GROUND-WATER QUALITY CLASSIFICATION FOR THE PRINCIPAL BASIN-FILL AQUIFER, SALT LAKE VALLEY, SALT LAKE COUNTY, UTAH

by

Janae Wallace and Mike Lowe

Utah Geological Survey

August 25, 2008

LICENSED PROFESSIONAL GEOLOGIST
JANAE J. WALLACE
5247814-2250
STATE OF UTAH

INTRODUCTION

This is a formal petition to the Utah Water Quality Board submitted by White City Water Improvement District acting on behalf of itself and other Salt Lake County water providers to classify ground-water quality in the principal basin-fill aquifer of Salt Lake Valley (figure 1) under "Administrative Rules for Ground Water Quality Protection R317-6, March 1, 2007," Section 317-6-5, Ground Water Classification for Aquifers, Utah Administrative Code.

Salt Lake County has the largest county population in Utah, estimated at 996,374 in 2006 (Demographic and Economic Analysis Section, 2007). Salt Lake County residents make up 38.1% of Utah's total population of 2,615,129 (Demographic and Economic Analysis Section, 2007). Based on projections made in 2005, the population of Salt Lake County is expected to increase to 1,053,258, 1,230,817, and 1,381,519 in 2010, 2020, and 2030, respectively (Demographic and Economic Analysis Section, 2005). The annual increase in population of Salt Lake County from 2005 to 2006 was 1.8%. The increase in population in Salt Lake County between 1990 and 2000 was 23.8% (Demographic and Economic Analysis Section, 2001).

The climate in Salt Lake Valley can be described as semi-arid with hot summers and moderately cold winters. However, due to the local topography and the large relief between the mountains and valley, the weather can be quite variable and is related to orographic effects and local weather patterns (Murphy, 1981). The mountains surrounding the valley typically receive substantially more precipitation and have cooler temperatures than the valley, and the southeast part of the county receives the most precipitation.

FACTUAL DATA

Sufficient information is available to classify the basin-fill aquifer in Salt Lake Valley. Data required to formally petition the Utah Water Quality Board were mostly obtained from

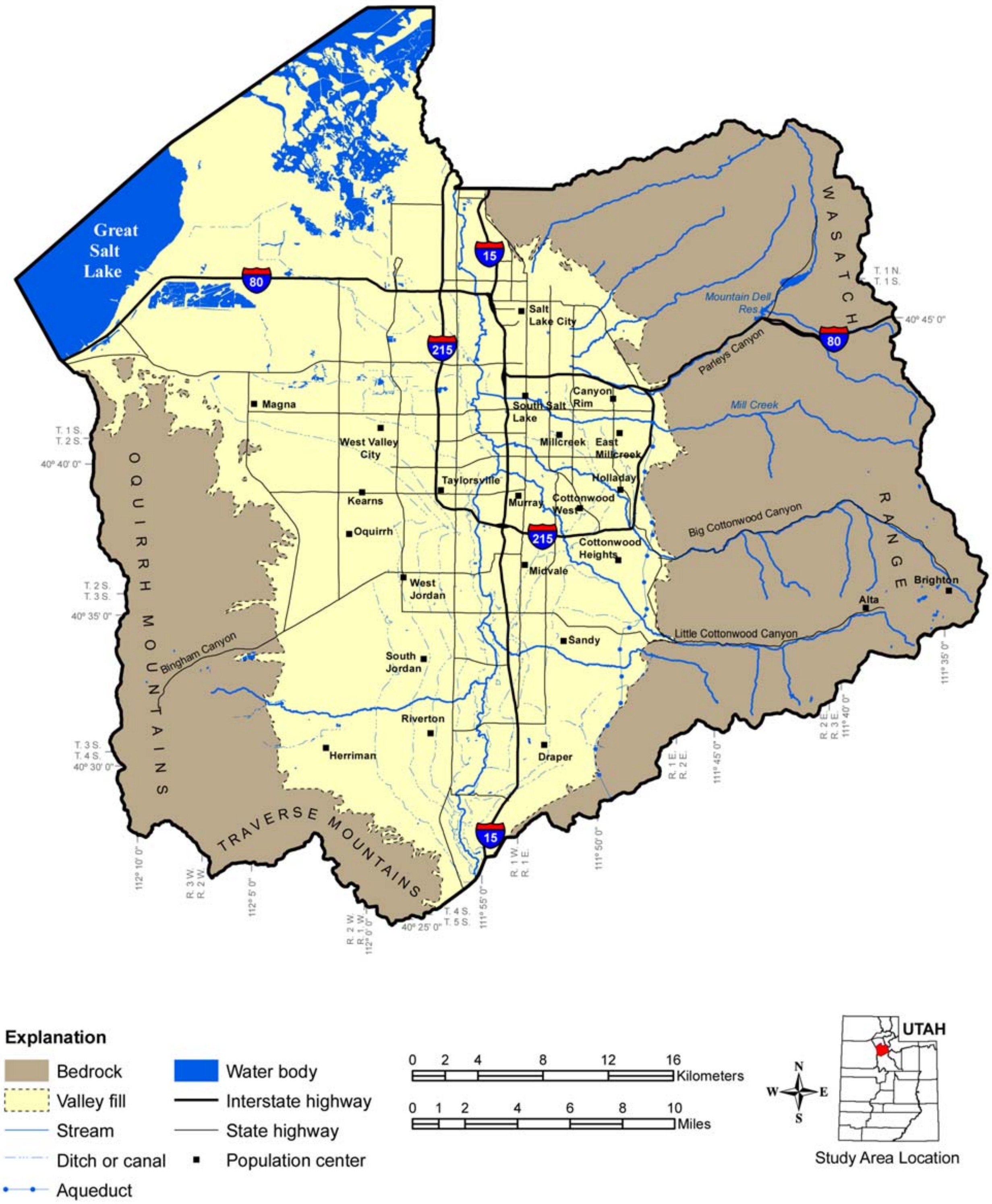

Figure 1. *Salt Lake Valley, Salt Lake County, Utah, study area.*

Utah Geological Survey

previously published studies. Most of the information required for classification is contained on maps and data tables submitted with this petition, including:

- Plate 1 - Ground-water quality map showing total-dissolved-solids concentrations.
- Plate 2 - Ground-water quality classification map showing ground-water quality classification, well locations, and ground-water flow direction.
- Plate 3 - Potential-contaminant-source map.

In addition, provided along with this petition are the following previously released publications containing valuable information about the Salt Lake Valley basin-fill aquifer:

- Chemical quality of ground water in Salt Lake Valley, Utah, 1969-85 (Waddell and others, 1987b)
- Water quality in the Great Salt Lake Basins Utah, Idaho, and Wyoming, 1998-2001 (Waddell and others, 2004).

