well casing will be capped with a vented PVC cap. A drain hole will be placed near the base of the protective casing. The protective casing will be permanently marked with well identification information.

The surface completion may be constructed at grade if the well is located in a public park, an area of heavy vehicular traffic, or otherwise cannot be completed above ground surface. The PVC well casing will be cut off below the ground surface. In this case, a protective steel well cover with locking cap will be placed over the well casing and cemented in below the ground surface, and a concrete valve box will be installed flush with ground surface and concreted in place. If an automatic water level recording device will not be placed in the well, then the well casing will be capped with a locking gasket-type cap, and a protective well cover will be placed over the well casing and cemented in place. The ground surface will be graded to slope away from the well.

4.1.5 Well Development

The wells will be developed after construction to remove turbidity created by the drilling and well construction process and to improve the hydraulic connection between the aquifer and the well. Development will begin no sooner than 24 hours after construction is complete to allow seals to stabilize. Development will be performed using a combination of surging, bailing, and/or pumping. Development will continue as long as the water withdrawn continues to decrease in turbidity or is to the satisfaction of the supervising geologist.

4.1.6 Handling of Drill Cuttings and Purge Water

Monitoring wells are not planned to be installed in areas where soil or groundwater contamination are suspected to be present. Drill cuttings and discharged groundwater will be examined visually and checked for odors during well construction and development activities. If there are no indications of potential contamination, cuttings and purged water will be disposed of on the ground surface near the well or in other locations as may be required by site-specific conditions. If contamination is observed, arrangements will be made by the SAJB for materials handling and disposal.

4.2 Horizontal and Vertical Surveys

At this time, it is anticipated that horizontal surveys will be performed using Global Positioning Satellite (GPS) methods. Horizontal locations will be determined to the nearest 10 feet and cited according to the Washington State Plane Coordinate System North Zone (NAD 1983). Procedures required for horizontal surveying will depend on the surveying method and equipment that is used.

Vertical control will be established using field surveying techniques. Vertical control will be to an accuracy of 0.1 foot. A City of Spokane datum will be used for vertical control. This datum is by 16.92 feet higher than the National Geodetic Survey Vertical Datum (NGVD) of 1929. Elevations will be determined for the following points:

- Monitoring wells
  - Ground surface and/or concrete pad
  - Water level measurement point (generally the top of the PVC well casing)
- Production wells
  - Ground surface and or concrete pad
  - Water level measurement point (generally an access port in the side of the pump column)
- Staff gages
  - Top of the gage or other appropriate point on the graduated scale attached to the gage, depending on accessibility
- Bridges
  - Reference point at the edge of the bridge either on the deck surface or a railing

Field quality control and data handling procedures are presented in Sections 6.2 and 7.2, respectively.

4.3 Aquifer Testing

Each aquifer test will consist of three phases: shutdown, pumping, and recovery. For the shutdown phase, all production wells within approximately 1000 feet of the large-capacity production well will be shutoff for a minimum of 24 hours, allowing for water levels to return to equilibrium. During the pumping phase, the large-capacity production well will be pumped continuously at a constant rate for a minimum of 8 hours, up to a maximum of 48 hours. For the recovery phase, the pumping well will be shutoff and any other wells located within 1000 ft will not be allowed to pump for a minimum of 12 hours.

4.3.1 Water Level Measurements

Water levels will be measured in the pumping and observations wells using a either electronic water level indicators, air lines with high-resolution air gauges, or pressure transducers linked to automated data recorders.

Depth to water measurements in individual monitoring wells will be made with electronic water level indicators. The sounder will be lowered slowly into the well in such a manner that the probe does not substantially penetrate below the water surface. The measurement will be checked by lifting the probe slightly above the top of the water column in the well then remeasuring the depth at which water is encountered. This procedure will be repeated until successive measurements agree to within 0.01 foot. Measurements will be recorded to within 0.01 foot in field logs. Procedures for calibrating water level sounders are discussed in Section 6.5. Data handling procedures are discussed in Section 7.4.

Depth to water measurements in wells fitted with airlines will be conducted with pressure gauges. Because of the uncertainty of the depth of the airlines, the data recorded will represent only relative changes in the water level. For each location, air gauges will be installed on the pumping well and at least one observation well; these gauges are accurate to within of 0.1 psi, or 0.23 feet. Prior to obtaining a water level measurement, air will be pumped into the airline using a handpump. By way of displacement, the air pressure reading multiplied by 2.31 ft/psi is equal to the height of the water column above the base of the airline. This procedure will be repeated until successive measurements agree to within 0.1 psi.

