Spokane Valley – Rathdrum Prairie Hydrologic Study

Proposed Project Scope

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I. EXECUTIVE SUMMARY

The Spokane Valley - Rathdrum Prairie (SVRP) aquifer represents the sole source of drinking water for over 400,000 residents in Spokane County, Washington, and Kootenai County, Idaho. The area includes the rapidly growing cities of Spokane, Spokane Valley, and Liberty Lake, Washington, and Coeur d'Alene and Post Falls, Idaho. Recent and projected urban, suburban, and industrial/commercial growth has raised concerns about potential future impacts on water availability and water quality in the SVRP aquifer and Spokane and Little Spokane Rivers. Water resource concerns include growing demands on ground water and declining ground water levels, low stream flow in reaches of the Spokane and Little Spokane Rivers, and water quality problems associated with changing land use activities. Management of the SVRP aquifer is complicated by the interstate, multi-jurisdictional nature of the aquifer. The states of Washington and Idaho have primary responsibility for water allocation and water quality. However, local governments are increasingly being called upon to consider water supply and quality implications in land-use planning. Water resource demands are increasing at a time when aquifer and river dynamics are not well understood. This understanding is essential in making proper management decisions concerning current and future ground water and surface water appropriations in the SVRP area.

The purpose of this study is to gain a better understanding of ground water and surface water resources in the SVRP area. This study will provide an improved scientific basis for evaluating water management alternatives for the SVRP aquifer and Spokane and Little Spokane Rivers. This study will provide the means for estimating the effects of additional ground water and surface water withdrawals on the SVRP aquifer and Spokane and Little Spokane Rivers, as well as simulating potential effects of climate change on water resources in the area. This study also will establish a network of dedicated monitoring wells for long-term collection of ground-water level and water-quality measurements, and will develop a common regional database for analyzing current and future ground water and surface water questions.

The study will include tasks to:

- Quantify the rates, locations, and mechanisms of aquifer recharge, and aquifer discharge to rivers and lakes;
- Quantify the rates and locations of aquifer withdrawals and surface water diversions;

- Use water chemistry to help identify sources of aquifer recharge and discharge, the direction of ground-water flow, and ground-water/surface-water interactions;
- Construct numerical ground-water and surface-water flow models to analyze aquifer characteristics and simulate changes in ground water levels and streamflows in response to simulated stresses;
- Develop a regional spatial database of geologic, land use, and hydrologic information; and
- Convey project results to federal, state and local decision-makers, the professional community, and the general public.

Several other studies of the SVRP aquifer and Spokane River system are currently underway. These studies are supported by a variety of federal, state, local, and private funds. Data collection for the SVRP aquifer study will be coordinated with the principal investigators of these studies to ensure that all available aquifer-related data are collected and synthesized into the SVRP aquifer study database and to eliminate the duplication of efforts.

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II. INTRODUCTION

The Spokane Valley - Rathdrum Prairie (SVRP) aquifer is the sole source of drinking water for over 400,000 residents in Spokane County, Washington, and Kootenai County, Idaho (Figure 1, located at back of document). The area includes the rapidly growing cities of Spokane, Spokane Valley, and Liberty Lake, Washington, and Coeur d'Alene and Post Falls, Idaho. Recent and projected urban, suburban, and industrial/commercial growth has raised concerns about potential future impacts on water availability and water quality in the SVRP aquifer, and Spokane and Little Spokane Rivers. Water resource concerns include growing demands on ground water and declining ground water levels, low stream flow in reaches of the Spokane and Little Spokane Rivers, and water quality problems associated with changing land use activities. Water resource demands are increasing at a time when aquifer and river dynamics are not well understood. This understanding is essential in making proper management decisions concerning ground water and surface water appropriations in the SVRP area.

Management of the SVRP aquifer is complicated by the interstate, multi-jurisdictional nature of the aquifer. The states of Washington and Idaho have primary responsibility for water allocation and water quality. However, local governments are increasingly being called upon to consider water supply and quality implications in land use planning. Aquifer management is also complicated by the interconnection between ground water and surface water: ground water exchanges with surface channels may influence surface channel flow rates and surface water quality.

The SVRP aquifer consists primarily of thick layers of coarse-grained sediments – gravels, cobbles, and boulders – deposited during a series of outburst floods resulting from repeated collapse of the ice dam that impounded ancient glacial Lake Missoula (Bretz, 1930). Sources of recharge to the aquifer include infiltration from precipitation, return flow from water applied at land surface, leakage from the Spokane and Little Spokane Rivers and adjacent lakes, and surface water and ground water inflow from tributary basins. The aquifer discharges into the Spokane and Little Spokane Rivers and Lake Spokane. Discharge from the aquifer also occurs through withdrawals from wells. The aquifer was designated a "Sole Source Aquifer" by the Environmental Protection Agency in 1978 (under the provisions of the Federal Safe Drinking Water Act of 1974) in response to local concerns about aquifer vulnerability to water quality degradation.

Coeur d'Alene Lake discharges into the Spokane River in Idaho. The lake is regulated at Post Falls Dam for hydroelectric power production, flood control, and irrigation. Surface water inflow from the 3,840 square mile drainage area to the lake is from the Coeur d'Alene, St. Joe, and St. Maries Rivers and numerous minor tributaries. The average annual flow in the Spokane River at Post Falls dam is 6,225 cubic feet per second. However in late summer the flow in the river is very low. Discharge from the aquifer to the Spokane River in Washington is an important source of flow during the late summer; ground water lies below the river bed in Idaho, and does not contribute to streamflow. Flow in the Spokane River is regulated during the summer at Post Falls dam to maintain the level of Coeur d'Alene Lake for recreational activities.

Numerous studies have been conducted on the SVRP aquifer by the U.S. Geological Survey, Spokane County, Idaho Department of Environmental Quality, CH2M Hill, Golder Associates, Eastern Washington University, University of Idaho, and others (Painter, 2000). These studies have included several modeling efforts, including one reconnaissance-level ground water model of the entire aquifer (Buchanan, 1999). These studies also form the basis for the more comprehensive, regional water resource evaluation needed for multi-jurisdictional water management of the SVRP aquifer.

