TREASURE VALLEY HYDROLOGIC PROJECT EXECUTIVE SUMMARY

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1. INTRODUCTION

1.1. Project Background

The Treasure Valley of southwestern Idaho has experienced significant population growth, local ground water declines, and periodic drought conditions in the last two decades. This led to public concern about the status and future of water resources in the valley. The following questions typify those that were asked about Treasure Valley water supplies:

1. Does the Treasure Valley have a ground water shortage?
2. How has and does land development impact Treasure Valley water supplies?
3. Where and to what degree are ground water levels declining?
4. What is the carrying capacity of the hydrologic system in the Treasure Valley?
5. How big is our aquifer system? Where are the aquifer boundaries?
6. How are shallow and deep aquifers connected?
7. How are Treasure Valley aquifer systems recharged and where does the recharge occur?
8. How susceptible is the Treasure Valley aquifer system to contamination?
9. What is the degree of hydraulic connection between Treasure Valley surface and ground water?
10. Is water conservation necessary to meet future water demands?
11. Can additional tools and/or data be developed to assist local, state, and federal governments with decisions on issues that impact water resources, such as land use planning, zoning, water rights, septic tank permitting, waste treatment, etc.?

The Treasure Valley Hydrologic Project (TVHP) was formed to provide technical information needed to address most of these issues and to provide a framework for future water management. The project included characterization of ground water flow in the Treasure Valley aquifer system, evaluation of flow system geochemistry, estimation of ground water residence times, and construction of a numerical model of ground water flow. The ground water flow model was used to evaluate potential changes in recharge and predict possible effects of increased ground water withdrawals.

1.2. Purpose and Objectives

The purpose of the TVHP was to develop a better understanding of ground water resources in the Treasure Valley and to evaluate the effects of potential change on ground water supplies. Specific objectives for the project included:

1. Developing a water budget of inflows and outflows to the Treasure Valley aquifer system.
2. Improving the understanding of the Treasure Valley hydrologic system.
3. Developing a spatially-oriented database of hydrologic data.
4. Developing a numerical model to simulate ground water flow in the regional hydrologic system.
5. Using the numerical model to simulate potential impacts to Treasure Valley ground water levels from changes in regional ground water withdrawals and/or recharge patterns.
6. Conveying project results to those making land and water resource planning decisions and to the general public.

1.3. Report Scope

This report presents a summary of the TVHP. It includes an overview of the project, summarizes results from primary project reports, and addresses the questions listed in Section 1.1. More detailed information is presented in the project reports, which are listed in Section 2.10. Brief answers to the questions posed in Section 1.1 are provided in Section 5.

2. PROJECT DESCRIPTION

The Treasure Valley of southwestern Idaho consists of the lower Boise River sub-basin and the area between the lower Boise River sub-basin and the Snake River (Figure 2-1). The lower Boise River sub-basin begins where the Boise River exits the mountains near Lucky Peak Reservoir. From Lucky Peak Dam, the lower Boise River flows about 64 (river) miles northwestward through the Treasure Valley to its confluence with the Snake River. The project area extends south to the Snake River because ground water flows from some portions of the lower Boise River basin south toward the Snake River.

The Treasure Valley includes the cities of Boise, Nampa, Caldwell, Meridian, Eagle, Kuna, and a number of smaller communities. The central portion of the valley is drained by the Boise River; the southern portion of the valley is drained by the Snake River.

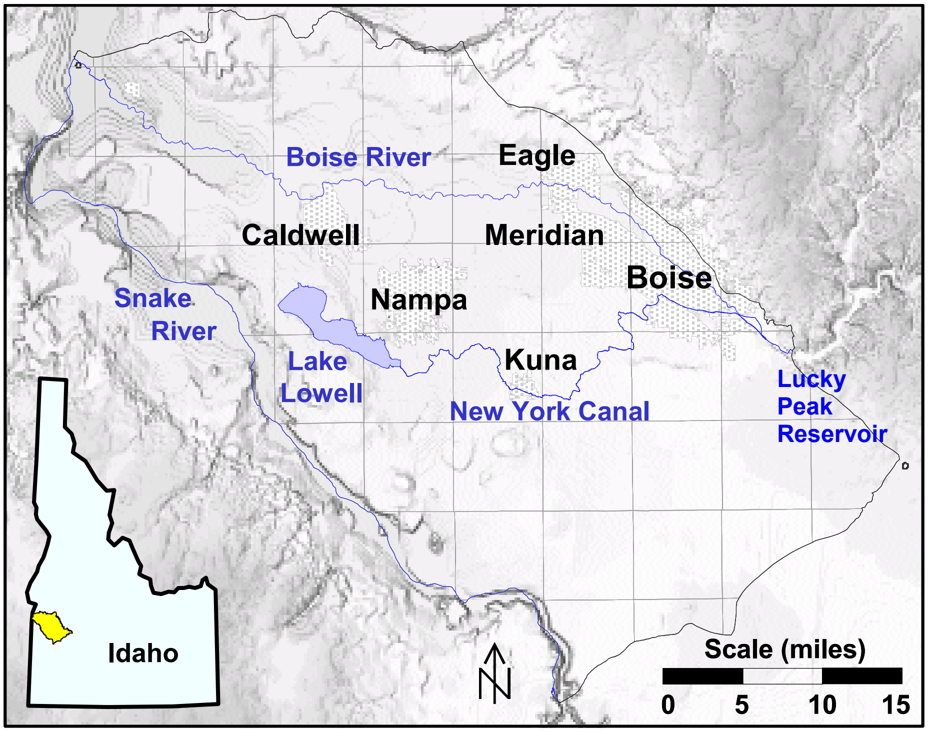

Figure 2-1: Treasure Valley and surrounding areas.

The TVHP consisted of numerous tasks designed to help define, evaluate, and quantify Treasure Valley aquifer and ground water flow characteristics and to simulate potential effects of hydrologic changes on the ground water flow system. The project included the following tasks:

1. Mass ground water level measurements
2. Monthly ground water level measurements
3. Construction of dedicated, multi-level ground water monitoring wells
4. Geologic interpretation
5. Seismic surveys
6. Seepage measurements
7. Geochemical analyses
8. Water quality analyses
9. Data development
10. Water budget development
11. Numerical modeling
12. Scenario development and simulation
13. Reporting
14. Public outreach

These tasks are summarized in the following sections.

2.1. Mass Ground Water Level Measurements

Mass ground water level measurements were conducted as part of the TVHP in the spring and fall of 1996, 1998, and 2000, and fall 2001. A mass measurement consists of collecting ground water level measurements in multiple wells over a short period of time (in this case, one to two weeks). The purpose of a mass ground water level measurement is to define a potentiometric surface at a point in time. A potentiometric surface represents the hydraulic head over an area. Potentiometric surfaces can be used to describe local and regional hydraulic gradients and can provide a baseline for large-scale water level changes over time.

Each measurement, conducted either by the U.S. Geologic Survey (USGS) or Kleinfelder, Inc., included over 245 wells throughout the Treasure Valley area (Table 2-1). Data collected by the USGS were included in the GWSI database; all data were included in the Idaho Department of Water Resources (IDWR) Well_Log database.

2.2. Monthly Ground Water Level Measurements

The TVHP monitoring well network consisted of approximately 70 wells[1] in which water levels were measured monthly from 1996 through 2001 and quarterly after 2001. The purpose of the periodic measurements was to provide a basis for evaluating seasonal fluctuations in water levels and establishing long-term water level trends.

Mass Measurement	Number of Wells	Measuring Entity
Spring 1996	339	USGS
Fall 1996	331	USGS
Spring 1998	381	USGS
Fall 1998	361	USGS
Spring 2000	305	USGS
Fall 2000	245	Kleinfelder, Inc.
Fall 2001	281	Kleinfelder, Inc.

Table 2-1: Numbers of wells measured in the mass water level measurements.

The monitoring was conducted in existing water wells, which were selected (in aggregate and individually) based on the following general criteria:

1. Spatial distribution throughout project area
2. Available drillers' reports
3. Reasonably detailed lithologic log
4. Discrete open interval, preferably corresponding with specific aquifer depths
5. Access to well by USGS, IDWR, or other personnel for conducting measurements

Results from these measurements are reported in Petrich and Urban (2004).