Many of the other publications listed in the previous work section of this document can be found online at: http://nrwrt1.nr.state.ut.us/cgi-bin/libview.exe?STARTUP.

GEOLOGIC SETTING

Salt Lake Valley is a north-south-trending valley located in north-central Utah southeast of Great Salt Lake. Salt Lake Valley is in the Salt Lake Valley segment of the Wasatch Front Valleys section of the Great Basin physiographic province (Stokes, 1977). The valley is bounded on the east and northeast by the central portion of the Wasatch Range, on the northwest by Great Salt Lake, on the west by the Oquirrh Mountains, and on the south by the Traverse Mountains. Elevations range from about 4200 feet (1280 m) in the lowest part of the valley near Great Salt Lake to more than 7000 feet (2130 m) in the Traverse Mountains, 9000 feet (2740 m) in the Oquirrh Mountains, and 11,000 feet (3350 m) in the Wasatch Range.

The Salt Lake Valley is also known as Jordan Valley because of the Jordan River, which flows northward into the valley through the Jordan Narrows, a water gap in the Traverse Mountains, and ultimately into Great Salt Lake. Six other major streams flow into the valley from the Wasatch Range to the east and into the Jordan River; these streams are mainly fed by snowmelt during the spring and early summer. Only minor amounts of water enter the valley from the Oquirrh Mountains.

The mountains that surround the Salt Lake Valley are composed of rocks that range in age from Precambrian to Tertiary. The Wasatch Range consists of Precambrian, Paleozoic, Mesozoic, and Cenozoic sedimentary rocks that have been intruded by Tertiary granitic and dioritic stocks. The Oquirrh Mountains consist of Paleozoic sedimentary rocks, predominantly the Oquirrh Formation, and intrusive and extrusive Cenozoic rocks. The Traverse Mountains are composed of Paleozoic sedimentary rocks and Cenozoic volcanics.

The Salt Lake Valley is a half-graben that is bounded by faults on its east, west, and south sides. Sediments have been filling this graben since the Tertiary. The Tertiary and Quaternary basin fill is up to 4000 feet (1220 m) thick in some areas of the valley (Mattick, 1970), and consists of unconsolidated to semi-consolidated clay, silt, sand, gravel, tuff, and lava. Quaternary sediments in the upper part of the basin fill range from 0 to 2000 feet (0-610 m) thick (Arnow and others, 1970). The depositional sequence in the basin fill is complex (Marine and Price, 1964) due to alternating periods of lacustrine and interlacustrine conditions during the late Tertiary and Quaternary. During the lacustrine periods, or deep-lake cycles, much of Salt Lake Valley was covered with water and offshore silt and clay were deposited in the central parts of the valley while deltaic (at the mouths of canyons) and nearshore sand and gravel were deposited along valley margins. During interlacustrine periods, sediments were deposited primarily as alluvial fans at canyon mouths and as fluvial-channel and floodplain sediments in the central parts of the valley. As a general rule, coarser grained sediments exist near valley margins and finer grained sediments exist in the middle and north end of the valley.

PREVIOUS STUDIES

Richardson (1906) conducted the first investigation of ground-water conditions in Salt Lake Valley; this study, which included Utah Valley, produced maps showing depth to ground water and the areas of flowing wells. Taylor and Leggette (1949) conducted a more thorough investigation that included many well records, and discussions of ground-water occurrence, recharge and discharge, and chemical quality. Lofgren (1952) discussed the status of ground-water development in Salt Lake Valley as of 1951. Marsell (1964) discussed water-supply issues as part of a comprehensive review of the geology of Salt Lake County. Marine and Price (1963) compiled selected hydrologic data, and Marine and Price (1964) updated previous studies and subdivided the valley into ground-water districts for water-resource management purposes. Iorns and others (1966a, 1966b) and Hely and others (1967, 1968, 1969) compiled hydrologic and climatalogic data that were used to produce a summary of ground-water hydrology in Salt Lake Valley (Mower, 1969a) and water resources in Salt Lake County (Hely and others, 1971). Arnow and Mattick (1968) evaluated the thickness of basin-fill deposits. Mower (1968) discussed ground-water discharge toward Great Salt Lake in basin-fill deposits. Mower (1969b) discussed ground-water inflow through channel fill in seven Wasatch Range canyons in Salt Lake County. Arnow and others (1970) used water-well logs to delineate the pre-Quaternary surface in Salt Lake Valley to be used as a general guide for water-well drilling. Mower (1970) discussed ground-water recharge to Salt Lake Valley from Utah Valley. Seiler and Waddell (1984) conducted an assessment of the shallow unconfined aquifer in Salt Lake Valley. Herbert and others (1985) conducted a seepage study of six canals in Salt Lake County. Waddell and others (1987a) evaluated ground-water conditions in Salt Lake Valley with emphasis on predicted effects of increased withdrawals from wells. Waddell and others (1987b) evaluated the chemical quality of ground water in the basin-fill aquifer for the 1969-85 time period. Baskin (1990) evaluated selected factors related to the potential contamination of the principal aquifer in Salt Lake Valley. Thiros (1992) compiled selected hydrologic data for Salt Lake Valley with emphasis on data from the shallow unconfined aquifer and confining layers. Anderson and others (1994; see also Anderson and Susong, 1995) mapped ground-water recharge and discharge areas for the principal aquifers along the Wasatch Front, including the principal aquifer in Salt Lake Valley. Thiros (1995) investigated the chemical composition and movement of ground water, and the hydrologic properties of basin-fill material, to better understand the flow system in Salt Lake Valley. Lambert (1995a) produced a three-dimensional, finite-difference, numerical ground-water flow model for the basin-fill aquifer, which was used to produce capture zones for selected public supply wells (Lambert, 1995b) and simulate the movement of sulfate in ground water (Lambert, 1996). Thiros (2003a) described the quality of ground-water in parts of the shallow unconfined aquifer in Salt Lake Valley. Thiros (2003b) described the hydrogeology of shallow basin-fill deposits in Salt Lake Valley. Thiros and Manning (2004) discussed the quality and sources of ground water used for public supply in Salt Lake Valley. Waddell and others (2004) assessed water quality in the Great Salt Lake basins, including Salt Lake Valley. Burden and others (2005) described changes in ground-water conditions in Utah, including Salt Lake Valley, from 1975 to 2005. Lowe and others (2005), Wallace and Lowe (2006), and Lowe and Wallace (2006) mapped ground-water sensitivity and vulnerability to pesticides.

Woodward and others (1974) mapped soils (scale 1:20,000) for Salt Lake County. Regional geologic maps covering the study area include the geologic map of Salt Lake County by Marsell and Threet (1964), the geologic map of the Tooele 1 x 2 degree quadrangle by Moore and Sorensen (1979), the geologic map of the Salt Lake City 30’ x 60’ quadrangle by Bryant (1990), the geologic map of the Salt Lake City segment of the Wasatch fault zone by Personius and Scott (1992), and the geologic map of the Oquirrh and Traverse Mountains by Tooker and Roberts (1998).