In addition to completed studies, several studies of the SVRP aquifer and Spokane River system are currently underway. Thse studies are supported by a variety of federal, state, local, and private funds. Data collection for the SVRP aquifer study will be coordinated with the principal investigators of these studies to ensure that all available aquifer-related data are collected and synthesized into the SVRP aquifer study database and to eliminate the duplication of efforts. Some of the current studies related to the SVRP aquifer and Spokane River include:

- *Watershed Planning—*
  Watershed assessment and planning studies for the Little, Lower, and Middle Spokane River watersheds (WRIAs 55 & 57, respectively) and Latah (Hangman) Creek (WRIA 56) are underway. These studies include assessments of the quantity of ground water and surface water in the watersheds, establishment of minimum in-stream flows for rivers and streams, and development of plans to manage impacts of future water withdrawals from the watersheds while protecting minimum in-stream flows. The state of Washington has already spent more than $900,000 on the assessment phase of the studies, and will probably spend an additional $1,500,000 to develop the plans.
- *Ground Water Management—*
  IDWR has created the Rathdrum Prairie Ground Water Management Area (GWMA) and a Ground Water Management Area Advisory Committee to ensure that an adequate water supply for irrigation and other uses will be met. Within a GWMA, applications for new water appropriations may be approved only after it

is determined that a sufficient water supply is available and other prior water rights will not be injured. The Committe will provide guidance in the preparation of a management plan for the GWMA. The plan will describe how to manage water resource issues.

- *Geologic Mapping—*
  The Washington Division of Geology and Earth Resources, in cooperation with the U.S. Geological Survey, is currently mapping the geology of the Spokane area. More than $250,000 has been spent by the two agencies to map a series of 1:24,000-scale quadrangles that straddle the SVRP aquifer in Washington State.

- *Spokane River Hydroelectric Project Relicensing—*
  Avista Corporation is leading a collaborative effort to relicense their Spokane River Hydroelectric Project in accordance with regulations promulgated by the Federal Energy Regulatory Commission. The “new” license will contain terms and conditions for the operation of five hydroelectric developments (dams & power-generating facilities) located along the Spokane River. Numerous agencies in the states of Washington and Idaho have been actively involved in the relicensing process for the past year, and will continue to play active roles in the collaborative relicensing process until it is completed in 2007.

- *Assessment of Impact of Hydropower Dams—*
  The Northwest Power and Conservation Council recently formed the Spokane Subbasin Work Team to conduct subbasin planning as part of the council’s program to evaluate alternatives to mitigate the impact of hydropower dams on fish and wildlife in the Columbia River basin. The work team will spend up to $100,000 during the next year to access impacts and evaluate habitat needs and enhancement opportunities in the Spokane River watershed.

- *Water Quality Cleanup Plans—*
  The Spokane River is listed as “impaired” for a number of pollutants. The Washington Department of Ecology has prepared, or is in the process of preparing, cleanup plans or total maximum daily load (TMDL) reports for each of the following parameters: biological oxygen demand, temperature, phosphorus, dissolved metals, PCBs, total dissolved gas, and dissolved oxygen. These studies include assessments of the loading capacity of pollutants in Lake Spokane and the Spokane River system, which has a long history of water quality problems.

- *Critical Aquifer Recharge Area Model (CARA)—*
  Kootenai County Planning and Zoning, Idaho Department of Environmental Quality and Panhandle Health District have provided funding to develop a computer model for use in select recharge areas that are currently facing development pressures. The model is intended for use by area planners to

guide the course of development in those areas to minimize the impact on the SVRP aquifer. More than $52,000 has been spent by the three agencies on CARA activities.

- *National Water Quality Assessment Program (NAWQA)*—
  The Northern Rockies Intermontane Basins (NROK) is one of several areas being studied as part of the NAWQA program conducted by the USGS. The NROK study includes efforts to characterize the water quality of the Spokane River and portions of the hydraulically-connected SVRP aquifer. One important aspect of the NROK study is to examine the occurrence and distribution of trace element and synthetic organic compounds in streambed sediments of the Coeur d'Alene and Spokane Rivers.

- *Geospatial Data Base Development – The National Map*—
  The USGS is currently implementing a National Map in the SVRP area. The National Map is a seamless, continuously maintained, and nationally consistent set of online, public domain, geographic base information that includes high-resolution surface elevation data, digital ortho-rectified imagery, land characterization data, hydrography, and other resource related data coverages. The National Map web-based map service can provide a consistent long-term website to maintain science data collected in the SVRP study area. The USGS has coordinated data sharing partnerships with local data providers to aquire and integrate best available geospatial data for the Spokane-Coeur d'Alene area. The USGS has spent about $700,000 in implementing the National Map in this area.

- *Coeur d'Alene River Basin Cleanup Plan*—
  Much of the metals mining wastes historically disposed in the Coeur d'Alene basin in northern Idaho have migrated through the basin into Coeur d'Alene Lake. Some of the mining wastes have moved through the lake basin into the Spokane River, and have been deposited as far west as Lake Roosevelt. The U.S. Environmental Protection Agency is working in consultation with the states of Idaho and Washington to complete and implement a plan that contains strategies for the cleanup of mining wastes in the Coeur d'Alene and Spokane River systems.

Water management issues have increasingly become regional in nature. Several groups, therefore, have proposed a comprehensive, regional study of the SVRP aquifer to serve as a scientific basis for addressing regional water concerns. Water resouce management questions include, but are not limited to, the following:

1. How much unappropriated water is available in the SVRP aquifer under various regulatory and/or legal constraints?
2. What would be the impacts of currently-proposed withdrawals from the SVRP aquifer (i.e., what would be the impact of current applications for ground water withdrawals if they were to be permitted)? Where and when would these impacts occur?
3. How can impacts from ground-water withdrawals be mitigated?
4. How does ground water pumping impact the Spokane and Little Spokane Rivers?
5. What would be the impacts on the aquifer and rivers associated with future growth scenarios?
6. How can late-summer low flows in the Spokane River be mitigated?
7. Can surface water recharge in Idaho be enhanced to benefit ground-water and surface-water users?
8. What would be the water quality impacts associated with urbanization on water resources in the SVRP area?