2.3. Dedicated TVHP Monitoring Wells

Four dedicated monitoring wells were constructed as part of this project (see Figure 2-2). Each monitoring well has multiple piezometers, each of which was completed (i.e., screened) at multiple discrete intervals, allowing the measurement of hydraulic head at various aquifer depths. Descriptions of these measurement wells are included in Petrich and Urban (2004).

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[1] These wells are also included in the mass measurements described in Section 4.2.

2.4. Geological Cross-Sections

Numerous geologic cross-sections were prepared for this project (Beukelman, 1997a; Beukelman, 1997b; Beukelman, 1997c; Beukelman, 1997d; Squires and Wood, 2001; Wood, 1996a). These cross-sections and other data were used to interpret several geologic surfaces, including the base of the sedimentary section (Wood, 1996b), a structural contour map of the top of the Miocene basalt (Wood, 1997b), and the top of the mudstone facies (Wood, 1997c).

2.5. Seismic Surveys

Several seismic surveys were conducted as part of the project by Boise State University Center for the Geophysical Investigation of the Shallow Subsurface (CGISS). These surveys (Liberty, 1996; Liberty and Wood, 2001) and interpretations based on the stratigraphic data (Liberty, 1996; Liberty, 1998; Liberty and Wood, 2001; Squires and Wood, 2001; Wood, 1997a; Wood and Clemens, in press) contributed to an improved understanding of subsurface stratigraphy in the Treasure Valley.

In addition, CGISS digitized geophysical logs from a number of existing Treasure Valley wells. These logs are available at http://cgiss.boisestate.edu/TVHP/TVHP.html.

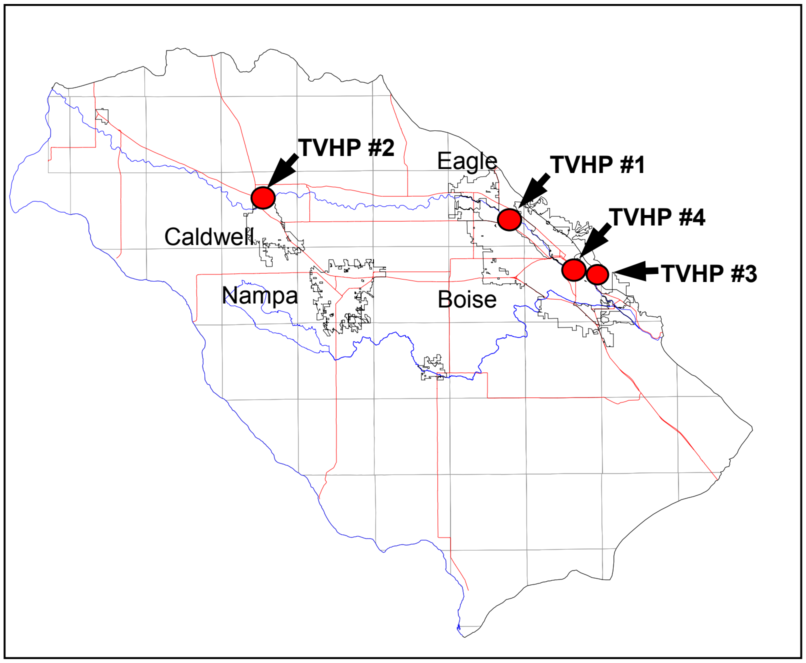

Figure 2-2: TVHP monitoring well locations (Petrich and Urban, 2004).

2.6. Seepage Measurements

Seepage measurements were conducted by the USGS in 39 irrigation and canal reaches in the lower Boise River basin, three reaches of the Boise River, and the New York Canal (Berenbrock, 1999; Carlson and Petrich, 1998). Results from these measurements contributed to an understanding of ground and surface water interaction along the New York Canal and throughout some of the valley's irrigated areas.

2.7. Water Chemistry Analyses

Water chemistry analyses consisted of the following:

1. Analyzing general water quality trends (this was done through the Statewide Ambient Ground Water Quality Monitoring Program - Neely and Crockett, 1998).
2. Describing hydrochemical characteristics of principal aquifers in the regional Treasure Valley ground water flow system (Hutchings and Petrich, 2002a). Information from these analyses was used to help describe regional ground water flow patterns.
3. Estimating residence times in the regional ground water flow system (Hutchings and Petrich, 2002a). Ground water residence time data gave insight into the effective rate of flow in the regional ground water flow system.
4. Evaluating the influence of canal seepage on deep aquifer recharge near the New York Canal based on chemistry and hydrologic data (Hutchings and Petrich, 2002b). Chemistry data were used to describe the depth of penetration of surface water and evaluate alternative sources of recharge to deep aquifers.

2.8. Water Budgets

Two water budgets for the Treasure Valley aquifer system were developed based on 1996 and 2000 calendar-year inflow and outflow estimates (Petrich and Urban, 2004; Urban, 2004). Inflows estimated in the water budgets included canal seepage, recharge from rivers and streams, recharge from Lake Lowell, subsurface inflow, recharge from precipitation, and surface water irrigation recharge from rural domestic septic systems. Discharge estimates included withdrawals for municipal, self-supplied industrial, irrigation, rural domestic, and livestock needs; discharge to rivers and drains; and underflow into the valley.

2.9. Spatial Data development

A variety of spatial data were collected, developed, and/or compiled as part of, or in conjunction with, the TVHP. Spatial data were used to augment the hydrologic data collected in the tasks outlined above. These data included the following:

1. Topographic data (USGS digital raster graphics [DRGs] at 1:24,000, 1:100,000, and 1:250,000 scales)
2. Land Use Data–Color Infrared Images (CIR) were analyzed using standard photo interpretation techniques. The CIR images were produced from scanned, geocorrected, and mosaicked 1:24,000-scale CIR aerial photographs

taken in 1998 and 2000. A suite of ARC/INFO AMLs were developed and used to conduct the image interpretation. The land use and land cover data was plotted at 1:24,000-scale, and the maps were verified in the field.

3. Shaded relief images were created from the National Elevation Dataset (NED).
4. Digital Line Graphs (DLGs) (for highways, etc) were obtained from the USGS and/or the US Census Bureau at a 1:100,000-scale.
5. Political boundaries were taken from the 2000 census (1:100,000-scale).
6. Hydrography data (e.g., canals, streams, rivers, drains) were taken from Pacific Northwest Ada and Canyon County hydrography data (USGS and Idaho Department of Lands; varied scales between 1:24,000 and 1:100,000). Data were enhanced by IDWR.
7. Irrigation district boundaries were created for the Snake River Basin Adjudication. The boundaries were generated from the (1) Bureau of Land Management's (BLM) Geographic Coordinate Data Base (GCDB)[2], (2) digitized from the 1987-88 National Aerial Photography Program (NAPP)[3], or (3) provided by irrigation districts or companies. Scales varied between 1:24,000 and 1:100,000.
8. Well information, including well location, lithology, depth, well construction details, yield, completion date, etc., was obtained from the drillers' reports and the IDWR Well_Log database.
9. Urban water purveyor boundaries were created from a number of different sources throughout the state of Idaho. The boundaries represent the municipal service areas of municipal delivery entities within the state (scale: 1:100,000). The boundaries were (1) generated for the 2000 Census, (2) digitized from the 1987-88 NAPP Photography, or (3) provided by individual cities. In the Treasure Valley, some of the initial municipal boundaries were obtained from the Southwest Community Planning Association (COMPASS) and from United Water Idaho, Inc. (UWI).
10. Surface Energy Balance Algorithm for Land (SEBAL) evapotranspiration (ET) data (Kramber, 2002) were provided by IDWR.

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[2] From http://www.blm.gov/gcdb/. This is a collection of geographic information representing the Public Land Survey System (PLSS) of the U.S. The GCDB grid is computed from BLM survey records (official plats and field notes), local survey records, and geodetic control information.

[3] The NAPP provides a standardized set of cloud-free aerial photographs covering the conterminous U.S. over 5- to 7-year cycles. The program began in 1987 and continues to be our most recent and consistent source of high-quality aerial photography. The photographs were acquired from an altitude of 20,000 feet and are available in black and white (B/W) or color infrared (CIR), depending on location and date. Each photo is centered on one-quarter section of a 7.5-minute USGS quadrangle, and covers approximately a 5.5 x 5.5 mile area.