GROUND-WATER CONDITIONS

Basin-Fill Aquifer

The basin-fill aquifer system in Salt Lake Valley includes (1) a confined aquifer in the central and northern parts of the basin, (2) a deep unconfined aquifer between the confined aquifer and the mountains, (3) a shallow unconfined aquifer overlying the artesian (confined) aquifer, and, locally, (4) unconfined perched aquifers (Hely and others, 1971) (figure 2). Together, the confined aquifer and the deep unconfined aquifer form the “principal aquifer”– most of the ground water discharged from wells in Salt Lake Valley is from the principal aquifer.

The confined aquifer consists primarily of Quaternary deposits of clay, silt, sand, and gravel, which, although layered, are all hydraulically interconnected (Hely and others, 1971). The Quaternary deposits range in thickness from 0 to over 2000 feet (0 to over 600 m) (Arnow and others, 1970); underlying these sediments are relatively impermeable consolidated and semi-consolidated Tertiary and pre-Tertiary deposits. However, a few areas exist where the Tertiary deposits consist of permeable sand and gravel that yield water to wells, and in these areas are considered part of the principal aquifer (Hely and others, 1971).

Overlying the confined aquifer is an upper confining layer composed of individual Quaternary deposits of clay, silt, and fine sand that collectively create a single impermeable layer. The confining layer is between 40 and 100 feet (12 and 30 m) thick, and the top of the layer is between 50 and 150 feet (15 and 46 m) below the land surface (Hely and others, 1971).

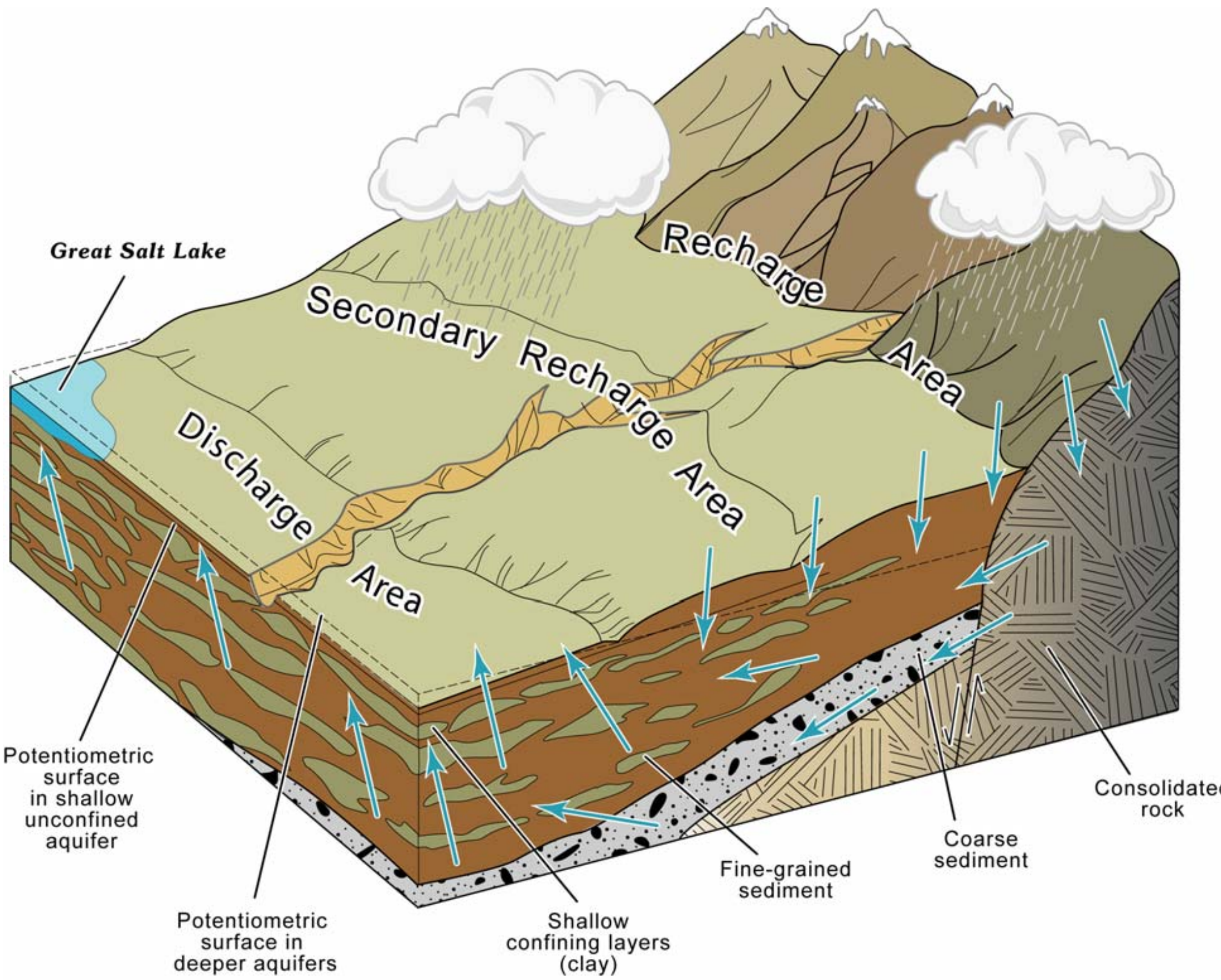

Figure 2. *Generalized block diagram showing water-bearing formations, probable direction of ground-water movement (arrows), and areas of recharge and discharge, Salt Lake Valley, Salt Lake County, Utah (modified from Hely and others, 1971, Thiros and Manning, 2004).*

The shallow unconfined aquifer overlies the confining layer and is composed primarily of fine-grained sediments (Hely and others, 1971). It is only slightly more permeable than the confining layer, and in some areas it is difficult to differentiate between the two (Hely and others, 1971). The shallow unconfined aquifer has a maximum thickness of about 50 feet (15 m) (Waddell and others, 1987b) and yields little water (the water is generally of low quality), thus, is rarely used for water supply (Seiler and Waddell, 1984).

The deep unconfined aquifer lies between the confined aquifer and the mountains. It is part of the principal aquifer, where the water table lies below the confining layer or the confining layer is absent (Hely and others, 1971). Perched aquifers exist above the deep unconfined aquifer where there is an unsaturated zone between the water table in the deep unconfined aquifer and the bottom of the upper confining layer. The principal areas having perched aquifers are east of Midvale and between Riverton and Herriman (Hely and others, 1971), but less extensive perched aquifers are scattered around the margins of Salt Lake Valley.