A pressure transducer and electronic data logger will be placed in at least one observation well for each aquifer test. Pressure transducers will be rated at a minimum of 10 pounds per square inch, which corresponds to a water level fluctuation of 23 feet. The data logger will be a Geokon, Aquastar, or equivalent model. The data logger will be programmed to record water levels at a frequency of approximately once per minute. Backup measurements will be taken with a manual electronic water level sounder when the data logger is installed and at each time data is retrieved. Water levels recorded by the data logger will be downloaded to an electronic format during each test for real-time analyses and following completion of the test.

Procedures for calibrating and maintaining data loggers are presented in Section 6.3 Procedures for data handling are presented in Section 7.3.

4.3.2 Flow Measurements

As the production well is being pumped, pumping rates will be measured using existing in-line flow meters maintained by SAJB members. These flowmeters typically are accurate to within +/- 2 percent. Because the production wells are part of their system's distribution system, flow rates will vary during the course of the pumping test because of changes in water demand and delivery pressures. To monitor these fluctuations, flow readings (both instantaneous and cumulative) will be recorded approximately every two hours during testing. Where available, SAJB members' wells may also electronically record production rates. Average flow rates achieved during the testing will be used in subsequent analysis to estimate aquifer parameters.

4.4 Discrete Groundwater Level Observations

Measurements of the depth to water in individual monitoring wells will be made with electronic water level indicators. Procedures to record depth to water measurements are presented in Section 4.3.1. Procedures for calibrating water level sounders are discussed in Section 6.4. Data handling procedures are discussed in Section 7.4

4.5 Surface Water Data Collection

Water level data will be collected at surface water stations that include stream gauging stations, staff gauges, and bridge decks located on the Spokane River. Measurements of the water level at streamflow gauging stations will be made directly in stilling wells, if present. If no facilities are available for direct measurement of the water level elevation, the agency maintaining the gage will be contacted for stage-discharge or water level information.

Measurements of the water level where staff gages are present will be performed visually. Water levels will be read to the nearest 0.01 foot or to whatever accuracy is possible according to the graduated scale on the gage. Some staff gauges operated by the USGS also may be equipped with electronic recording devices.

Measurements from bridge decks will be performed with a manual electronic water level sounder using the same general procedures discussed in Section 4.4. However, weights may be added to the sounder, depending upon the distance between the bridge deck and the water surface, the water turbulence, and the wind velocity at the time of measurement.

4.7 Geochemical Evaluation

Representative groundwater samples will be collected from a minimum of 5 selected wells in North Spokane to characterize the chemical distinction between wells completed in the shallower portions of the aquifer to wells believed to produce water from a deeper confined portion of the Spokane Aquifer. Depending on the type of well selected and its distribution system, water samples will be collected from either the nearest tap or will be obtained using an appropriate sampling device.

Under either case, the volume of standing water in the well will be calculated or estimated and a minimum of three of these volumes will be purged from the well prior to sampling. After each well volume has been purged, temperature, pH, and conductivity will be measured. Samples will be collected from the well only after the field parameters agree within 10 percent of the previous measurement.

4.6 Seismic Reflection Profiles

Seismic reflection profiles will be performed using the *SeisPulse Near Offset* method (patent pending) of seismic surveying, developed by IntrpreTECH/SeisPulse LLC of Lacey, Washington. This method uses the *SeisPulse* seismic source and two independent recording geophones separated 10 feet from the source. Each seismic charge and its resultant waves are recorded individually on an instantaneous floating point seismic recording system. A minimum of 6 shots will be performed at each station. The method does not rely on detonating explosive charges as the seismic energy source, and is therefore quiet. The equipment can be used in urban or rural settings.

Prior to field work, approximate structural thicknesses of major geologic features will be determined from available existing well data. This information will be used to determine the seismic interval velocity necessary to apply to the seismic section at each station. Structural features (depth to bedrock) and stratigraphic features (the depth to groundwater and the location of especially high-conductivity deposits) will be interpreted and timed at each recording station. The distance between stations will be determined in the field based upon the length of the profile, the availability of nearby stratigraphic and hydrogeologic information (primarily from well logs), and logistical considerations.