2.10. Project Reports, Data, and Information

Reports prepared as a part of, or in conjunction with, the TVHP include the following:

- Characterization of Ground Water Flow in the Lower Boise River Basin (Petrich and Urban, 2004)
- Simulation of Ground Water Flow in the Lower Boise River Basin (Petrich, 2004a)
- Simulation of Potential Increased Treasure Valley Ground Water Withdrawals Associated with Unprocessed Well Applications (Petrich, 2004b)
- Water Budget for the Treasure Valley Aquifer System for the years 1996 and 2000 (Urban, 2004)
- Geologic and Tectonic History of the Western Snake River Plain, Idaho and Oregon (Wood and Clemens, in press)
- Hydrogeologic Conditions in the Boise Front Geothermal Aquifer (Petrich, 2003a)
- Investigation of Hydrogeologic Conditions and Ground Water Flow in the Boise Front Geothermal Aquifer–Executive Summary (Petrich, 2003b)
- Simulation of Increased Ground Water Withdrawals in the Treasure Valley Associated with Unprocessed Well Applications (Petrich, 2004b)
- Treasure Valley's Water Future–Summary of the Treasure Valley Water Summit (COMPASS et al., 2002)
- Ground Water Recharge and Flow in the Regional Treasure Valley Aquifer System (Hutchings and Petrich, 2002a)
- Influence of canal seepage on aquifer recharge near the New York Canal (Hutchings and Petrich, 2002b)
- Developing evapotranspiration data for Idaho's Treasure Valley using Surface Energy Balance Algorithm for Land (SEBAL) Treasure Valley (Kramber, 2002)
- Stratigraphic Studies of the Boise (Idaho) Aquifer System using Borehole Geophysical logs with Emphasis on Facies Identification of Sand Aquifers (Squires and Wood, 2001)
- Domestic, Commercial, Municipal, and Industrial Water Demand Assessment and Forecast in Ada and Canyon Counties, Idaho (Cook et al., 2001)
- Seismic Reflection Project - UPRR 2000 Profile (Liberty and Wood, 2001)
- Hydrogeology, Geochemistry, and Well Construction of the Treasure Valley hydrologic Project Monitoring Well #1 (Dittus et al., 1999)
- 1996 Water Budget for the Treasure Valley Aquifer System (Urban and Petrich, 1998)

- New York Canal Geologic Cross-Section, Seepage Gain/Loss Data, and Ground Water Hydrographs: Compilation and Findings (Carlson and Petrich, 1998)
- Seismic Reflection Imaging of a Geothermal Aquifer in an Urban Setting (Liberty, 1998)
- Structure Contour Map of the Top of the Mudstone Facies, Western Snake Supporting Data for Groundwater Conditions and Aquifer Testing of the Tenmile Ridge Area of South Boise, Ada County, Idaho (Dittus et al., 1998)
- Ground water quality characterization and initial trend analysis for the Treasure Valley shallow and deep hydrologic subareas (Neely and Crockett, 1998)
- Structure Contour map of the Top of the Mudstone Facies, Western Snake River Plain, Idaho (Wood, 1997c)
- Cross Section of the Treasure Valley in the Boise Area: Notes on the Geology of the Boise, Ontario, Parma, and Notus areas (Beukelman, 1997a; Beukelman, 1997b; Beukelman, 1997c; Beukelman, 1997d)
- Preliminary Map of the Base of the Sedimentary Section of the Western Snake River Plain (Wood, 1996b)

2.11. Outreach

Outreach for the TVHP included project workshops, preparation of project brochures and newspaper inserts, public presentations, and the first-ever Treasure Valley Water Summit.

2.11.1. Treasure Valley Water Summit

The Treasure Valley Water Summit was a primary outreach effort of the TVHP. On January 14 and 15, 2002, more than 300 people participated in the Treasure Valley Water Summit, a community-wide discussion about Treasure Valley water issues. Topics focused on the current state of water resources, the potential effects of population growth on water resources, and strategies for planning a water future. Participants included citizens, elected officials, federal, state, and local government, scientists, planners, and engineers, representatives of agriculture and industry, private developers, and legal professionals. In April 2002, the Summit results were summarized for valley decision-makers. A summary report (COMPASS et al., 2002) and accompanying appendices give agendas, discussion group summaries, and summaries of selected presentations.

2.11.2. Presentations

The following is a partial list of presentations given as part of the TVHP:

- *Treasure Valley Hydrology* (2003)
  Association of Idaho Cities and the Community Planning Association of Southwest Idaho (Petrich)
- *Simulation of Increased Withdrawals* (2003)
  United Water Idaho, Inc. (Petrich)
- *Treasure Valley Hydrologic Project Overview* (2003)
  U.S. Bureau of Reclamation (Petrich)
- *An Update: Ground and Surface Water Hydrology in the Proposed Conjunctive Administration Area, Treasure Valley* (2003)
  Idaho Department of Water Resources (Petrich).
- *Treasure Valley Hydrology – an Overview* (2003)
  BSU Civil Engineering class (Petrich)
- *Simulation of Increased Ground Water Withdrawals in the Lower Boise River Basin, Idaho* (2003)
  MODFLOW2003, Golden, CO (Petrich)
- *Treasure Valley Hydrology* (2002)
  Treasure Valley Water Summit (Petrich)
- *Treasure Valley Hydrology* (2002)
  Treasure Valley Water Summit Follow-Up (Petrich)
- *Treasure Valley Hydrology* (2002)
  Canyon County Planning Commission (Petrich)
- *Treasure Valley Hydrologic Project Progress Report* (2002)
  U.S. Environmental Protection Agency (Castelin and Petrich)
- *Ground and Surface Water Hydrology in the Proposed Conjunctive Administration Area, Treasure Valley* (2002)
  Idaho Department of Water Resources (Petrich).
- *Treasure Valley Ground Water Data* (2000)
  DEQ Source Water Assessment team (Petrich)
- *Treasure Valley Hydrologic Project Progress Summary* (2001)
  City of Eagle (Petrich).
- *Introduction to Ground Water Flow Modeling* (2001)
  Idaho Water Users Association (Petrich)
- *Treasure Valley Hydrology* (2001)
  BSU geology class (Petrich)
- *Treasure Valley Hydrology* (2001)
  BSU geology class (Petrich)
- *Treasure Valley Aquifer Description* (2000)
  Board of Realtors (Petrich and Castelin

- *Well Logs and Ground Water Studies* (2000)
  Idaho Ground Water Association (Petrich)
- *Project Update* (2000)
  United Water Idaho, Inc. (Petrich and Castelin).
- *Project Update* (1999)
  United Water Idaho, Inc. (Petrich).
- *Project Overview and Flow Model Development* (1999)
  Agricultural Research Service (Petrich and Hutchings).
- *Calibration of the Treasure Valley Ground Water Model using Parameter estimation* (1999)
  Idaho Ground Water Connections Conference (Petrich)
- *Characterization of the Treasure Valley Ground Water Flow System* (1999)
  Boise River 2000 (Petrich and Castelin)
- *Surface and Ground Water Interaction near the New York Canal* (1999)
  Idaho Ground Water Connections Conference (Carlson)
- *Development and Calibration of a Regional Ground Water Flow Model of the Lower Boise River Basin, Southwestern Idaho* (1999)
  Annual Meeting of the Geological Society of America (Petrich)
- *Treasure Valley Model Development* (1998)
  American Society of Civil Engineers (Petrich)
- *Treasure Valley Hydrology* (1998)
  Ground Water Resource Conference, Changchun, China (Petrich)
- *Treasure Valley Hydrologic Project: an Overview* (1997)
  Idaho Ground Water Connections Conference (Petrich)
- *Treasure Valley Ground Water Flow Model – an Overview* (1997)
  Idaho Association of Professional Geologists (Petrich)
- *Treasure Valley Hydrologic Project – an Overview* (1997)
  Idaho Water Users Association (Petrich)
- *Development of a Hydrologic Data Platform for Conjunctive Management in Southwest Idaho* (1999)
  Pacific Northwest Focus Ground Water Conference (Petrich)

2.11.3. Web Site

IDWR is developing a comprehensive web site (http://www.idwr.state.id.us) that describes Treasure Valley hydrology, a project description, and project results. All project reports are being posted to this web site.