Specific information that would help address some of the management questions listed above, include the following:

1. The rates, locations, and mechanisms of recharge to the SVRP aquifer.
2. Current amount of water being withdrawn from the aquifer and the spatial and temporal distribution of the withdrawals.
3. The rates, locations, and temporal aspects of ground-water and surface-water exchange.
4. The effects of ground-water withdrawals and dam operation on streamflows.
5. Spatial and temporal distribution of surface-water withdrawals.
6. Chemical characteristics of surface water and ground water.

This document presents a proposed project scope for a regional study of the SVRP aquifer, and was developed by the Washington Department of Ecology (WDOE), the Idaho Department of Water Resources (IDWR), and the U.S. Geological Survey (USGS) in consultation with local stakeholders. This document will form the basis for development of a more comprehensive work plan by WDOE, IDWR, and the USGS in continued consultation with local stakeholders. This proposed project scope describes the specific tasks and methods to be used to accomplish the project objectives. Each task will be further developed in a detailed project work plan.

III. PURPOSE AND OBJECTIVES

The purpose of this study is to gain a better understanding of surface water and ground water resources in the SVRP study area. The principle study objective is the development of a comprehensive data set to provide an improved scientific basis for water management of the SVRP aquifer. The study will include the construction of numerical ground-water and surface-water flow models to support the conjunctive management of both ground and surface water in the SVRP area.

The results of this study will provide tools for the evaluation of alternate water resource management scenarios. However, the determination of these scenarios and application of the ground-water and surface-water models will not be conducted as part of this study. Application of the numerical models to water resource management scenarios will occur as a cooperative effort by Washington and Idaho water resource managers.

Specific study objectives include the following:

1. Quantify the rates, locations, and mechanisms of recharge to the SVRP aquifer from precipitation, return flow from water applied at land surface and sewers and septic systems, leakage from adjacent lakes and the Spokane and Little Spokane Rivers, and surface water and ground-water inflow from tributary basins and adjacent uplands.

2. Quantify the rates and spatial and temporal distribution of ground-water withdrawals and surface-water diversions for municipal, commercial, industrial, rural domestic, and irrigation purposes.

3. Quantify current rates (and spatial and temporal distribution) of ground-water/surface-water exchange, and delineate gaining and losing reaches for the Spokane and Little Spokane Rivers.

4. Develop a comprehensive water budget for the SVRP aquifer and document temporal variations in budget components.

5. Quantify the spatial and temporal variation in Spokane and Little Spokane River flow and quantify the timing and frequency of low flows and high flows. Determine long-term trends for streamflow.

6. Identify sources of aquifer recharge and discharge, the direction of ground water flow, and ground-water/surface-water interactions using water chemistry.
7. Develop an independent, spatially-oriented database of geologic, hydrologic, land use, and other data sets to include information on aquifer recharge and discharge, aquifer hydraulic properties, ground-water levels, streamflow, lake levels, and water chemistry.
8. Construct a numerical ground-water model representing the current understanding of aquifer flow characteristics. Calibrate the model to steady-state and transient hydraulic conditions on the basis of current and historical data using automated parameter estimation methods that enable quantification of parameter uncertainty. The model will be used to simulate changes in ground water levels and streamflows to projected increases in regional aquifer withdrawals. Use of parameter estimation methods will allow for the evaluation of uncertainty and sensitivity associated with model simulations.
9. Construct a numerical surface-water model to simulate flows in the Spokane and Little Spokane Rivers. The model will include Coeur d'Alene Lake and the operation of Post Falls Dam. The ground-water and surface-water models will be integrated to illustrate ground-water/surface-water interactions.
10. Convey information about regional water resources and knowledge gained from the study to federal, state and local decision-makers, the professional community, and the general public.

This project will be different from current or previous studies because of the comprehensive, integrated, regional approach in providing a scientific foundation for management of the multi-jurisdictional aquifer system.

IV. PROJECT OUTLINE

This section provides a description of tasks needed to meet project objectives. Specific methods to be used are described where possible. The selection of appropriate methods, and method development and refinement will continue during the project. After funding for the project is acquired, the management team, advisory committee members, and project participants will develop a detailed project workplan. (See Section V for the organizational structure of the project).

A. Develop Project Workplan

A detailed project workplan will be developed to outline specific tasks, responsibilities, timelines, and budgets for all project activities. The workplan will be developed by the project management team, advisory committee members, and project participants. Elements of the workplan may be refined during the project in response to new information.

B. Develop Hydrologic Database

This task includes the development of a spatially-oriented database of existing geology, land use, and hydrology for the SVRP aquifer area. The purpose of the database is to (1) identify, check, and integrate existing data from multiple agencies, and (2) provide a framework for storing and integrating new data. Using a combination of Geographic Information System (GIS) and data management software, the database will support a variety of uses inside and outside of this project. Selected hydrologic information from the SVRP aquifer study area also will be stored in the USGS NWIS database. The USGS National Map will be considered for use as the principal geospatial database for the SVRP study. Water use data will be stored in a site-specific database (SWUDS) currently under development by the USGS.

The database will be populated with existing data and continually updated with new data as they become available. All data will be checked for accuracy. The database will include the following spatial and time series data:

1. Land surface information, including topography (possible use of high-resolution elevation (LIDAR) data), political boundaries, major highways, water purveyor boundaries, and soil information;
2. Land use information, such as locations of urban boundaries, rural subdivision boundaries, impermeable areas, drainage and sewer district boundaries, locations of irrigated lands, and water use information;
3. Hydrologic and geologic information, including hydrography, precipitation and selected meteorological data, well location and construction, surficial and bedrock geology, ground-water elevations, stream discharge and stage, geophysical surveys, water budget components, and aquifer characteristics; and
4. Ground water and surface water chemistry data.