Section 5
Analytical Procedures

Groundwater samples will be collected from a minimum of five wells located in North Spokane that draw water from a lower, confined portion of the Spokane Aquifer. Following sample collection, these samples will be cooled to approximately 4 °C until delivered to a local, Ecology-accredited analytical laboratory. Samples will be analyzed for the following parameters:

- Major cations (sodium, potassium, magnesium, and calcium)
- Major anions (bicarbonate, chloride, and sulfate)
- Iron and manganese
- Cyanide
- Radon

The selected laboratory will provide pre-preserved sample containers and coolers. The laboratory will be required to provide backup analytical data necessary to assess the validity of the data, which will include instrument calibration data, method blank, and holding time information.

Specific analytical methods will be consistent with *Standards Methods of Examination of Water and Wastewater*, APHA 1995, or *Methods for Chemical Analysis of Water and Wastes*, EPA 1983.

Section 6

Quality Control Procedures

6.1.1 Siting, Access, Utility Clearance

Siting and access issues will be addressed with individual property owners and therefore will not require quality control procedures. Utility clearances will be performed by contacting the one-call utility locating system (456-8000) at least 48 hours prior to the beginning of drilling activities at each site. Telephone conversation records will be maintained in a project notebook documenting the initial utility location request at each well site and subsequent discussions with utility locator personnel. Information regarding private utilities will be sought from private property owners if a well is to be located outside of the public right-of-way. If necessary, a private utility locating service will be used.

6.1.2 Borehole Drilling

Drilling will be performed by a licensed well construction operator responsible for conforming with WAC 173-160 for design and construction of resource protection wells. For each monitoring well, the well contractor will submit a start card to the Washington State Department of Ecology at least 72 hours prior to drilling. A copy of the start card will be provided to the supervising geologist before drilling begins.

The driller will maintain a daily record of activities at the well construction site. The daily record will be reviewed by the supervising geologist, and a copy will be placed in the project files. The drilling record will include the lengths of individual sections of temporary casing lowered into the borehole during drilling activities. The supervising geologist will also maintain a field notebook of the well drilling activities.

6.1.3 Geologic Logging

The supervising geologist will perform geologic logging of the borehole during drilling. The geologic log will be recorded on the field form "Soil Boring Log" shown in Attachment 1. Heading information will be completely filled out on each log sheet, and technical items will be recorded in the appropriate columns of the form. Selected geologic and drilling information will also be recorded in the geologist's field notebook.

Geologic logging of grab samples of drill cuttings will be performed in general accordance (due to materials and methods) with ASTM D-2488-90: *Standard Practice for Description and Identification of Soil (Visual-Manual Procedure).* Other information that will be recorded on the form will include water level measurements during drilling, changes in drilling speed, borehole caving or heaving, depths of changes in subsurface materials, and the dates and times the boring was begun and completed. Because of the

drilling method, the accuracy of determining changes in subsurface materials is within one foot.

6.1.4 Well Design and Construction

Monitoring wells will be designed and installed in accordance with standards contained in WAC 173-160 for design and construction of resource protection wells. Monitoring well construction will be performed by the drilling subcontractor and will be observed by the field geologist. Other specific quality control procedures to be implemented in the field include the following:

- The PVC screen and casing will be steam-cleaned and inspected for damage before being lowered into the borehole. Lengths of each section of PVC screen and casing will be recorded, along with the positions of casing centralizers.

- The supervising geologist will inspect the well screen to ensure that it meets design specifications required for use of the heat pulse flowmeter (which will be used for groundwater velocity measurements). The geologist will also inspect other downhole materials before they are placed in the borehole to ensure that they meet design specifications.

- The filter pack and overlying filter pack seal will be poured into the annulus slowly to prevent bridging. To prevent caving of the formation, the casing will be pulled back so that filter pack material is always inside the casing. The level of the filter pack will be monitored by sounding with a weighted tape before and after each period of pulling back casing.

- Above the filter pack, the annulus will be filled with bentonite chips. The top of the chips will be sounded frequently to minimize the potential for bridging and subsequent formation of discontinuities in the seal. The borehole annulus will be filled to ground surface.

- The temporary borehole casing will be removed as the filter pack, filter pack seal, and grout seal are being placed. The relative location of the top of the annular materials and the bottom of the temporary casing will be monitored using a weighted measuring tape and information on the lengths of the temporary steel casing.