3. DESCRIPTION OF GROUND WATER FLOW

This section presents a summary of Treasure Valley ground water flow characteristics, water level measurements, and aquifer inflows and outflows (from Petrich and Urban, 2004). The summary represents the "conceptual model" of ground water flow that was used as the basis for aquifer simulations.

The Treasure Valley aquifer system is comprised of a complex series of interbedded, tilted, faulted, and eroded sediments, extending to depths of over 6,000 feet in the deepest parts of the basin (Wood and Clemens, in press). The valley contains shallow, local flow systems (with ground water residence times ranging from years to hundreds of years) and a deeper, regional flow system (with residence times ranging from thousands to tens of thousands of years). Few water wells extend beyond a depth of 1,200 feet.

The Treasure Valley sedimentary section reflects a history of lacustrine, deltaic, fluvial, and alluvial deposition (Wood and Clemens, in press). In general, basin sedimentary deposits grade from coarser, more permeable sediments near the Boise Front[4] to finer, less permeable sediments at the distal end of the basin. At the basin scale, sediments also grade finer with depth. Highly permeable deposits associated with deltaic and/or fluvial deposition are often sandwiched between lacustrine deposits of lower permeability.

Ground water flow in the Treasure Valley is controlled by aquifer characteristics and hydraulic gradient. Aquifer characteristics influencing ground water flow include grain size, sorting, stratigraphic layering, sedimentary layer dip, sediment grain cementation, and the degree of fracturing (e.g., rock aquifers). Additional controls on the movement of ground water are attributed to structural processes, including faulting throughout the basin and along the basin margin.

Ground water chemistry data (Hutchings and Petrich, 2002a) indicate different ground water chemistry north of the fault zone compared to the area south of the fault zone, suggesting restricted flow across the fault zone. Basin downwarping and an associated downslope trend in sediment deposition contribute to steeply dipping sedimentary deposits that may cause deeper aquifer units to pinch out at depth (Wood, 1997). Based on seismic imaging and outcrop mapping, aquifer sediments of various fault blocks dip at angles ranging from zero to approximately 12 degrees (Wood, 1997).

Fractures within shallow Pleistocene basalts, or along upper and lower surfaces of individual basalt flows, can contribute to ground water movement. For instance, basalt fractures and course-grained sediments underlying the basalt may contribute greatly to

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[4] Boise Front describes the portion of the Idaho Batholith that forms the northeastern boundary of the lower Boise River basin.

transmitting leakage from the New York Canal (and other surface water channels) into shallow aquifers.

An erosional unconformity associated with changing lake levels in Pliocene Lake Idaho truncates down-dipping units near the basin margin near Boise (Squires and Wood, 2001; Squires et al., 1992; Wood, 1997a). The unconformity separates lacustrine and deltaic sediments (tilted in the Boise area) from overlying lacustrine/deltaic sediments. Coarse-grained sediments associated with the erosional unconformity (Wood, 1997; Squires et al., 1992) appear to serve as a manifold for deeper, regional ground water migrating horizontally into the basin from alluvial fan sediments in the eastern portion of the basin (corroborated by E. Squires, pers. comm., 2002).

Potentiometric surface contours indicate ground water movement in a northwesterly to southwesterly direction, depending on depth and location (Figure 3-1 through Figure 3-4). Potentiometric surface contours in shallow aquifer zones reflect surface hydrologic conditions, such as mounding under the New York and Mora Canals, or discharge to the Boise River. Mounding in the vicinity of the New York Canal represents a local ground water divide, with shallow ground water north of the canal flowing toward the Boise River, and shallow ground water south of the canal flowing toward the Snake River. Potentiometric surface contours from shallow aquifers show ground water flow toward and discharge to the Boise River in mid- to lower reaches. Potentiometric surface contours in deeper zones indicate a more uniform westerly flow direction (e.g., Figure 3-3). Downward hydraulic gradients are indicated along the Boise Foothills, the eastern part of the study area (e.g., TVHP#4, Figure 3-5), and in the vicinity of the New York and Mora Canals. Upward gradients are evident in the central and western portions of the valley (e.g., TVHP#2, Figure 3-5), especially in the vicinity of the lower Boise River.

Individual hydrographs indicate relatively stable water levels in many areas, although water level declines have occurred in a number of wells (Petrich and Urban, 2004). Wells in two areas, southeast Boise and south of Lake Lowell, have experienced declines of approximately 30 feet and 65 feet, respectively. Water levels in these areas appear to have stabilized in recent years. Additional ground water level declines were observed in the areas between northwest Boise and Eagle and southwest Boise, Meridian, and Kuna). Most of the long-term declines in these wells have been less than 10 feet. Reasons for the declines may include increased withdrawals from the measured wells (very few of the monitoring wells are dedicated to monitoring alone), increased nearby withdrawals, and/or changes in local infiltration rates. Further investigation of these apparent declines is warranted to determine if they reflect regional or local conditions. Additional monitoring wells would also be warranted in these areas of apparent declines.

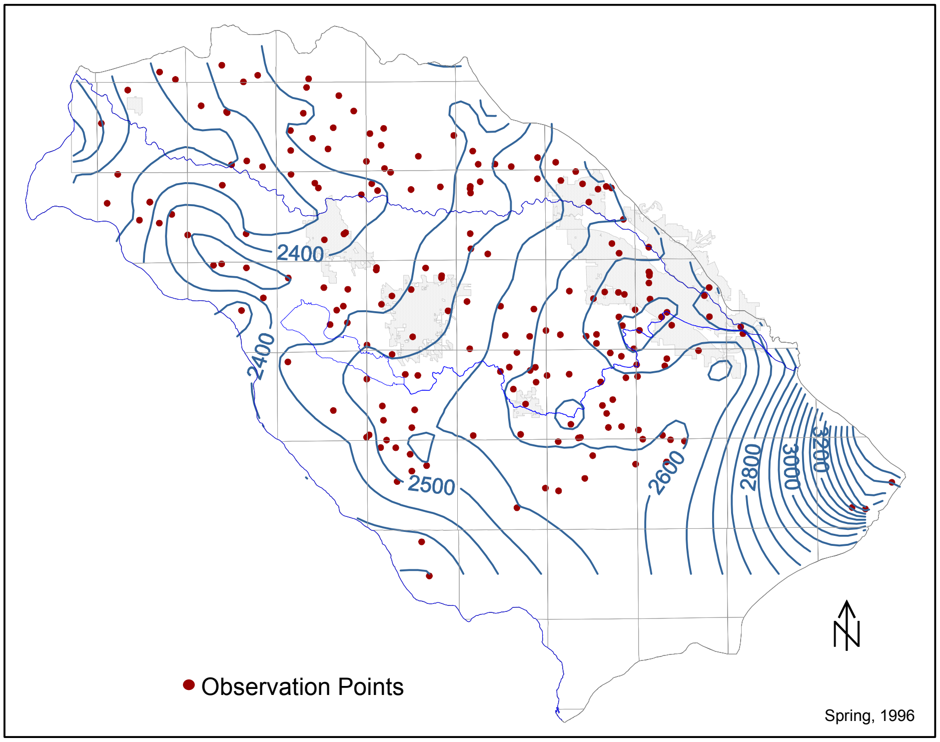


Figure 3-1: Potentiometric surface based on 1996 water level measurements from wells completed in model layer 1.