A project website will be created to provide information about SVRP hydrology, a project description, periodic project updates, and a directory of data available through the project. The website may house some data, and provide links to various agency sources for other data.

C. Ground and Surface Water Monitoring

The goal of this task is to measure the spatial and temporal distribution of ground-water levels, lake levels, and stream flow. These measurements will be used to calibrate the numerical ground-water model for steady state and transient conditions. Existing data will be analyzed, and additional data will be collected where it is needed.

Spatial and temporal ground-water level information is critical to understanding aquifer ground-water flow and the exchange of ground water and surface water. This task consists of (1) establishing an inventory of a subset of existing wells in the study area, (2) conducting synoptic ground-water level measurements in a subset of wells throughout the study area, (3) conducting periodic ground-water level measurements in selected wells, (4) installing new, dedicated monitoring wells, and (5) instrumenting selected wells with continuous water-level recorders and data loggers. Data collection stations may be equipped with remote telemetry devices (modems) to allow for cost effective data retrieval and real-time monitoring. Data collection installations will be structured to allow for continuing, long-term monitoring.

An inventory of wells in the study area will be conducted to identify available ground-water monitoring wells in the study area and to obtain owner permission for access to wells, and to determine the locations of wells withdrawing ground water from the aquifer. Wells incorporated into the ground water level monitoring network will be surveyed or tied into a consistent coordinate system.

Synoptic ground-water level measurements will consist of measuring ground water levels in as many wells as possible throughout the entire extent of the aquifer over a short period of time. At least two synoptic measurements will be made to capture seasonal high and low ground water levels in the aquifer. Additional water-level measurements may be made to determine the magnitude of any long term change in water storage in the aquifer. Potentiometric surface maps will be constructed from water-level measurements to determine aquifer ground-water gradients, flow directions, and seasonal changes in water levels. Data from these measurements will form the basis for aquifer simulations under steady-state conditions using the time-averaged approach. Monthly ground-water level measurements will be conducted in selected wells to define seasonal ground water-level changes, define ground-water inflow from tributary basins and adjacent lakes, and to define stream-aquifer interactions with the Spokane River and lower reach of the Little Spokane River. The USGS currently operates four continuous water-level recorder wells in the study area. Additional wells may be instrumented with continuous water level recorders. Periodic and continuous water level measurements will be used to calibrate the model for transient conditions. Several ground water monitoring wells will be constructed as part of this project. The purpose of the wells is to (1) better define aquifer characteristics, (2) enable ground water level measurements in wells not effected by pumping, and to (3) measure ground water levels in areas where no wells exist.

Stream discharge and stage measurements will help provide a basis for defining gaining and losing reaches of the Spokane and Little Spokane Rivers, and estimating the quantities of water exchanged between rivers and the aquifer. Lake-level measurements will be used to estimate quantities of water exchanged between lakes and the aquifer. The USGS currently operates seven streamgages and three lake-level monitors in the study area. Additional streamgages and lake-level monitors may be established as part of this study. Stream flow will be measured over a range of flow rates to quantify seasonal variations in flow. If existing records are insufficient, seepage studies will be conducted during various times of the year to identify gaining and losing reaches and determine ground water/ surface water interaction. The seepage studies will also be used to locate additional stream gaging stations if necessary. Stream transects may be conducted on select reaches of the Spokane and Little Spokane Rivers to establish cross-sectional stream channel profiles. Where possible, historic streamflow trends will be calculated using existing USGS records. Streammflow statistics analyzed for trends will include annual flow, the base-flow index (BFI), and peak flows (annual and monthly). Flows will be adjusted for diversions and dam operations. These trends may be used for calibration of the transient flow model. The USGS NAWQA NROK study delineated major gaining and losing reaches of the Spokane River and identified effects of ground-water recharge from an 18-mile reach of the river on aquifer water chemistry. These data can be used to quantify exchange of ground and surface water. Additional samples of ground water and surface water may be collected and analyzed for selected water chemistry parameters to help identify and quantify ground-water/surface- water interactions in other parts of the study area.

D. Water Budget

A comprehensive water budget will be developed to identify the amount of water entering and leaving the SVRP aquifer from all sources. A water budget is important from a regional water management perspective because it provides an estimate of the balance between total aquifer withdrawals and aquifer recharge and discharge. This information is key to estimating the amount of water that may be available for additional appropriation.

Sources of recharge to the SVRP aquifer include infiltration from precipitation, return flow from water applied at land surface, leakage from sewers and septic systems, leakage from adjacent lakes (Lake Coeur d'Alene, Lake Pend Oreille, Spirit Lake, Twin Lake, Hayden Lake, Hauser Lake, Newman Lake, and Liberty Lake) and the Spokane and Little Spokane Rivers, and surface water and ground water inflow from tributary basins and adjacent uplands. Improving current estimates of recharge from these sources is an important component of this study, and will result in increased accuracy of model results. Ground-water discharge from the SVRP aquifer occurs through withdrawals from wells, and as baseflow to the Spokane and Little Spokane Rivers. Water in the vadose zone may be lost to evapotranspiration.

This task includes (1) development of individual water balances for lakes above and adjacent to the aquifer, (2) delineating gaining and losing reaches of the Spokane and Little Spokane Rivers, and quantifying the seasonal exchange of ground water and surface water based on stream discharge measurements, (3) estimating surface recharge using the Deep Percolation Model (Bauer and Vaccaro, 1987) and data from the study area (evapotranspiration measurements, known crop types, soil properties, land use, precipitation, ground water levels, and estimates of irrigation, septic system, and other return flows) (4) estimating surface losses of water based on evapotranspiration measurements, and (5) improving understanding of aquifer geometry in peripheral basins and monitoring ground-water levels in these basins and in the main aquifer to estimate inflow to the main aquifer. Water chemistry (isotope, common ion, etc.) may be used in some areas to help quantify recharge rates to the aquifer.