Well construction details will be recorded on the field form titled "Monitoring Well Construction Details" shown in Attachment 2. Heading information will be completely filled out on each log sheet, and technical items will be recorded in the appropriate locations on the form. Field personnel will review completed logs for accuracy, clarity, and thoroughness of detail. Other well construction information, including material quantities, will also be recorded in the field notebook.

6.1.5 Well Development

Wells will be developed by surging and bailing/pumping using either a bailer or compressed air or a submersible pump. The field geologist will record descriptions of the turbidity of water samples, the time and date, the approximate volume of water removed since the beginning of development, and other pertinent observations.

6.1.6 Handling of Drill Cuttings and Purge Water

Notes will be made in the field notebook of the handling and disposal of drill cuttings and water purged from the well during installation and development. If potential contamination is observed, a record will be made in the field notebook.

6.2 Horizontal and Vertical Surveys

Horizontal and vertical surveys will be conducted to identify coordinate locations for the wells in the monitoring well network. Hand held GPS equipment will be used to identify horizontal coordinates of the wells. GPS or Transit level loops will provide elevation data.

6.3 Aquifer Testing

6.3.1 Water Level Measurements

Water levels obtained during aquifer testing will be measured using electronic water level indicators, airlines and air pressure gauges, and/or with pressure transducers and data logging systems.

Only one electronic water level indicator will be used during aquifer testing. There is no need to calibrate the indicator because only the relative water level difference will be measured. Water level measurements will be recorded to the nearest 0.01 foot.

Air pressure gauges to be used during aquifer testing have been calibrated at the factory and will be used in accordance with the manufacture's guidelines. These gauges have a reported accuracy of +/- 0.5 percent.

Specific quality control procedures to be implemented during installation of the data loggers and retrieval of digitally recorded data include the following:

- The pressure transducer cable will be secured to the outside of the well casing to prevent accidental slippage of the transducer during the monitoring period.

- The transducer will be placed 10 feet below the top of the water column or at an alternate depth if deemed appropriate at the time of installation. The depth of the transducer will be recorded to the nearest 0.01 foot.

- The depth to water will be measured with a manual electronic water level sounder before the transducer is placed in the water column. The depth to water will be remeasured after the transducer has been placed in the water column as part of the calibration and start-up procedure for the data logger. Quality control procedures for manual water level measurements are discussed in Section 6.5

- The data logger batteries will be checked and changed if required during installation and each time data is retrieved.

- During installation, the performance of the transducer will be assessed by lowering the transducer further down in the water column and observing the corresponding change in data logger readings.

- The data logger will be programmed to record water levels to the nearest 0.01 foot.

- At the time of data retrieval, the depth to water will be measured manually and with the data logger to ensure that the transducer is recording correctly, as well as to determine if the transducer needs to be repositioned within the well.

6.3.2 Groundwater Flow Measurements

Groundwater flow measurements will be monitored using in-line flowmeters. The accuracy of these flowmeters is typically +/- 2 percent. These flowmeters are generally field checked annually by SAJB members. To account for any short-term fluctuations during the constant-rate pumping test (caused by system demand or delivery pressure changes), average flow rates for the entire pumping test will be used for calculation of aquifer parameters.

6.4 Discrete Groundwater Level Observations

It is anticipated that multiple electronic water level sounders will be used during the discrete monitoring event. In order to obtain equivalent water level elevation information throughout the monitoring network, the sounders will be calibrated by measuring the water level in a single well with each sounder at the beginning of the monitoring event. No other sounders will be used for water level measurements in wells or at surface water stations without being calibrated to a previously calibrated sounder. Water level measurements will be recorded to the nearest 0.01 foot.

6.5 Surface Water Data Collection

Quality control procedures for measurements of water levels in stilling wells and from bridges are similar to those described in Section 6.4. At each station or bridge, three measurements of the water level will be taken and recorded in the field notebook. The average value of the three measurements will be used as the representative depth to water. The field notebook will also indicate the degree of water turbulence and wind and whether a weight was added to the sounder.

No field quality control procedures are necessary for visual readings of water levels from staff gages. However, unreadable gauges or other unusual conditions will be noted in the field notebook.

6.6 Seismic Reflection Profiles

Field record quality will be determined by visually monitoring each recorded shot before summing. Unsuitable records will be discarded and re-shot. Further field quality will be accomplished by printing raw field data recorded at the conclusion of a line or the conclusion of a working day. Unacceptable field records will be re-shot and integrated into their proper data processing sequence.