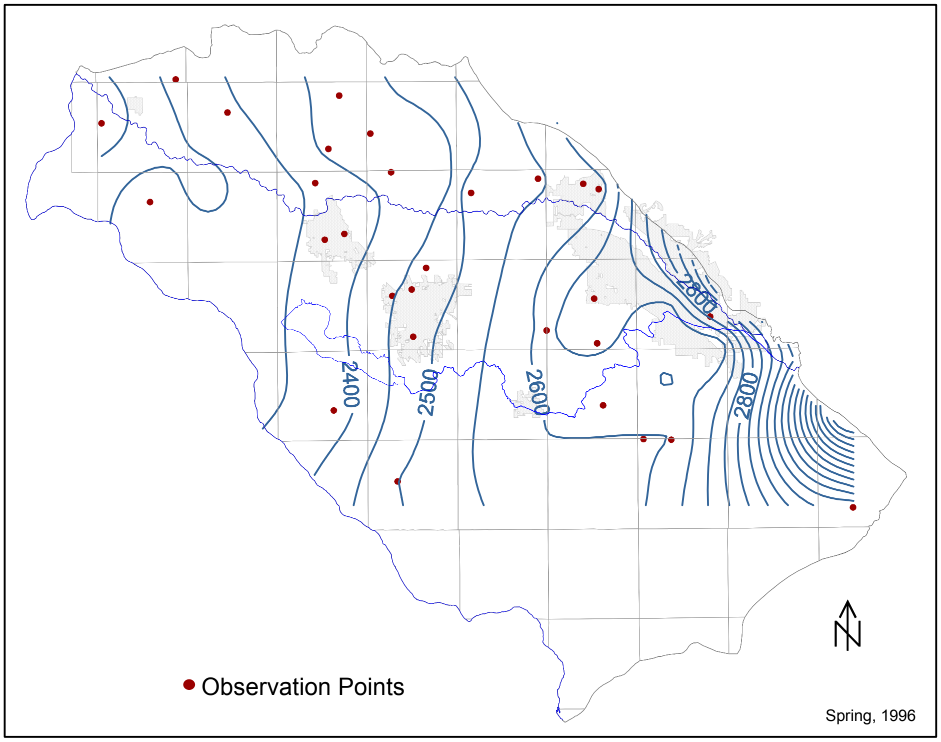


Figure 3-2: Potentiometric surface based on 1996 water level measurements from wells completed in model layer 2.

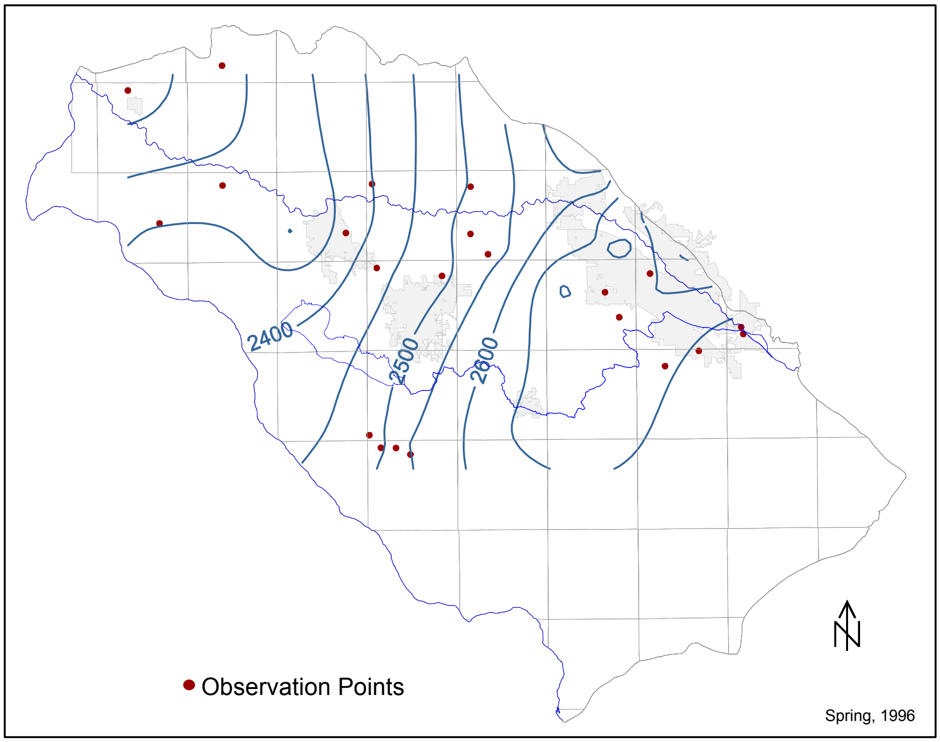


Figure 3-3: Potentiometric surface based on 1996 water level measurements from wells completed in model layer 3.

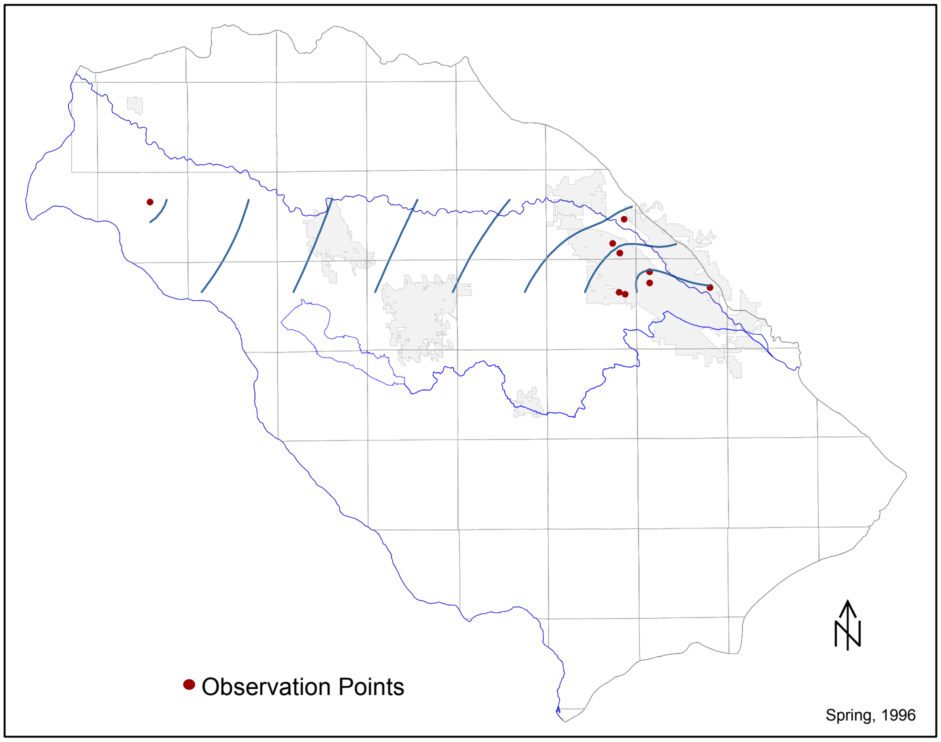
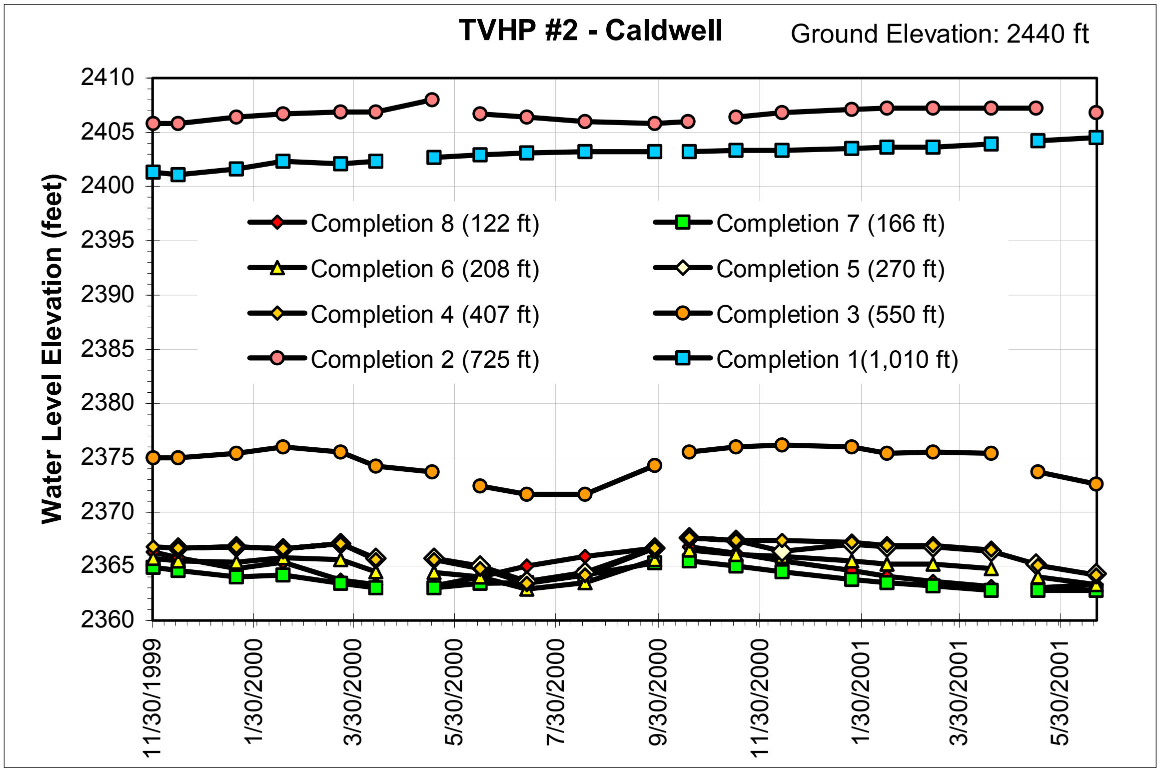
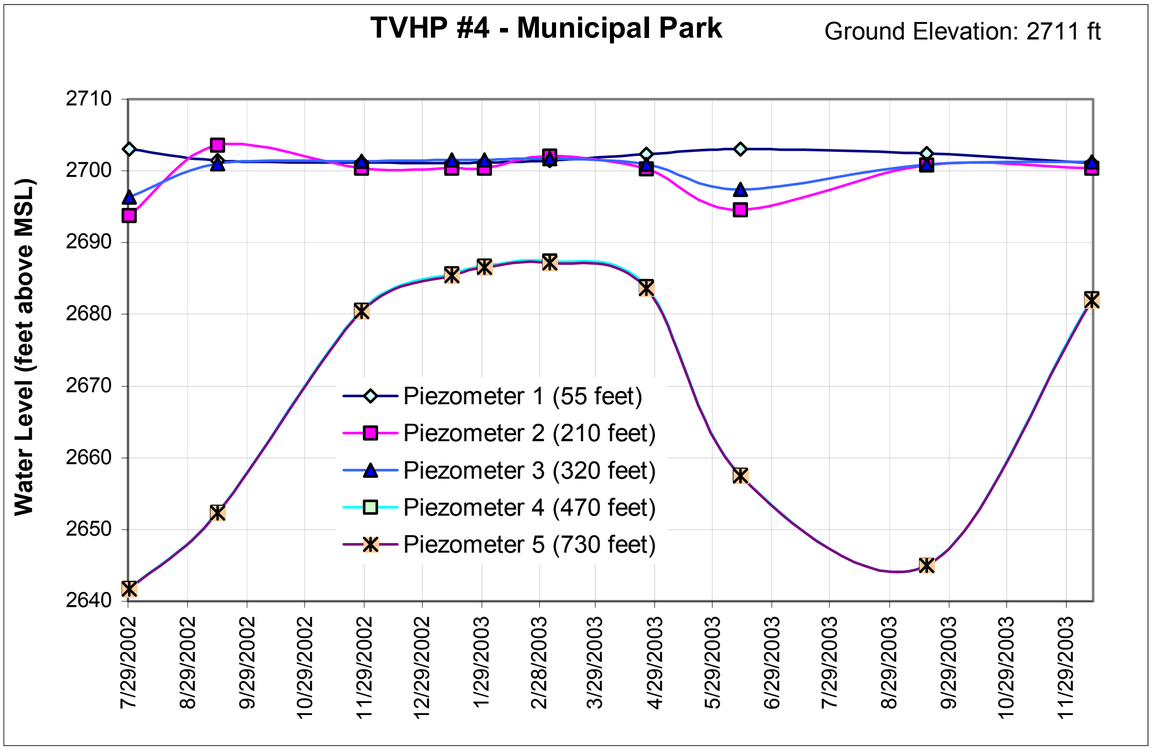