Additional meteorological measurements also may be needed for characterizing the spatial distribution of precipitation. The installation of meteorological stations throughout the study area to record the temporal and spatial distribution of air temperature and precipitation will be considered to supplement existing stations. Data collection stations may be equipped with remote telemetry devices (modems) to allow for cost effective data retrieval and real-time monitoring. Data collection installations will be structured to allow for continuing, long-term monitoring. Historic water use data (ground-water withdrawals and surface-water diversions) have been compiled for the Washington portion of the SVRP aquifer (Golder and Associates, 2001); these data will be updated to reflect current usage. Similar data will be collected for the Idaho portion of the SVRP aquifer. Estimates for municipal, rural domestic, commercial/industrial, and agricultural irrigation withdrawals will be made on the basis of ground-water pumping (where available), population census, and land use data, water rights information, and industry standards.

E. Hydrogeologic Characterization

The goal of hydrogeologic characterization is to describe the geologic and hydrologic conditions that control ground water flow in the SVRP aquifer in order to develop a ground-water model. The purpose of this task is to define the areal extent, thickness, and lithologic composition of the SVRP aquifer, characterize aquifer boundary conditions, and document the spatial distribution of aquifer hydraulic properties. An improved understanding of the physical dimensions, composition, and hydraulic properties of the aquifer system will result in increased accuracy of numerical model results. Previous investigations have focused on characterization of the Spokane Valley part of the aquifer system, and considerable information needs to be collected in the area of the Rathdrum Prairie in order to adequately characterize the entire SVRP aquifer.

Characterization methods will include (1) collecting, reviewing, and evaluating existing geologic maps, geologic cross-sections, seismic data, and well logs; (2) conducting additional seismic (refraction/reflection) and electrical resistivity surveys; (3) installation of monitoring wells and the collection of ground water level data; (4) geophysical logging of new and existing wells; and (5) determination of aquifer hydraulic properties (hydraulic conductivity, transmissivity, and storativity) using existing aquifer test and specific capacity data, and documenting the relation between the spatial distribution (lateral and vertical) of aquifer properties and aquifer lithologies. Additional hydraulic property data collection may be considered in previously uninvestigated areas of the aquifer.

The characterization data will be used to interpret the lateral and vertical distribution of lithologic units within the SVRP aquifer and the distribution, character, and morphology of geologic units beneath and adjacent to the aquifer. The evaluation of this data can be used to determine aquifer boundaries, location of confining units, type of aquifer (confined or unconfined), faults, and other features that affect ground water movement.

Surface geophysical surveys will include a combination of seismic reflection and seismic refraction. Seismic refraction will be used to define the overall depth to bedrock over the aerial extent of the aquifer. Seismic refraction profiles will be created at intervals across the major axis of the aquifer. Seismic reflection will be used to delineate variations in aquifer lithology. Test bore holes will be located along geophysical surveys to aid in the interpretation of the surveys. Some boreholes will be completed for long-term water-level monitoring and water sampling of multiple aquifer layers. Soil and rock samples from test boreholes will be evaluated in the laboratory for hydraulic properties (permeability, porosity, grain-size distribution, etc.).

Existing wells will be used in aquifer test when possible, and additional monitoring wells will be constructed where necessary. It may be difficult to successfully conduct aquifer tests in many wells because of the high withdrawal rates required to impact water levels in the highly transmissive aquifer. Specific-capacity data from municipal supply wells also will be used to estimate aquifer properties. It also may be possible to obtain large-scale estimates of aquifer properties through the analysis of ground-water-level fluctuations caused by changes in nearby surface-water levels. Additional monitoring of ground-water levels and river/lake levels will be done with this objective in mind.

F. Ground-Water Model

A numerical ground-water-flow model will be developed as part of this study to simulate ground- water movement in the SVRP aquifer and the interaction of ground water and surface water. Software selection will depend on specific model uses. Water resources managers may use the model to (1) interpret SVRP aquifer water budget data; (2) estimate aquifer parameter values; (3) evaluate potential SVRP aquifer water management options such as increasing aquifer system withdrawals; (4) evaluate alternatives for mitigating future ground-water or surface-water withdrawals; and (5) estimate the regional impacts of contaminant releases on water quality..

The model will be used to help interpret aquifer recharge and discharge estimates. Recharge and underflow are expected to be highly correlated with horizontal hydraulic conductivity. A ground-water model, in conjunction with parameter estimation software, will enable quantification of the correlation between these parameters, and will provide a basis for quantifying the significance of improved aquifer inflow/outflow estimates.

Spokane River streamflow is the most complete, detailed, and longest hydrologic record in the study area and will be used for model calibration. Other water budget components (recharge and discharge), ground-water levels, and measured aquifer parameter values also will be used to calibrate aquifer parameter values for the ground-water flow model. Because of potential correlation among parameters, it will be important to quantify the uncertainty associated with the model predictions using measured parameter values.

Model construction will take place incrementally and in a parallel effort to data collection and water budget development. The initial calibration would be done using information from available reports. The uncertainty estimate for the initial calibration will form the basis for collecting additional data and measuring improvements to the model calibration. Subsequent model calibrations will use previously published and newly collected information. Synoptic ground-water level measurements will be used to calibrate the model under steady-state conditions using the time averaged approach. Periodic and continuous ground-water level measurements and historic streamflow records will be used to calibrate the model under transient conditions. Transient model calibration measurements will likely include several years of data and a range of climatic/hydraulic conditions. A ground-water level data set also will be used for model verification.

There is a variety of software available for simulating ground water and surface water flow. Ground water flow simulation software already applied to the SVRP aquifer system include the U.S. Geological Survey MODFLOW model (McDonald and Harbaugh, 1988), and the integrated ground and surface water software MIKE-SHE from the Danish Hydraulic Institute (DHI).