Recharge to the ground-water flow system in the basin-fill aquifer is primarily from inflow from consolidated rock along the valley margins; seepage from rivers, streams, and canals that have a water-level elevation higher than the water table, infiltration of precipitation on the valley floor; and infiltration from unconsumed irrigation water (Hely and others, 1971). Ground water flows from the recharge areas in the mountains and near the valley margins to the deep unconfined aquifer, then toward the central and northern parts of the valley, where the principal aquifer is confined. This creates an upward gradient, and ground water in the confined aquifer flows upward into the confining layer and then into the shallow unconfined aquifer, where it discharges into the Jordan River, springs, drains, canals, and Great Salt Lake, or is lost through evapotranspiration. Ground water in the principal aquifer is either discharged into the shallow unconfined aquifer or is withdrawn by wells (Hely and others, 1971).

Transmissivity and storage coefficients range from 1000 to 50,000 feet squared per day (90-5000 m^2/d) and 0.15 to less than 0.0001 for the unconfined and confined parts of the principal aquifer, respectively (Hely and others, 1971). The transmissivity of the shallow unconfined aquifer ranges from 50 to 4000 feet squared per day (5-370 m^2/d) (Waddell and others, 1987b), and the storage coefficient is estimated to average 0.15 (Hely and others, 1971). The vertical hydraulic conductivity of the confining bed between the shallow unconfined and principal aquifer is estimated to average 0.025 feet per day (0.008 m/d) (Hely and others, 1971).

Water levels in wells completed in the principal aquifer generally declined in most parts of Salt Lake Valley between 1975 and 2005 (Burden and others, 2005), with the greatest declines in the central-eastern and southern parts of the valley (figure 3). Water levels rose in wells in the northwestern and northeastern parts of the valley during the same time period.

Ground-Water Quality From Previous Work

The chemical composition of ground water in Salt Lake Valley varies with location and depth, primarily due to quality of recharge sources and water-rock interactions as it moves through the aquifer. Most of the recharge occurs on the east side of the valley, and ground water in the principal aquifer typically has lower total-dissolved-solids (TDS) concentrations near the mouths of the larger streams (Big Cottonwood Creek, Little Cottonwood Creek) in southeastern Salt Lake Valley (Hely and others, 1971); calcium-magnesium-bicarbonate type ground water is generally found in this part of the valley (Thiros, 1995). Both bicarbonate-type ground water and sodium-chloride-type ground water exist in the northwestern part of Salt Lake Valley (Thiros, 1995). Ground water in the principal aquifer with the highest TDS concentrations is generally found in the vicinity of Great Salt Lake in the northwestern part of the valley (Hely and others, 1971). Based on wells completed in the principal aquifer from 1988 to 1992, the TDS

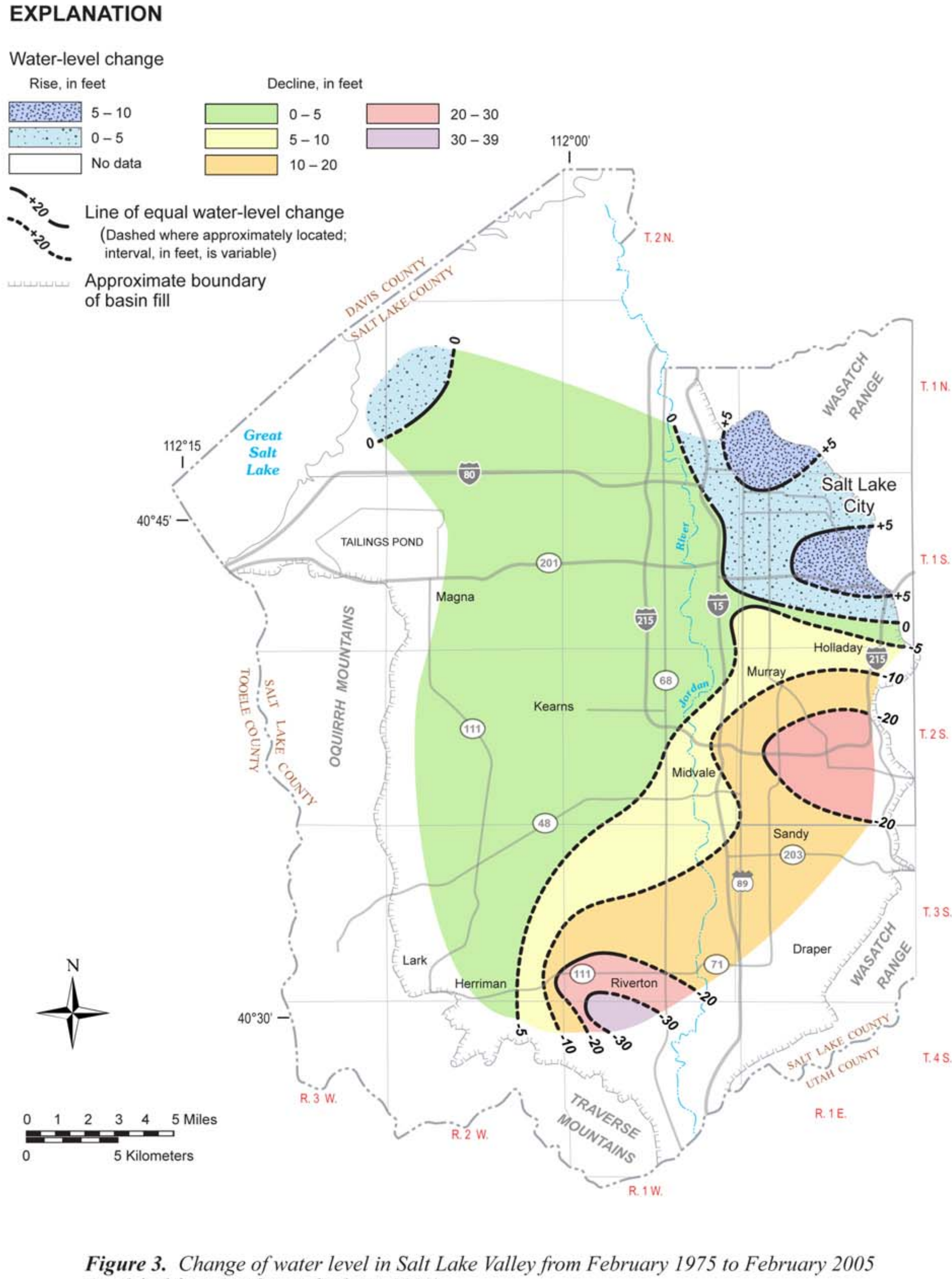

Figure 3. *Change of water level in Salt Lake Valley from February 1975 to February 2005 (modified from Burden and others, 2000).*

concentrations ranged from 110 mg/L on the southeast side of the valley to 48,100 mg/L on the northwest side (Thiros, 1995). Ground water in the principal aquifer generally has lower TDS concentrations than water in the shallow unconfined aquifer (Hely and others, 1971).