Figure 3-4: Potentiometric surface based on 1996 water level measurements from wells completed in model layer 4.



From Petrich and Urban (2004)



From Petrich and Urban (2004)

Figure 3-5: Water level data from the Caldwell and Boise Municipal Park wells.

A number of shallow monitoring wells indicated water level decreases. Shallow wells may be especially sensitive to changes in local surface water irrigation patterns in areas where the water table is not in direct hydraulic connection with surface channels. Ground water level changes are less likely in shallow wells in areas where the water table is controlled by topography (by virtue of drains and canals).

Seasonal water level fluctuations are evident in many Treasure Valley wells. The fluctuations are generally a response to seasonal increases in withdrawals (e.g., summer irrigation withdrawals) or increases in recharge associated with surface water irrigation.

The largest component of recharge to shallow aquifers is seepage from the canal system and infiltration associated with irrigated agriculture (Urban and Petrich, 1998). Water enters shallow aquifers as infiltration from canals, irrigated areas, and other water bodies (e.g., Lake Lowell), and possibly from upper reaches of the Boise River (e.g., Barber Dam to Capitol Street Bridge) during high flows. Infiltration from surface channels occurs if and when (1) water is available and (2) hydraulic heads in the channel (or lake) are higher than the surrounding aquifer heads. Additional recharge sources include mountain front recharge, underflow from the granitic Idaho Batholith and tributary sedimentary aquifers, and direct precipitation.

Shallow aquifer levels increased by as much as 100 feet in some areas in response to the initiation of large-scale flood irrigation in the late 1800s and early 1900s. Shallow ground water levels rose to and have remained at (or near) ground surface in many areas (at least seasonally), discharging to drains and other surface channels.

Shallow and intermediate aquifers are separated from deeper zones by interbedded silt and clay layers in many parts of the valley. While individual clay layers are not necessarily areally extensive, multiple clay layers in aggregate form effective barriers to vertical ground water movement.

Recharge to the deeper aquifers begins as downward flow through coarse-grained alluvial fan sediments in the eastern portion of the basin and as underflow at basin margins. Ground water is then thought to flow horizontally into the basin via more permeable sediments (e.g., coarse-grained sediments of the geological unconformity overlying Chalk Hills sediments) intersecting the alluvial fan sediments.

This is illustrated in water chemistry data collected from shallow aquifers near the New York Canal. Water in the canal, as in upper portions of the Boise River, has relatively low specific conductance (and by inference, total dissolved solids). In shallow aquifers underlying the canal, specific conductance was found to increase with depth, corresponding with canal water that has infiltrated through soil horizons. In contrast, water in deeper sand units separated from upper zones by multiple clay layers, has lower specific conductance than water in overlying horizons (Hutchings and Petrich, 2002a; Hutchings and Petrich, 2002b). This finding indicates that water in at least some deeper aquifers originates at the basin margins and does not enter the ground water regime through the carbon-rich sediments found in Treasure Valley soils.

Residence times of Treasure Valley ground water were generally found to increase with depth and with distance along a regional east-to-west-trending flow path (Hutchings and Petrich, 2002a). Residence time estimates in the regional aquifer system ranged from thousands to tens of thousands of years. The youngest waters entered the subsurface a few thousand years ago and were found along the northeastern boundary of the basin, adjacent to the Boise Foothills. The oldest waters entered the subsurface between 20,000 and 40,000 years ago and were found in the western reaches of the basin near the Snake River. Ground water in the deep deltaic aquifers beneath Boise entered the subsurface between 10,000 and 20,000 years ago.

Comparisons between measured water chemistry constituents and established models of geochemical processes (Hutchings and Petrich, 2002a) show that (1) ground water near the northeastern basin margin has experienced little interaction with aquifer minerals, and (2) ground water beyond the northeastern basin margin has experienced substantial interaction with aquifer minerals. Geochemical evolution of Treasure Valley ground water appears to be influenced by a solution of both carbonate and silicate minerals.

Ground water discharge to rivers, drains, and canals represents the dominant form of discharge from the Treasure Valley aquifer system (Urban and Petrich, 1998). The primary form of natural discharge from the deeper aquifers is thought to be regional upwelling in the southern and western portions of the basin, with ultimate discharge to the Boise River and/or Snake River. Rates of discharge from the deeper aquifers in the western portions of the valley are unknown but are probably low because of the thick accumulation of lacustrine clays separating these aquifers from ground surface.

Relatively long residence times in the regional flow system (over 20,000 years) implies that (1) regional aquifers are not very transmissive, (2) recharge rates to the deeper regional aquifers are limited, and/or (3) regional aquifers are discharge-limited. Although there are abundant silt and clay layers with low hydraulic conductivity, productive sand layers are present throughout central portions of the valley. These sand zones are tapped by many irrigation and municipal wells. Recharge to the deeper, regional system is limited, but generally has been sufficient for current rates of withdrawal. Thick lacustrine clays at the distal end of the valley likely inhibit upward (discharge) flow, limiting the amount of water that can flow through the system.