One of the software requirements for this project will be the capability to use parameter estimation and sensitivity software such as Watermark Computing PEST or U.S. Geological Survey UCODE. These model-independent parameter estimation and sensitivity codes are widely used in the calibration of hydrologic models. Both PEST and UCODE can be used to perform automated parameter estimation for MODFLOW and other software. Parameter estimation software enables automatic quantification of parameters and prediction of uncertainty in parameter estimates. A full analysis of the appropriate model for use in the SVRP study will be undertaken as part of the development of a detailed study workplan. The selection of non-proprietary open-source software will ensure access to the model codes for examination and possible modification and sharing of the calibrated models..

The ground water flow model may be used to estimate responses (e.g., stream depletion at a channel reach) resulting from a simulated stress at some point within the aquifer. Stress simulations will help establish cause and effect relationships based on physical aquifer and channel characteristics. These simulations could help form the basis for the conjunctive management of ground water and surface water in the SVRP area.

A model-independent database would enable rapid reconstruction, if necessary, of various model configurations to answer specific aquifer or aquifer management questions. The effectiveness of the model will depend on its ease of use and interaction with the database and GIS.

Model results and/or model estimated parameters will be available for use in other water quality models, contaminant transport models, and integrated ground and surface water models. For example, results from MODFLOW can be used with the particle-tracking software MODPATH (Pollock, 1994) to simulate ground-water flow paths throughout the SVRP aquifer. MODPATH simulations could provide a basis for identifying potential areas of impact associated with regional land-use changes.

G. Surface-Water Model

A surface-water-flow model will be constructed to simulate flows in the Spokane and Little Spokane Rivers within the SVRP aquifer area. The surface water model will be integrated with the ground water model to illustrate how surface water and ground water interact. The surface water model will be used to show the effects of the operation of Post Falls dam and the interaction of surface water and ground water on flow in the river. Post Falls dam is used to regulate the flow in the Spokane River and control the water level in Lake Coeur d'Alene. The lake level is maintained for recreation at levels that are higher in the summer than levels that occurred naturally before the construction of Post Falls Dam. Several surface water flow models are available that can be integrated directly with a ground water model, including MIKE-SHE (DHI) and the surface-water routing module in MODFLOW (USGS).

H. Water Chemistry Analyses

Water chemistry may be used to charcterize ground-water flow, and to investigate ground-water/surface-water interactions. Ground-water-recharge dates, determined from environmental tracer analyses (tritium, CFCs, carbon-14) of ground-water samples may be used to characterize ground-water movement in the aquifer. The USGS NAWQA NROK study delineated major gaining and losing reaches of the Spokane River and identified effects of ground-water recharge from an 18-mile reach of the river on aquifer water chemistry. Additional samples of ground water and surface water may be collected and analyzed for selected water chemistry parameters to help identify and quantify ground-water/surface-water interactions in other parts of the study area. This workplan does not include an evaluation of water quality regarding the suitability of water in the study area for various uses or potential contamination of water resources. However, the proposed ground and surface water models may form the basis of future contaminant transport models, and could have relevance to resolving water quality issues under the Clean Water Act .

I. Public Outreach

The purpose of this task is to raise the general level of understanding about water issues in the Spokane-Rathdrum area. Public outreach efforts will consist of (1) establishing an informal clearinghouse for dissemination of all aquifer data collected and technical reports published during the course of the SVRP aquifer study; (2) publishing news releases and fact sheets; (3) developing a project website and the use of the National Map web to serve geospatial data; and (4) giving public and professional presentations, including special seminars. At the conclusion of the study, a SVRP Aquifer Water Summit will be held to provide an opportunity to present and discuss project results with elected officials, water managers, the professional community, and the general public. Similar events in the Treasure Valley in southwestern Idaho, and the Pullman-Moscow basin in southeastern Washington and western Idaho have been highly effective in setting the stage for local participation in the management of water resources.

J. Presentation of Project Results

Project information and results will be presented on an ongoing basis and upon project completion. Fact sheets and other short report format publications may be used to disseminate data and information during the study. The project will produce several peer-reviewed reports describing (1) the hydrogeologic system and the water budget, (2) the data in the hydrologic database (with an accompanying CD-ROM containing the data), and (3) numerical modeling methods and results. Project reports and associated information will be made available via the project website, in print, and on CD-ROM.

V. ORGANIZATIONAL STRUCTURE

Management of water in the SVRP area is complicated by the interstate, multi-jurisdictional nature of the watershed and underlying aquifer. Numerous organizations have a direct interest in regional and local water management, and numerous organizations and individuals have expertise, experience, and perspective to contribute to an interstate hydrologic study. The proposed organizational approach therefore consists of a partnership between government agencies, university researchers, and members of the public and private sector. The organizational structure (Figure 2) consists of a management team, technical and policy advisory committees, a technical team, and various public and private participants.

State agencies in Washington and Idaho (Washington Department of Ecology, Idaho Department of Water Resources, and the Idaho Department of Environmental Quality) have primary responsibility for water allocation and water quality in the SVRP area. As such, the agencies have the responsibility for guiding the study in such a way as to produce information and data needed for long-term, effective, water management. These agencies and the U.S. Geological Survey would form a Management Team to administer the project. The Management Team may choose to name one or more local project manager(s) to coordinate technical and/or outreach efforts.

Management team members may choose to establish a local caucus with which to consult on selected management team decisions. For example, the Spokane County Water Quality Management Program is conducting watershed planning and water quality management in Spokane County; the Management Team may wish to consult on some aspects of this study with local agencies such as Spokane County, the City of Spokane, and/or the Spokane Watershed Planning Unit.

The Policy Advisory Committee (PAC), consisting of representatives of various regional, local, and individual stakeholders, will help develop and refine water management and planning questions for the study. The PAC also may participate in developing approaches for implementing water management strategies on the basis of study results. The PAC also would help identify public participation, information, outreach, and education needs. The current stakeholder group would play a major role in helping to establish the PAC.

A Technical Advisory Committee (TAC) will be formed to provide advice and incremental peer review on technical issues. The TAC will consist of scientists and engineers with expertise in water management, regional geology, local ground water hydrology, water quality, and/or numerical modeling techniques. Composed of public- and private-sector members, the TAC will ensure the study builds on existing knowledge and understanding, is objective, and is scientifically sound. The TAC will assist in refining the project scope; developing a detailed project workplan; monitoring project progress; and reviewing project results. Membership on this committee would be determined by the Management Team based on nominations from the Management Team, stakeholder group, PAC, and/or others.