Eleven basic data processing sequences will be performed on raw field data. Each data processing sequence will be printed and examined for data quality.

6.7 Geochemical Evaluation

The analytical laboratory selected to analyze groundwater samples will be expected to employ standard QA/QC procedures in accordance with the Washington State Department of Ecology accreditation program. Ecology-accredited laboratories are expected to maintain internal QA/QC programs and must pass annual performance audits.

Section 7

Data Handling Procedures

Raw field data will be kept in retrievable form during and after field activities. Raw field data and other observations made during data collection activities will be recorded in ink in waterproof field notebooks, except for certain data that will be recorded on standard field forms or with automated recording equipment. Specific documentation and data handling procedures are discussed in the following sections.

7.1 Well Installation

As discussed in Section 6.1, field records will be maintained in the field notebook. Each page of the field notebook that contains new entries will be signed by the supervising geologist at the end of the day. In addition to the field notebook, specific field forms will be filled out for geologic logging (Attachment 1) and as-built well construction details (Attachment 2). These forms will be filed in the project notebook as they are completed, and copies will be filed in a separate location. Specific quality control procedures associated with the completion of these forms are discussed in Sections 6.1.3 and 6.1.4.

7.2 Horizontal and Vertical Surveys

Data handling protocols will depend upon the type of surveying method. Data handling will be supervised by a Licensed Surveyor or Professional Engineer.

7.3 Aquifer Testing

Manual water level measurements and airline readings will be recorded on field data forms. An example of these forms is shown in Attachment 3. Transducer installation will be recorded on field data forms as shown in Attachment 4.

Data retrieval will be performed by CH2M HILL staff experienced in the use of pressure transducers and data logging equipment. Data that is retrieved from the data loggers will be downloaded onto individual diskettes. These diskettes will be filed in a project notebook, and backup copies will also be maintained on a computer network in a database. Digital water level data will be incorporated into electronic spreadsheets that convert the data into elevations. Water level elevations will be reported to the nearest 0.01 foot.

7.4 Discrete Groundwater Level Observations

Water level measurements will be recorded with the date and time in field notebooks. For production wells, the field notebook will indicate whether the well was pumping at the time of the water level measurement and the discharge amount if obtainable. The water level measurements will be entered into a spreadsheet which will convert the measurements to water level elevations, reported to the nearest 0.01 foot. An example of a field data sheet for water level measurements is shown in Attachment 5.

7.5 Surface Water Data Collection

Water level measurements will be recorded with the date and time in field notebooks. Water level information will be converted to water level elevations using spreadsheets, as discussed in Section 7.4. Water levels will be reported to the nearest 0.01 foot at staff gauges and stilling wells. Water levels measured from bridges will be reported to the nearest 0.1 foot.

7.6 Seismic Reflection Profiles

Seismic reflection profiling activities will be recorded in a field notebook. The sub-contractor will furnish a geophysical activities report that includes the data and structural interpretations.