In summary, the Treasure Valley aquifer system consists of shallow aquifers containing local ground water flow systems and a deeper, regional ground water flow system. Recharge to the shallow system consists largely of infiltration from irrigated fields and canals. Primary discharge is to the Boise and Snake Rivers and other streams and to drains discharging into these channels. The deeper, regional flow system consists of (1) recharge in alluvial sediments in southeast Boise and at the base of the mountain front north of Boise, (2) movement of ground water from the recharge areas into the deeper Boise area fluvio-lacustrine aquifers, and (3) movement of ground water from the Boise area aquifers into regional lacustrine/deltaic aquifers in the central and western portions of the valley.

4. MODEL RESULTS

A numerical model of regional ground water flow in the Treasure Valley aquifer system was developed to evaluate (1) the effects of large-scale increases in ground water withdrawals on regional ground water levels and (2) the potential effects of altered recharge rates (associated with conversion of agricultural to urban land use) on regional ground water levels. The model was constructed using the three-dimensional, finite difference MODFLOW code (Harbaugh et al., 2000; McDonald and Harbaugh, 1988; McDonald and Harbaugh, 1996). The model was calibrated under steady-state hydraulic conditions using the automated parameter estimation code PEST (Doherty, 1998; Doherty, 2000). Horizontal and vertical hydraulic conductivity parameters were calibrated to 200 averaged water level observations and six actual and estimated vertical head differences. This section summarizes model results[5].

The model calibrated with higher horizontal hydraulic conductivity (K_h) values in the uppermost shallow aquifer zones, corresponding with known areas of coarser-grained sediments. PEST-calibrated parameter values also indicate relatively higher K_h and vertical hydraulic conductivity (K_v) values in areas of the eastern and central portion of the valley associated with fluvial/deltaic deposition. Simulated fluxes between model layers in the base calibration indicated that a relatively small amount of water moves vertically between model layers, especially in the lower layers. Based on simulation results, most recharge occurring in shallow aquifer zones does not reach lower zones.

A recalibration with a 10% increase or decrease in recharge led to minimal changes in water levels or parameter value estimates because shallow ground water levels in central portions of the basin are controlled, in part, by elevations of surface water channels. Increased or decreased recharge resulted in changes in the rates of water discharging to model drain, general head boundary (Lake Lowell), constant head (Snake River), and river (Boise River) cells. Changes in land use that lead to decreases in shallow-aquifer recharge may not have a substantial effect on shallow ground water levels until the water table elevations remain below those of nearby surface channels.

Simulations indicated that some ground water level declines might occur with a 20% withdrawal increase over 1996 levels. Simulated modest declines were observed in the Boise area in upper model layers (which roughly encompass the upper 400 feet of aquifer depth). Greater simulated declines were observed in the central portion of the valley (especially in the Lake Lowell area) in lower model layers (which roughly encompass aquifers zones extending from 400 to 1,200 feet in depth). The sources of water for the simulated 20% increase in withdrawals included increased leakage from

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[5] These results are based on a variety of assumptions and limitations, which are described in Petrich (2003d).

the Boise River, decreased discharge to agricultural drains, and decreased discharge to the Snake River.

These predicted changes were based on differences in water levels or mass balances between the base simulation and predictive simulations. The comparisons between the two represent changes in both the calibration and hydraulic stress (Petrich, 2004a). Additional comparisons should be done between minimized heads in both the base and predictive simulations.

Currently, there are over 450 unprocessed new water right applications in the lower Boise River basin, an area of southwestern Idaho home to approximately 35% of Idaho's population. The additional water has been requested for irrigation, municipal, commercial, and aesthetic uses. The water requested for non-supplemental uses[6] could represent an approximate 20% increase over 1996 levels of ground water withdrawals. The potential impact on regional ground water levels from processing these new well applications was evaluated using the ground water flow model.

Aquifer level declines might occur if all of these currently unprocessed, non-supplemental, ground water rights were granted. Average water level declines could range from 10 feet to over 40 feet, depending on location within the valley, the actual amount of withdrawals, and the depth of extraction. These predicted changes were based on differences in water levels or mass balances between the base simulation and predictive simulations (additional comparisons should be done between minimized heads in both the base and predictive simulations). Local areas of simulated declines were noted south of Lake Lowell, in an area in the northwestern portion of the model, and in portions of the area between Boise, Meridian, and Kuna. These may be associated with unrealistically high simulated stresses or excessively low simulated aquifer parameter values. The simulated declines may also indicate potential problems in supplying the increasing ground water demands in these areas. The least declines were predicted in the uppermost model layer, which corresponds roughly with the uppermost 200 feet of aquifer. Most of the estimated new withdrawals in the uppermost layer represented water that would otherwise have discharged to drains.

What do these predictions mean for water managers? First, predicted water level declines based on the comparisons between base and predictive simulations reflect both calibration and stress changes. Additional simulations should be conducted to compare minimized base water levels with predicted water levels. These simulations may reduce the area and magnitude of predicted declines. Second, some additional withdrawal increases might be considered in areas of stable water levels, even if predictions suggest possible water level decreases. Any increases in withdrawals should be accompanied by monitoring of water levels and extraction rates. Third,

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[6] "Supplemental" ground water is used for irrigating areas that are irrigated with surface water when surface water is available. "Non-supplemental" uses include all other ground water uses.

managers might use caution in approving additional withdrawals in areas of currently decreasing water levels and predicted water level declines. Finally, model predictions for some areas (some shallow aquifers, for instance) indicate that additional withdrawals are probably possible without affecting ground water levels. However, additional extractions in these areas may increase losses from, or decrease discharge to, surface water channels.

5. ANSWERS TO PROJECT QUESTIONS

A number of questions regarding ground water resources were raised at the beginning of the TVHP. Typical questions asked at the beginning of the project were listed in Section 1.1. This section provides answers for those questions based on project results.

1. *Does the Treasure Valley have a ground water shortage?*

The Treasure Valley does not currently have a water shortage. In total, there is a sufficient amount of water in the basin. In fact, approximately one million acre-feet of water flows out of the basin every year. However, water is not always available where and when it is needed. Currently-unprocessed well applications indicate an unfulfilled demand for water. In dry years, there may be an insufficient amount of water available for irrigation or other uses. The challenge facing IDWR and Treasure Valley water users will be to manage water so that it is available where and when it is needed.

2. *How big is our aquifer system? Where are the aquifer boundaries?*

In general, the aquifer system extends from the Boise Foothills on the north and northeast to the Snake River (Figure 2-1) on the south and west. Little is known about aquifer boundaries in the far eastern portion of the basin because of the lack of wells in this area.

Aquifer sediments extend to depths of approximately 6,000 feet (Wood and Clemens, in press). However, much of the lower portion of these sediments consists of fine-grained clay and silt, from which it is difficult to extract water. Also, elevated temperatures (e.g., greater than 85°F) in some of the deeper aquifers prevent development for cold-water uses. Most wells in the valley are less than 1,200 feet in depth; many of these draw water from the upper 250 feet of aquifer depth.

3. *Where and to what degree are ground water levels declining?*

Plots of water levels in wells (*hydrographs*) indicate relatively stable water levels in many areas, although water level declines have occurred in a number of wells. Wells in two areas, southeast Boise and south of Lake Lowell, have experienced declines of approximately 30 feet and 65 feet, respectively. Water levels in these areas appear to have stabilized in recent years. Additional ground water level declines were observed in individual wells in other areas, including the area between Eagle, west Boise, Meridian, and Kuna. Most of the long-term declines in these wells have been less than 10 feet. Reasons for the declines may include increased withdrawals from the measured wells (very few of the monitoring wells are dedicated to monitoring alone), increased nearby withdrawals, and/or changes in local infiltration rates. Further investigation of these apparent declines is warranted to determine if they reflect local (near-well) or regional conditions. Additional monitoring is also warranted in these areas of apparent declines.

A number of shallow monitoring wells indicated water level increases or decreases. Shallow wells may be especially sensitive to changes in local surface water irrigation patterns in areas where the water table is not in direct hydraulic connection with surface channels. Ground water level changes are less likely in shallow wells in areas where the water table is controlled by topography (by virtue of drains and canals).