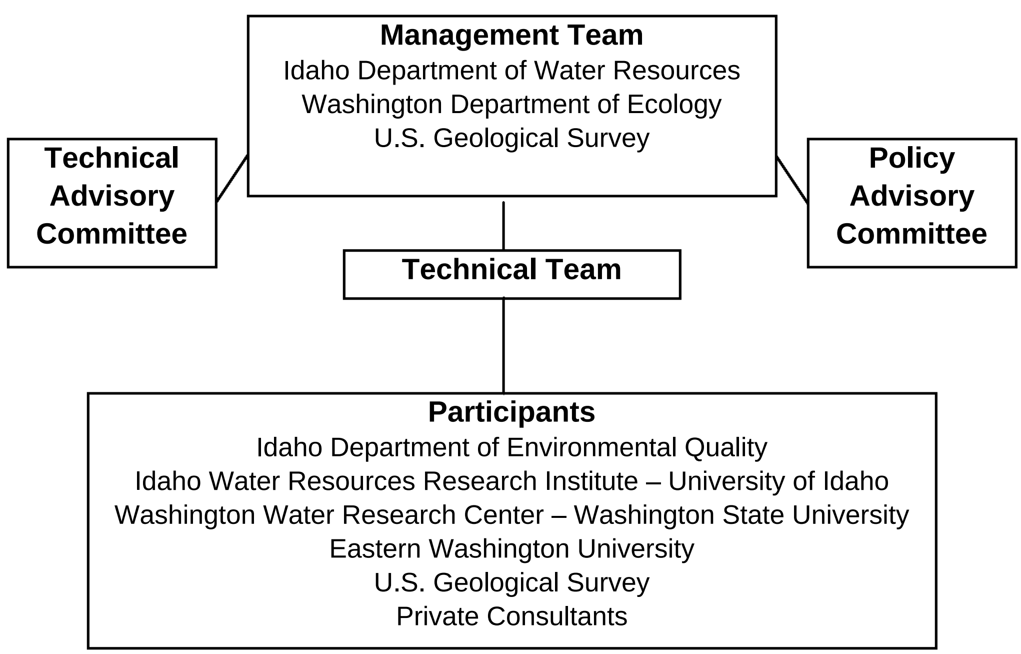

Figure 2: Proposed organizational structure

Specific study tasks may be completed by a consortium of participants with demonstrated expertise in various aspects of this study. Study participants are expected to include the USGS, university researchers (Idaho Water Resources Research Institute/University of Idaho, Washington Water Research Center/Washington State University, and Eastern Washington University), private companies, and/or WDOE and IDWR staff. Assignments will be made under contract by the management team based on the needs of specific work plan tasks, demonstrated expertise and experience, and available funding. Funding for USGS tasks may be provided by direct federal appropriation; funding for tasks being performed by other organizations or individuals may be provided under contract with the administering agencies.

VI. PRELIMINARY BUDGET

The following projected costs are preliminary, and will be refined during development of the detailed workplan for this study.

Preliminary Spokane Rathdrum Aquifer Study Budget

TASKS	Cost
A. Develop Project Workplan	$ 150,000
B. Develop Hydrologic Database	$ 225,000
C. Ground and Surface Water Monitoring	$ 350,000
D. Water Budget	$ 225,000
E. Hydrogeologic Characterization	$ 1,500,000
F. Ground Water Model	$ 450,000
G. Surface Water Model	$ 100,000
H. Water Chemistry Analysis	$ 200,000
I. Public Outreach	$ 200,000
J. Presentation of Results	$ 100,000
Total Project Cost	$ 3,500,000

VII. PRELIMINARY SCHEDULE

A preliminary schedule is shown in Figure 3. The start time for individual tasks will change depending on when the project starts. Some tasks requiring field work can only be completed during summer months when weather is suitable. Other tasks such as database construction and model construction can begin as soon as funding is available. Some monitoring tasks are shown continuing for the duration of the project although data collection may only occur monthly.