Total-dissolved-solids concentrations for ground water in the shallow unconfined aquifer range from 331 mg/L in the eastern portion to 20,900 mg/L for the western portion of the valley (Thiros, 1995). The proximity to land surface, evapotranspiration, dissolution of minerals, and recharge from water diverted from the Jordan River create more localized variations and higher dissolved-solids concentrations in water from the shallow unconfined aquifer (Hely and others, 1971; Thiros, 1995). Chloride concentrations have steadily increased in the principal aquifer, probably from salt used for de-icing roads (Thiros, 1995).

Ground water between the mouth of Bingham Canyon and the Jordan River has been contaminated by seepage from evaporation ponds associated with mining activities (Hely and others, 1971). The contaminated ground water is acidic and has TDS concentrations as high as 75,000 mg/L (Waddell and others, 1987a). Ground water in the shallow unconfined aquifer in the vicinity of South Salt Lake near the Jordan River has also been contaminated by leachate from uranium-mill tailings; ground water from this area has TDS concentrations as high as 21,000 mg/L, and is contaminated with chloride, sulfate, iron, and uranium (Waddell and others, 1987a). Volatile organic compounds and pesticides (primarily atrazine) are commonly found in monitoring wells completed in the shallow unconfined aquifers; most of the volatile organic compounds and all of the pesticides were below drinking water standards (Waddell and others, 2004).

Hydrogeologic Setting

Hydrogeologic setting is delineated on ground-water recharge-area maps which typically show (1) primary recharge areas, (2) secondary recharge areas, and (3) discharge areas (Anderson and others, 1994), illustrated schematically in figure 4. Primary recharge areas, commonly the uplands and coarse-grained unconsolidated deposits along basin margins, do not contain thick, continuous, fine-grained layers (confining layers) and have a downward ground-water gradient. Secondary recharge areas, commonly mountain-front benches, have fine-grained layers thicker than 20 feet (6 m) and a downward ground-water gradient. Ground-water discharge areas are generally in basin lowlands. Discharge areas for unconfined aquifers occur where the water table intersects the ground surface to form springs, seeps, lakes, wetlands, or gaining streams (Lowe and Snyder, 1996). Discharge areas for confined aquifers occur where the ground-water gradient is upward and water discharges to a shallow unconfined aquifer above the upper confining bed, or to a spring. Water from wells that penetrate confined aquifers may flow to the surface naturally. The extent of both recharge and discharge areas may vary seasonally and from dry years to wet years.

Anderson and others (1994) used drillers' logs of water wells in Salt Lake Valley to delineate primary recharge areas and discharge areas, based on the presence of confining layers and relative water levels in the principal and shallow unconfined aquifers. Although this technique is useful for acquiring a general idea of where recharge and discharge areas are likely located, it is subject to a number of limitations. The use of drillers' logs requires interpretation because of the variable quality of the logs. Correlation of geology from well logs is difficult because lithologic descriptions prepared by various drillers are generalized and commonly inconsistent. Use of water-level data from well logs is also problematic because levels in the

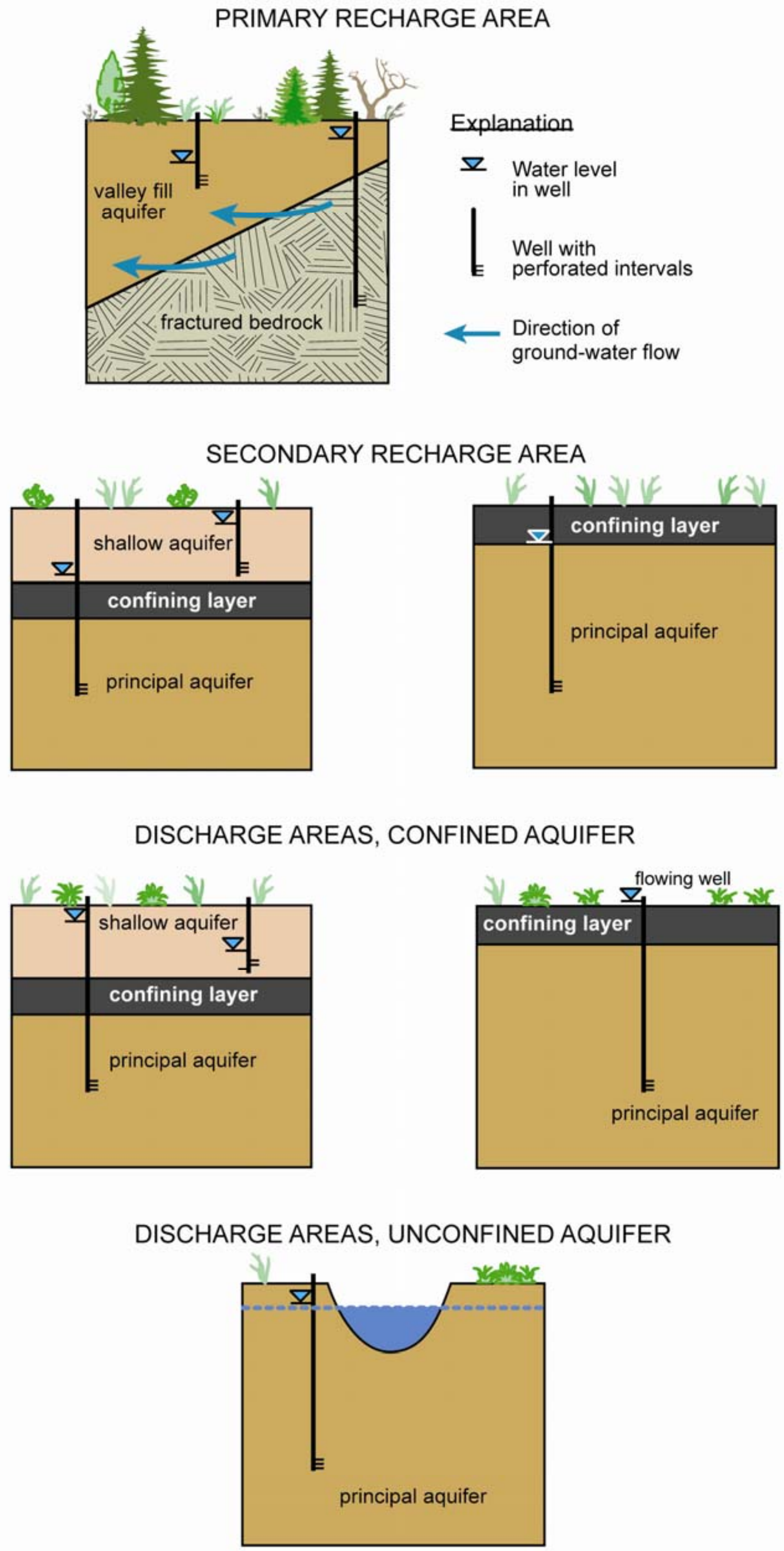

Figure 4. *Relative water levels in wells in recharge and discharge areas (modified from Snyder and Lowe, 1998).*

shallow unconfined aquifer are often not recorded and because water levels were measured during different seasons and years.