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Attachment 1

CH2MHILL

PROJECT NUMBER	WELL NUMBER

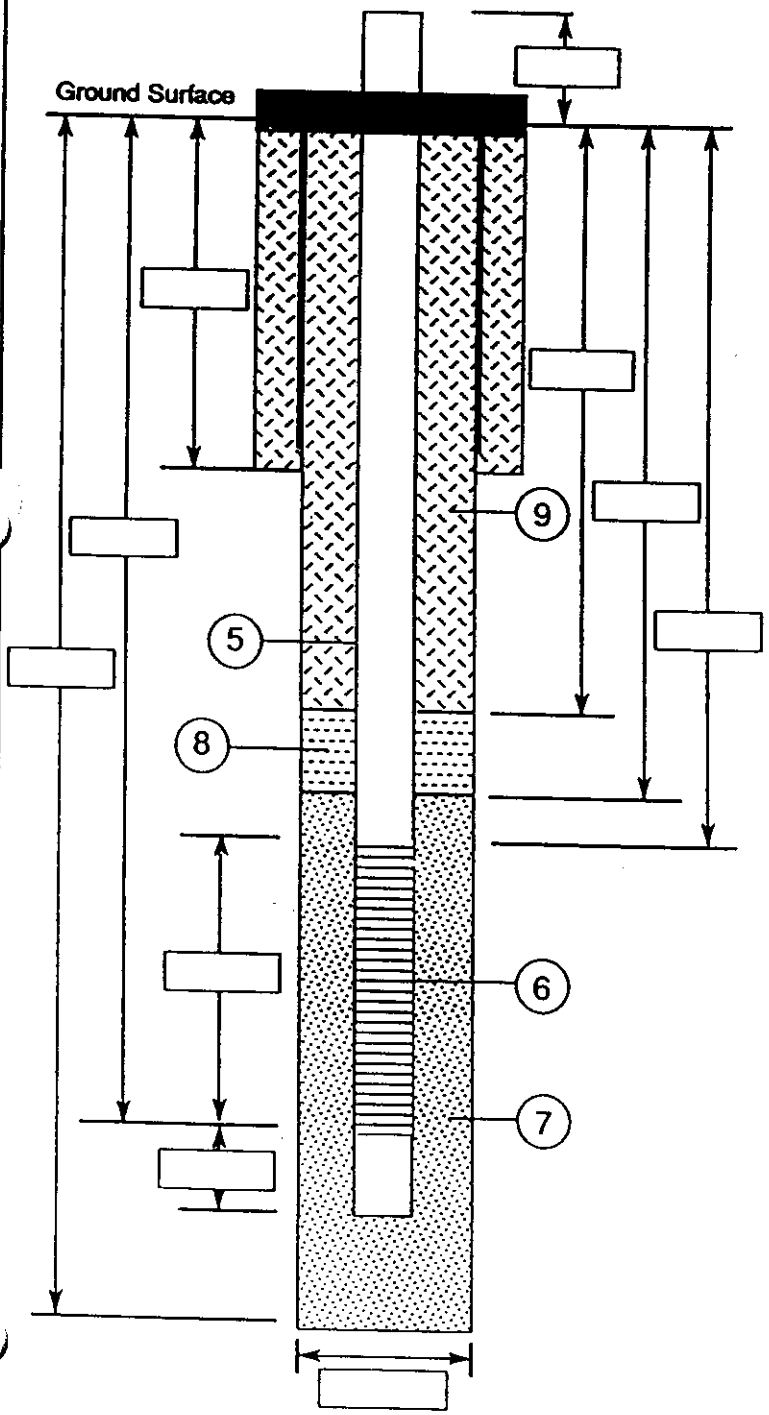
MONITORING WELL CONSTRUCTION DETAILS

PROJECT _____ LOCATION _____

DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

START _____ FINISH _____ LOGGER _____ WATER LEVEL AND DATE _____



1) Ground elevation at well _____

2) Top of casing elevation _____

3) Wellhead/protective cover description _____

_____

4) Diameter/type of surface casing(s) _____

a) Quantity(s) of surface casing grout used _____

5) Diameter/type of well casing _____

_____

6) Type/slot size of screen _____

_____

7) Type screen filter _____

a) Quantity used _____ size _____

8) Type of seal _____

a) Quantity used _____

9) Grout _____

a) Grout mix used _____

b) Method of grout placement _____

c) Quantity of well casing grout used _____

10) Development method (see reverse) _____

11) Development Time _____

12) Estimated volume of water purged _____

13) Comments:

Note: All measurements are from ground surface.

Attachment 2

CH2M HILL PUMPING TEST DATA

WELL ____________
PUMPING / OBSERVATION WELL
PUMPING / RECOVERY DATA
PAGE ____ OF ____

TYPE of PUMPING TEST ____________
HOW Q MEASURED ____________
HOW WL's MEASURED ____________
PUMPED WELL NO. ____________
RADIUS of PUMPED WELL ____________
DISTANCE from PUMPED WELL ____________

M.P. for WL's ____________ elev. ____________
DEPTH of PUMP/AIRLINE ____________ wrt ____________
% SUBMERGENCE : initial ____________ ; pumping ____________
PUMP ON : date ____________ time ____________
PUMP OFF : date ____________ time ____________

TIME t = ____ at t' = 0					WATER LEVEL DATA STATIC WATER LEVEL ____					WATER PRODUCT.		COMMENTS
CLOCK TIME	ELAPSED TIME mins / hrs	t	t'	t / t'	READING	CONVERSIONS or CORRECTIONS	WATER LEVEL	S or S'			Q	(NOTE ANY CHANGES IN OBSERVERS)