VIII. REFERENCES

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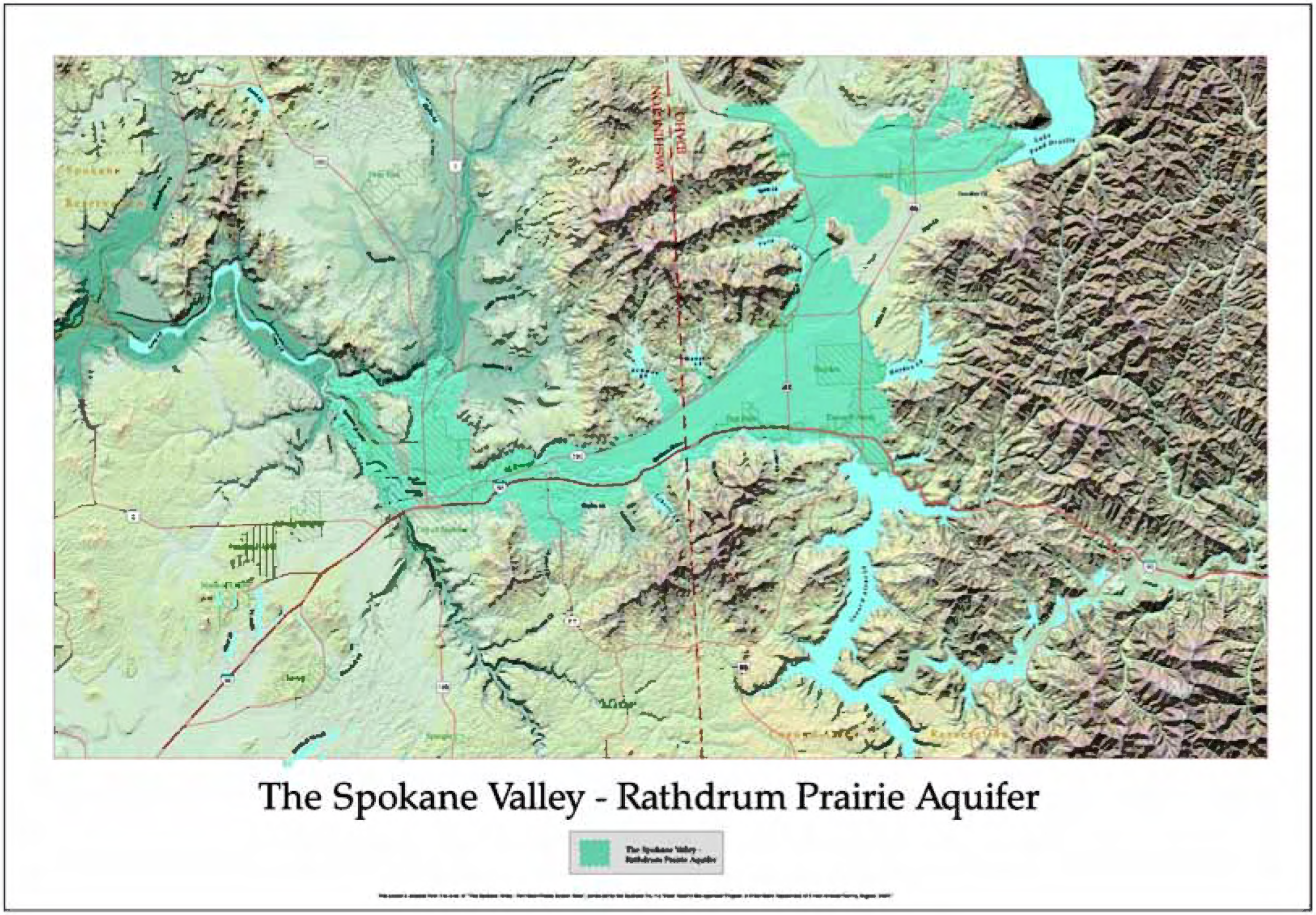

Figure 1. Study Area

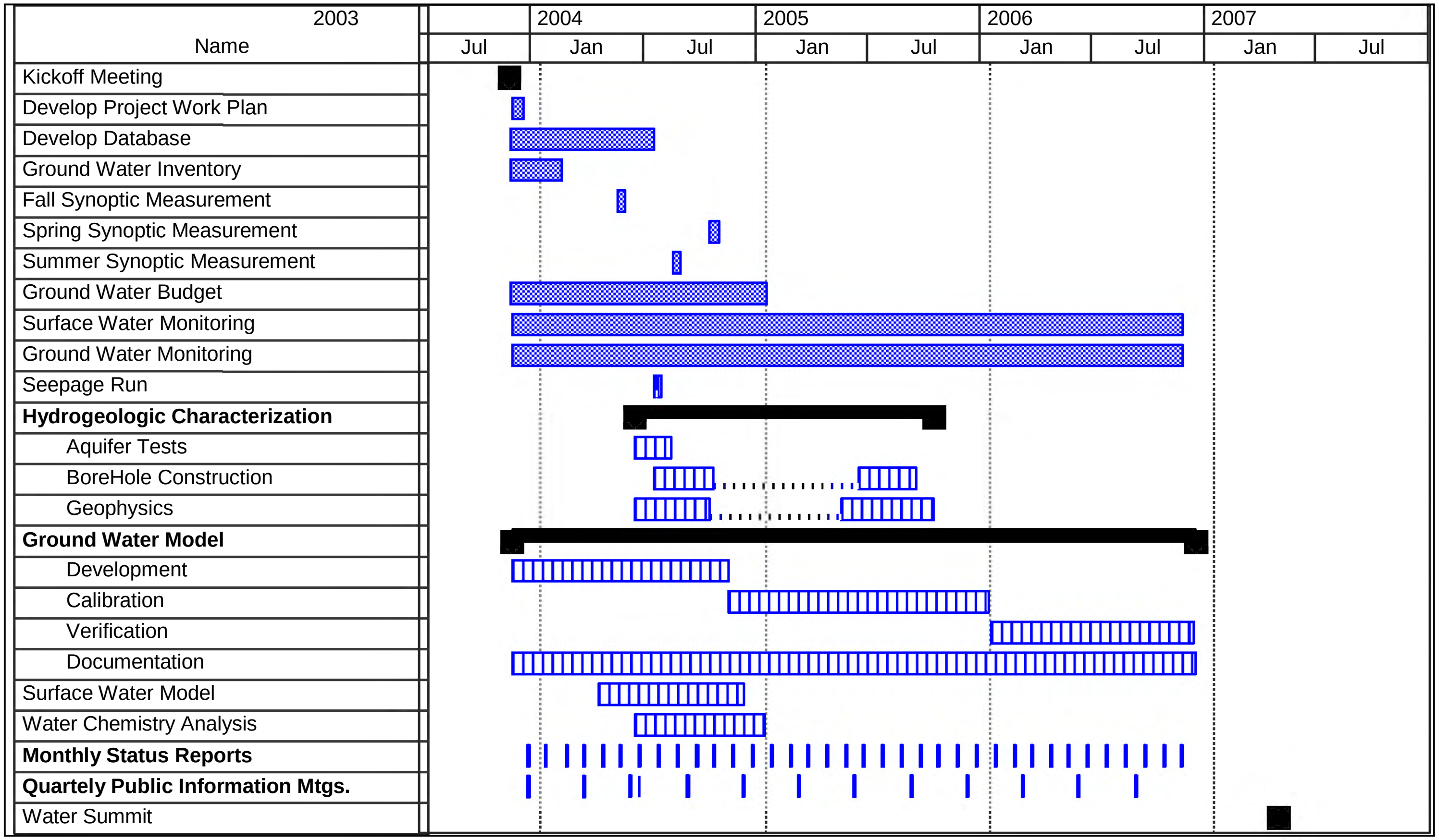

Figure 3. Preliminary Study Schedule