Confining layers are any fine-grained (clay and/or silt) layer thicker than 20 feet (6 m) (Anderson and others, 1994; Anderson and Susong, 1995). Some drillers' logs show both clay and sand in the same interval, with no information describing relative percentages; these are not classified as confining layers (Anderson and others, 1994). If both silt and clay are checked on the log and the word "sandy" is written in the remarks column, then the layer is assumed to be a predominantly clay confining layer (Anderson and others, 1994). Some drillers' logs show clay together with gravel, cobbles, or boulders; these also are not classified as confining layers, although in some areas of Utah layers of clay containing gravel, cobbles, or boulders can act as confining layers.

The primary recharge area for the principal aquifer system in Salt Lake Valley consists of the uplands along the margins of the basin, as well as basin fill not containing confining layers (figure 4), generally located along the mountain fronts. Ground-water flow in primary recharge areas has a downward component. Secondary recharge areas, if present, are locations where confining layers exist, but ground-water flow maintains a downward component. Secondary recharge areas generally extend toward the center of the basin to the point where ground-water flow is upward (figure 4). The ground-water flow gradient, also called the hydraulic gradient, is upward when the potentiometric surface of the principal aquifer system is higher than the water table in the shallow unconfined aquifer (Anderson and others, 1994). Water-level data for the shallow unconfined aquifer are not abundant, but exist on some well logs. When the confining layer extends to the ground surface, secondary recharge areas exist where the potentiometric surface in the principal aquifer system is below the ground surface.

Ground-water discharge areas generally are at lower elevations than recharge areas. In discharge areas, the water in confined aquifers discharges to the land surface or to a shallow unconfined aquifer (figure 4). For this to happen, the hydraulic head in the principal aquifer system must be higher than the water table in the shallow unconfined aquifer. Otherwise, downward pressure from the shallow aquifer exceeds the upward pressure from the confined aquifer, creating a net downward gradient indicative of secondary recharge areas. Flowing (artesian) wells, indicative of discharge areas, are marked on drillers' logs and on U.S. Geological Survey 7.5-minute quadrangle maps. Wells with potentiometric surfaces above the top of the confining layer can be identified from well logs. Surface water, springs, or phreatophytic plants characteristic of wetlands can be another indicator of ground-water discharge. In some instances, however, this discharge may be from a shallow unconfined aquifer. An understanding of the topography, surficial geology, and ground-water hydrology is necessary before using these wetlands to indicate discharge from the principal aquifer system.

Anderson and others' (1994) map (figure 5; plate 3) shows that primary recharge areas, the areas most susceptible to contamination from contaminants applied to the land surface, comprise about 29% of the surface area of the basin-fill aquifer. Secondary recharge areas make up an additional 29% of the surface area of the basin-fill aquifer. Ground-water discharge areas, which provide extensive protection to the principal aquifer from surface contamination, make up 42% of the surface area of the basin-fill aquifer.

GROUND-WATER QUALITY CLASSIFICATION DATA

To facilitate this ground-water quality classification, the Utah Geological Survey used water-quality data from 189 wells provided to us by the U.S. Geological Survey (USGS) and downloaded from the U.S. Environmental Protection Agency (EPA) STORET website (appendix

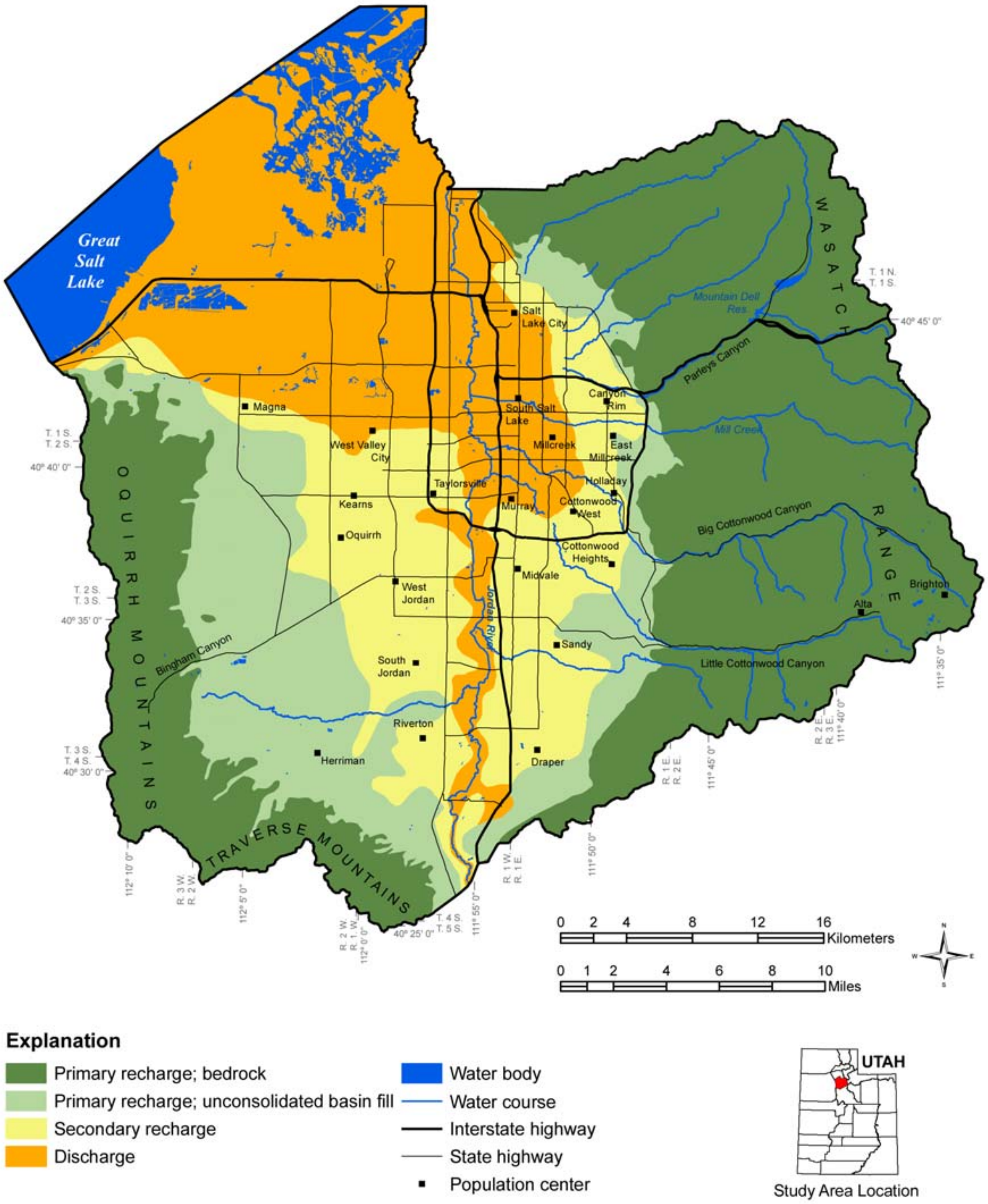

Figure 5. *Recharge and discharge areas in Salt Lake Valley, Salt Lake County, Utah (modified from Anderson and others 1994).*

A). Most of the data provided by the USGS are from ground-water samples collected from public-supply wells during May/June 2001.