Attachment 3

DATA LOGGER/TRANSDUCER AQUIFER TEST FORM

PROJECT/PROJECT NO: ______________________

TYPE OF TEST: ______________________

NAME: ______________________

DATE: ______________________

WELL NUMBER: ______________________ Observation / Pumping

TYPE OF DATA: Background / Pumping / Recovery

DATA LOGGER SN: ______________________

TRANSDUCER: Serial No.: ________ Gauge Factor ________

Range: ________ Temp. Factor ________

Offset: ________ Channel No. ________

DEPTH TO WATER: (ft. bmp)

Before inst. ________ (Time: ___:___:___)

After inst. ________ (Time: ___:___:___)

Zero Reading ________ (Time: ___:___:___)

Water Level ________ (Time: ___:___:___)

DATA SET RETRIEVAL AND FILING INFORMATION:

	DATE	TIME
Recording Started	__/__/__	__:__:__
Recording Stopped	__/__/__	__:__:__

File Name: ______________________

MANUAL BACKUP MEASUREMENTS

TIME	W.L.	TIME	W.L.	TIME	W.L.
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	
__:__:__		__:__:__		__:__:__	

Attachment 4

SPOKANE AQUIFER JOINT BOARD WELLHEAD PROTECTION PROGRAM

CH2M HILL Engineers

Well #: _____

Land Owner

Physical Address: _____

_____

_____

Phone # : _____

Contact Name: _____

Northing: _____

Easting: _____

Reference Elevation: _____

Date of Survey: _____

Fall '96 Date/Depth: _____

Fall '96 Elevation: _____

Nearby Wells Operating: Y N

How Far/What Direction:

¼ mi. .5 mi. .75 mi. 1 mi. N S E W

Location Map

Comments:

Attachment 5

April 28, 1997

136236.DC.10

Nancy Weller
Project Manager for Water Quality Programs
Dept. of Ecology
4601 N. Monroe, Suite 202
Spokane, WA 99205-1295

Dear Ms. Weller:

Subject: Robert Garrigues review of Spokane Aquifer Joint Board QA/QC Plan

This letter will address Robert Garrigues' review comments specifically regarding the water quality sampling component of the QA/QC Plan prepared for the Spokane Joint Aquifer Board wellhead protection program. We are only commenting on the water quality comments of Mr. Garrigues, as these were the only addressable comments needed.

When the QA/QC plan was written in 1996, groundwater sampling and analysis procedures were rather generalized and vague. They were written in this manner because at the time of writing, specific water quality sampling locations were not yet selected and an analytical suite was not completely identified.

After further review and discussions with other groups in the Spokane region, we have found the data will be collected by others. The Spokane County Water Quality Management Program (WQMP) office has decided to perform this sampling activity as a part of an ongoing water quality study for the shallow aquifer in the same vicinity. As such, CH2M Hill can obtain the data from WQMP and does not need to duplicate the groundwater sampling identified in the plan. Therefore comments with regard to water quality sampling are not being revised at this time for the submitted QA/QC plan.

Spokane Office
9 South Washington, Suite 400
Spokane, WA 99204-0219
509 747-2000
Fax No. 509 623-1622

136236.DC.10

In the event that the County does not complete the deep aquifer groundwater sampling as anticipated, CH2M Hill will proceed with the sampling. At that time, we will prepare a revised sampling and analytical procedures and present them for your review. If we do conduct the sampling, the following are some general procedures that will be followed:

- Groundwater samples will be collected from existing domestic wells and observation wells. For the domestic wells, water samples will be collected at the nearest tap to the pump prior to any water treatment or storage. For observation wells, water samples will be collected using bailers or portable submersible pumps only after an appropriate volume of water has been removed.
- Samples will be analyzed for inorganic parameters including: calcium, magnesium, potassium, sodium, manganese, iron, bicarbonate, chloride, TDS, nitrate, conductivity, sulfate, and pH.
- Analysis will be conducted by an Ecology-accredited laboratory using standard analytical procedures. The selected laboratory will supply appropriate sample containers for sample collection with respect to the specific analytical requirements.

As the water quality sampling procedures were the only item to address in Mr. Garrigues comments, we assume that this letter will suffice as amendment to the QA/QC plan. We further assume that with these comments, Ecology will return a signed copy of the QA/QC plan to us.