Seasonal water level fluctuations are evident in many Treasure Valley wells. The fluctuations are generally a response to seasonal increases in withdrawals (e.g., summer irrigation withdrawals) or increases in recharge associated with surface water irrigation.

4. What is the carrying capacity of the hydrologic system in the Treasure Valley?

The carrying capacity of the hydrologic system is difficult to determine. The ultimate carrying capacity will be influenced by the valley's population, demand for water, spatial and seasonal distribution of water demand, cost of water, and other factors. Currently more than one million acre-feet of water are discharged from the valley to the Snake River every year. Some of this water may be available for further development.

There currently appears to be more capacity for ground water withdrawals in some areas (e.g., the western portion of the valley) and less in other areas (e.g., southeast Boise). Current ground water withdrawals represent a small portion of the total amount of water used in the valley. Some of the water leaving the basin may be available for additional use. The key to using existing supplies for a growing population will include the successful negotiation of transfers of water between different water uses and users.

5. What is the degree of hydraulic connection between Treasure Valley surface and ground water?

There is a high degree of connection between surface water and shallow aquifers in the Treasure Valley. Water readily seeps into or out of surface channels, depending on the difference in hydraulic head between the aquifer and surface water body.

Currently, canals drain much of the central portion of the valley. As long as aquifers are in direct hydraulic connection with surface channels, increases in withdrawals from shallow aquifers, or decreases in recharge, will lead to decreases in drain discharge in these areas or increases in losses from surface channels. If aquifer levels are below surface channels, increases in withdrawals and/or decreases in shallow recharge may lead to shallow ground water level declines.

6. How are shallow and deep aquifers connected?

Deep aquifers in the Treasure Valley are generally separated from shallow zones by layers of fine-grained sediments, such as clay and silt. This leads to confined or partially-confined conditions in deeper aquifers, indicated by water levels in wells rising above those of the deeper aquifers themselves.

There are relatively few data describing the degree of vertical hydraulic connection within the deeper, regional aquifer system. Substantial clay zones would be expected to limit vertical flow. Model simulations indicated little vertical movement in central and westerns portions of the valley because of relatively low simulated vertical hydraulic conductivity values.

7. How are Treasure Valley aquifer systems recharged and where does the recharge occur?

The primary source of ground water recharge to Treasure Valley aquifers comes from seepage and infiltration from canals and flood-irrigated fields. However, much of this recharge ultimately discharges to surface channels such as streams, rivers, and drains. Recharge to the deeper aquifers occurs primarily in the eastern portion of the basin and along the Boise Front. Only a very small portion of the total infiltration entering shallow aquifers recharges deeper aquifers.

Thick clay zones in most of the valley prevent a larger amount of water from moving downward from shallow aquifers into deeper, regional aquifers. The clay zones are generally absent in the easternmost portions of the basin, which allows downward movement of water in the eastern portion of the basin.

Similarly, there is a relatively small amount of upward ground water movement from the deep aquifers into shallow zones in the western portion of the basin. Again, thick clay zones inhibit upward flow. One of the reasons that ground water residence times in the deeper aquifers are so long is that ground water from the deep aquifer cannot return easily to ground surface.

8. How has and does land development impact Treasure Valley water supplies?

Land use in the Treasure Valley has changed substantially during the last 150 years. First, extensive construction of canals and surface irrigation in the late 1800s and early 1900s led to increases in shallow ground water levels, as much as 80 to 100 feet in some places. Water levels rose so much that shallow ground in some areas in the central portion of the valley became saturated, requiring the construction of drainage channels.

During the last several decades, the valley has experienced rapid urbanization. Community wells provide water for much of the population growth, especially in growing cities like Boise, Nampa, Caldwell, Meridian, and Eagle. In general, water for these communities comes from deeper aquifers.

Similarly, population growth in the urban-rural interface has led to the construction of many new domestic wells. These wells draw water mostly from shallow aquifers, but also from intermediate and deep aquifers, depending on location.

The extent to which urbanization of agricultural lands leads to changes in shallow aquifer recharge is not clear. Newly developed residential and commercial areas may have less irrigated area, but water may be applied at higher rates and for longer seasons than the previously agricultural area. This is an area that merits further investigation.

Some urban developments are using pressurized irrigation systems with surface water that was used previously for agricultural irrigation. Pressurized irrigation system water stemming from surface water sources may contribute to shallow aquifer recharge. Such irrigation systems reduce the need for irrigation with treated municipal water (which generally comes from deeper aquifers).

Simulations show that modest decreases in shallow aquifer recharge (e.g., 10%) on a regional basis will generally result in increased seepage from canals and/or decreased flow to drains. Increased withdrawals from shallow aquifers would have similar effects.

9. How susceptible is the Treasure Valley aquifer system to contamination?

The Treasure Valley aquifer system is susceptible to contamination in a number of ways. Land use activities can lead to direct contamination of shallow aquifers. Wells completed with poor surface seals can allow contaminants to move into the aquifer from ground surface. Wells completed in multiple aquifers, or wells with inadequate seals between aquifers, can allow contaminants in upper aquifers to migrate to deeper zones. Similarly, in areas with upward hydraulic gradients, these can lead to unnecessary flow from deeper zones to shallower zones.

10. Is water conservation necessary to meet future water demands?

Efficient use of a resource is always a worthwhile goal. There are clearly opportunities for water conservation, especially if the source of water is the deeper, regional aquifer system. However, surface water irrigation, through canal leakage or infiltration from irrigated fields, is the source of a large portion of recharge to shallow aquifers. Increasing efficiency in these areas could lead to decreased discharge to drains. If ground water levels decline below that of drains, the increased efficiency may lead to exacerbated declines in shallow aquifer levels. This may impact some shallow wells. Some form of managed aquifer recharge may be required if increases in agricultural irrigation efficiency lead to declining water levels.

11. Can tools and/or data be developed to assist local, state, and federal governments with decisions on issues that impact water resources, such as land use planning, zoning, water rights, septic tank permitting, waste treatment, etc.?

The tools and data developed as part of the TVHP have helped and will continue to help water managers make better decisions about water resource issues. Numerical modeling will assist in the evaluation of regional water management strategies. The model will also provide a basis for developing possible conjunctive administration options. Data from the numerical model have and will continue to be used to evaluate source water areas for public water supply wells. Spatial and hydrologic data are available for a variety of resource evaluations.

The study focused on regional-scale ground water flow. The study did not provide answers to site-specific land use planning, zoning, septic tank permitting, or waste treatment questions. Results of this study, however, provide a framework for addressing water resource questions on a local scale.

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Appendix A: Conversion Factors

Volume

1 cubic foot of water = 7.4805 gallons = 62.37 pounds of water
1 acre-foot (af) = enough water to cover 1 acre of land 1 foot deep
1 acre-foot (af) = 43,560 cubic feet
1 acre-foot (af) = 325,850 gallons
1 million gallons = 3.0689 acre-feet

Flow Rates

1 cubic foot per second (cfs) = 448.83 gallons per minute (gpm) = 26,930 gallons per hour
1 cubic foot per second (cfs) = 646,635 gallons per day = 1.935 acre-feet per day
1 cubic foot per second (cfs) for 30 days = 59.502 acre-feet
1 cubic foot per second (cfs) for 1 year = 723.94 acre-feet
1 cubic meter per second (cms) = 25.31 cubic feet per second
1 cubic meter per second (cms) = 15,850 gallons per minute
1 million gallons per day (mgd) = 1,120.147 acre-feet per year
1 miner’s inch = 9 gallons per minute
1 miner’s inch = 0.02 cubic feet per second

Hydraulic Conductivity

1 gallon per day per foot^2 (gal/day/ft^2) = 0.134 foot/day = 0.0408 meters/day

Economic

$0.10 per 1,000 gallons = $32.59 per acre-foot

APPENDIX B: SOURCES OF REPORTS AND INFORMATION

Data and information generated from this project are available from the following source:

Idaho Department of Water Resources
1301 North Orchard Street
Boise, ID 83706-2237
Contact: Scott Urban, (208) 327-5441
(208) 327-7866 (fax)
E-mail: surban@idwr.state.id.us
Website: http://www.idwr.state.id.us
(*project reports, data, maps, GIS coverages, and other information*)

Costs associated with this publication are available from the Idaho Department of Water Resources in accordance with Section 60-202, *Idaho Code*. IDWR-21000-20-03/2004.