Total-Dissolved-Solids Concentrations

The Utah Water Quality Board's drinking-water quality (health) standard for total dissolved solids is 2000 mg/L for public-supply wells. The secondary ground-water quality standard is 500 mg/L (U.S. Environmental Protection Agency, 2008), and is primarily due to imparting a potential unpleasant taste to the water. Plate 1 shows the distribution of TDS in Salt Lake Valley's basin-fill aquifer. Based on data from ground-water samples from 189 wells, TDS ranges from 110 to 63,556 mg/L (appendix A, plate 1). The average TDS is 2215 mg/L and the median TDS is 480 mg/L. Ground water from 23 wells exceeds 3000 mg/L TDS.

Nitrate Concentrations

The ground-water quality (health) standard for nitrate is 10 mg/L (U.S. Environmental Protection Agency, 2008). More than 10 mg/L of nitrate in drinking water can result in a condition known as methemoglobinemia, or "blue baby syndrome" in infants under six months (Comley, 1945), which can be life threatening without immediate medical attention (U.S. Environmental Protection Agency, 2008). This condition is characterized by a reduced ability for blood to carry oxygen. Stomach cancer in human beings has been associated with nitrate from drinking water and was reported in Columbia and Denmark (Cuello and others, 1976, Fraser and others, 1980). Based on data from ground-water samples from 189 wells, nitrate-as-nitrogen concentrations range from less than 0.26 to 5.99 mg/L, and the average nitrate-as nitrogen concentration is 1.8 mg/L and the median is 1.28 mg/L.

Other Constituents

Based on the data obtained from the USGS and the EPA STORET website, 25 wells exceeded primary water-quality standards and 5 wells exceeded secondary water-quality standards (U.S. Environmental Protection Agency, 2008). Nineteen wells exceeded the primary water-quality standard/maximum contaminant level (MCL) of 10 µg/L for arsenic (5 from USGS data [Thiros and Manning, 2004] and 14 from STORET data). Small amounts of arsenic can cause skin damage or circulatory system problems, and may increase the risk of cancer. Five wells exceeded the standard for cadmium (MCL of 5 µg/L); excess cadmium can cause vomiting and nausea in humans at 15 mg/L. Four wells exceeded the EPA standard for copper (MCL of 1300 µg/L); excess copper can cause symptoms of gastroenteritis, including nausea and vomiting. Four wells exceeded the EPA standard for zinc (MCL of 5000 µg/L); excess zinc is typically associated with corrosion of piping and is not considered harmful to health. Two wells exceeded the EPA standard for selenium (MCL of 50 µg/L); symptoms of selenium toxicity include skin, nail, and hair damage and also excessive salivation, shallow breathing, breath odor, and diarrhea in humans and animals. Other signs of acute selenium poisoning are vomiting, spasms, and death from respiratory failure. Secondary standards were exceeded for aluminum in 2 wells, iron in 10 wells, manganese in 3 wells, and sulfur in 18 wells. Secondary standards are typically associated with unpleasant coloration and odors, and pose no harmful health effect on human beings (U.S. Environmental Protection Agency, 2008). Most of these reported elevated concentrations are associated with wells located in the southwestern part of the study area (see STORET data http://iaspub.epa.gov/stormodb/DW_RESULT_COUNT -- users must download their own files to obtain STORET files, specific dates and sites cannot be obtained from this link; below is an example of one link used to obtain data for this petition: http://www.epa.gov/storpubl/modern/downloads/slc_SDR20070328). Thiros and Manning

(2004) attributed high arsenic levels for four of the five public-supply wells located on the west side of the valley to the relative abundance of arsenic-bearing minerals in the fine-grained deposits there and the relatively lower amount of recharge available to transport arsenic.

PROPOSED CLASSIFICATION

Under "Administrative Rules for Ground Water Quality Protection R317-6, March 1, 2007," Section 317-6-3, Ground Water Classes, Utah Administrative Code, Utah's ground-water quality classes are based on TDS concentrations as shown in table 1. Two other classes, IB and IC, are not based on ground-water chemistry. Class IB ground water, called Irreplaceable ground water, is a source of water for a community public drinking-water system for which no reliable supply of comparable quality and quantity is available because of economic or institutional constraints; this class has not been considered as part of this petition. Class IC ground water, called Ecologically Important ground water, is a source of ground-water discharge important to the continued existence of wildlife habitat. Ground-water protection levels for classes IA and IB, as set under "Administrative Rules for Ground Water Quality Protection R317-6, March 1, 2007," Section 317-6-4, Ground Water Class Protection Levels, Utah Administrative Code, are more stringent than for other ground-water quality classes.

White City Water Improvement District, acting on behalf of itself and other Salt Lake County water providers, is petitioning the Utah Water Quality Board to classify the principal basin-fill aquifer in Salt Lake Valley as shown on plate 2. The classification is based on data from ground water from the 189 wells presented in appendix A. Where insufficient data exist, extrapolation of ground-water quality conditions is required. We based the extrapolation on local geologic characteristics. The classes (plate 2) are described below.

Table 1. *Ground-water quality classes under the Utah Water Quality Board's total-dissolved-solids- (TDS) based classification system (modified from Utah Division of Water Quality, 1998).*

Ground-Water Quality Class	TDS Concentration	Beneficial Use
Class IA/IB[1]/IC[2]	Less than 500 mg/L[3]	Pristine/Irreplaceable/ Ecologically Important
Class II	500 to less than 3000 mg/L	Drinking Water[4]
Class III	3,000 to less than 10,000 mg/L	Limited Use[5]
Class IV	10,000 mg/L and greater	Saline[6]

[1]Irreplaceable ground water (Class IB) is a source of water for a community public drinking-water system for which no other reliable supply of comparable quality and quantity is available due to economic or institutional constraints; it is a ground-water quality class that is not based on TDS.
[2]Ecologically Important ground water (Class IC) is a source of ground-water discharge important to the continued existence of wildlife habitat; it is a ground-water quality class that is not based on TDS.
[3]For concentrations less than 7000 mg/L, mg/L is about equal to parts per million (ppm).
[4]Water having TDS concentrations in the upper range of this class must generally undergo some treatment before being used as drinking water.
[5]Generally used for industrial purposes.
[6]May have economic value as brine.