Should you have any additional comments or questions, please feel free to contact either Brad Phelps or myself at 509.747.2000.

Sincerely,

CH2M HILL

Mark Henry
Hydrogeologist

SPK/DOCUMENT3

RECEIVED
JAN 1 3 1997

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N. Monroe, Suite 202 • Spokane, Washington 99205-1295 • (509) 456-2926

January 10, 1997

Mr. Brad Phelps
CH2M Hill
9 South Washington, #400
Spokane, WA 99204

Dear Mr. Phelps:

RE: QA/QC Plan
Spokane Aquifer Joint Board Wellhead Protection Program
Grant No. G9600216

Enclosed is a copy of the evaluation comments provided by Robert Garrigues on the referenced QA/QC plan. If you have any questions, or need to discuss the comments, please contact Mr. Garrigues directly. His phone number is (360) 407-6638. It would be good for you to discuss any revisions with him so that your next draft can be the final one which he can sign.

Please send your revised Plan to me. Although I do not review it, I do need to keep track of the process for the grant records.

If you have any questions for me, give me a call at 625-5194.

Sincerely,

Nancy Weller

Nancy Weller
Project Manager
Water Quality Program

Enclosure
NCW:chl

Weller, Nancy C.

From:	Garrigues, Robert S.
To:	Weller, Nancy C.
Cc:	Nuechterlein, Carl; Goldstein, Larry; Kendra, William
Subject:	Review of Water Quality Monitoring Plan for the Spokane Aquifer Joint Board Wellhead Protection Program
Date:	Tuesday, December 03, 1996 4:17PM

I was asked to do a technical review of the subject QA/QC plan this morning.

The brief project schedule on page 1-2 indicates that most components of the project are supposed to be completed by October 1996. Obviously it would be pointless to do a technical review of the QA/QC plan if the subject project is finished.

With this in mind, I called Brad Phelps at CH2M HILL this afternoon to ask about the status of the project. He confirmed that the project was indeed on time as per the stated schedule and that most components were completed as of some time in November 1996.

The Aquifer test component of the project is the only one that has not yet been done. The aquifer tests are scheduled for the spring of 1997. Since the aquifer tests have not been done, I reviewed the aquifer test procedures and QA/QC description. Although the description is not as detailed as I would like to see, the procedures look reasonable and seem to conform to accepted aquifer test practices.

According to Brad Phelps, the ground-water sampling component of the project has to be reevaluated because the city of Spokane already collected samples in the vicinity. CH2M HILL needs to see the results from those samples before deciding whether to do any new sampling. Given this, I cannot do a meaningful review of the ground-water sampling component of the project. I should point out though, that the sampling-procedure description given in the QA/QC plan is too general. The description needs more detail about specifics such as: sampling site locations relative to holding tanks or water-treatment systems; the types of analyses intended (are the metals dissolved or total?); preservation methods, if any; sample holding times; the name of the lab to be used; detailed description of "an appropriate sampling device"; and types of sample bottles to be used for each analyte.

I am returning the paper copy of the plan you you via campus mail.

CH2M HILL TRANSMITTAL

TO: Department of Ecology
4601 North Monroe
Spokane , WA 99205

FROM: Sharon O'Shaughnessy, SPK
CH2M HILL
CH2M HILL

ATTN: Nancy Weller

DATE: November 13, 1996

RE: QA/QC Plan for Field Data Collection for the SAJB

PROJECT NUMBER: 136236.DEZZ

WE ARE SENDING YOU:

♦ ATTACHED	UNDER SEPARATE COVER VIA	
SHOP DRAWINGS	♦ DOCUMENTS	TRACINGS
PRINTS	SPECIFICATIONS	CATALOGS
COPY OF LETTER	OTHER:	

QUANTITY	DESCRIPTION
1	Original of the "Field Data Collection Plan - Quality assurance/quality control Plan" for the Spokane Aquifer Joint Board Wellhead Protection Program

IF MATERIAL RECEIVED IS NOT AS LISTED, PLEASE NOTIFY US AT ONCE

REMARKS:

After approval, please sign, and return to:

Brad Phelps
CH2M HILL
9 South Washington, #400
Spokane, WA 99204

If you have any questions, please contact Brad Phelps at: (509) 747-2000, extension 218.

COPY TO:

CH2M HILL
CH2M HILL

Voice: (509) 747-2000 x 215 **FAX: (509) 623-1622**