Isolated wells having elevated concentrations of specific constituents are not mapped as contaminant plumes when adjacent to water wells having low concentrations of the same constituents. We do not classify single wells; only areas of extensive contamination are considered as Class III (plate 2).

Class IA- Pristine ground water: For this class, TDS concentrations in Salt Lake Valley range from 110 to 496 mg/L (appendix A). Class IA areas are mapped in much of eastern Salt Lake Valley, and in an area west of Kearns (plate 2). Areas having Pristine water quality cover about 19% of the total basin-fill material.

Class II- Drinking Water Quality ground water: For this class, TDS concentrations in the Salt Lake Valley basin-fill aquifer range from 512 to 2588 mg/L (appendix A). Class II areas are mapped in central, western, and northeastern Salt Lake Valley (plate 2). Total basin-fill area coverage of Class II water quality is 62% (plate 2).

Class III- Limited-Use ground water: For this class, TDS concentrations in the Salt Lake Valley basin-fill aquifer range from 3134 to 9436 mg/L (appendix A). Class III areas are mapped in northern Salt Lake Valley, proximal to Great Salt Lake (plate 2). The shallow unconfined aquifer has been contaminated in other areas (Waddell and others, 2004; Thiros, 2003a), but the contamination is not known to have impacted the principal aquifer. Total basin-fill area coverage of Class III water quality is 7% (plate 2).

Class IV - Saline ground water: For this class, TDS concentrations in the Salt Lake Valley basin-fill aquifer range from 11,196 to 63,556 mg/L (appendix A). Class IV ground water exists at the mouth of Bingham Canyon in western Salt Lake Valley, and along the margins of Great Salt Lake in northern Salt Lake Valley. Total basin-fill area coverage of Class IV water quality is 12% (plate 2).

CURRENT BENEFICIAL USES

In the Salt Lake Valley area, ground water from the basin-fill aquifer is an important source of domestic and municipal culinary water for people living within the valley; surface water is an important source of water used for agricultural irrigation (Wadell and other, 2004). Most water use in Great Salt Lake Basin is from surface water (85%) with 15% of water use from ground water (Wadell and others, 2004). Total estimated well water withdrawal in 2005 for the Salt Lake Valley was 110,000 acre-feet. Public-supply well water withdrawal was 59.5%, industrial use was 18.5%, and other use was 22% (Burden and others, 2005).

WATER-SUPPLY WELLS

There are 11,700 perfected water wells in Salt Lake Valley based on Utah Division of Water Rights records, 299 of which are public-supply wells (Mark Jensen, Division of Drinking Water, personal communication, March 2007). The location of all wells is shown on plate 2.

POTENTIAL CONTAMINANT SOURCES

Potential ground-water contaminant sources were compiled by information obtained from unpublished data from CH2M-Hill, and web sites for the Utah Division of Environmental Response and Remediation and the Utah Department of Technology Services Automated Geographic Reference Center (2007); these data include some facilities related to mining, industrial uses, fuel storage, public swimming pools, and junkyard/salvage areas (appendix B, plate 3). Numerous other unmapped potential contaminant sources likely exist in urbanized areas of Salt Lake Valley. A primary objective was to identify potential contaminant sources to establish a relationship between water quality and land-use practices. The 3084 potential contaminant sources shown on plate 3 and listed in appendix B are in the following categories:

(1) Mining, which includes abandoned and active gravel, phosphate, carbonate, and ore metals (e.g., copper and silver) mining operations.

(2) Junkyard/salvage areas that potentially contribute metals, solvents, and petroleum products.

(3) Government facility/equipment storage associated with a variety of sources such as salt storage facilities, public swimming pools, and transportation/equipment storage that may contribute salt, chlorine, metals, solvents, and petroleum.

(4) Cemeteries, nurseries, greenhouses, ball parks, and golf courses that may contribute chemical preservatives, fertilizer, and pesticides.

(5) Storage tanks and leaking underground storage tanks that may contribute pollutants such as fuel and oil.

(6) Equipment vehicle storage and maintenance that may contribute pollutants such as fuel and oil.

(7) Manufacturing and industrial uses that may contribute pollutants such as fuel and oil.

(8) Public swimming pools that may contribute chlorine and solvents.

(9) Remediation efforts that may contribute pollutants associated with hazardous material contamination remediation.

(10) Wastewater treatment plants and sewage lagoons which may contribute pollutants such as nitrates, fuel, and oil.

In addition to the above-described potential contaminants, septic tank soil-absorption systems in Salt Lake County exist primarily in the eastern tributary canyons along the Wasatch Front, and may potentially pollute ground water. The estimated number of septic-tank systems in Salt Lake County is between 2000 and 3000, mainly in Emigration, Millcreek, and Rose Canyons (Salt Lake County Health Department, Brian Bennion, personal communication, March 29, 2007). Septic-tank systems may contribute contaminants such as nitrate and solvents. Mapped contaminants that impact the shallow unconfined aquifer are from Waddell and others (1987b) and are located near the mouth of Bingham Canyon, in the Midvale contamination area, and in the Vitro contamination area (plate 3). All approved water wells, shown on plate 2, are also considered potential contaminant sources; abandoned or poorly constructed wells may act as conduits to the aquifer.

EXISTING POLLUTION SOURCES

Existing pollution sources include those contaminants that have been documented and/or are currently being treated; potential contaminants address pollutants that have the potential to deteriorate ground water. There are three areas mapped as existing sources of pollution in Salt Lake Valley (Waddell and others, 1987b), mostly associated with mining activities (plate 3).

GROUND-WATER FLOW

Ground-water flow is from the Wasatch Range on the eastern margin and the Oquirrh Mountains along the western valley margin toward the basin center to the Jordan River, and downstream (ultimately north) toward Great Salt Lake (plate 2) (from Thiros and Manning, 2004).

SUMMARY

Ground water is an important source of drinking water in Salt Lake Valley. Ground-water quality classification is a tool that can be used in Utah to manage potential ground-water contamination sources and protect the quality of ground-water resources. The results of the proposed ground-water quality classification for Salt Lake Valley indicate that the basin-fill aquifer contains mostly high-quality ground-water resources that warrant protection. Based on chemical analyses of water from 189 wells either provided to us by the U.S. Geological Survey or compiled from EPA STORET data (appendix A; http://iaspub.epa.gov/stormodb/DW_RESULT_COUNT), 19% of the basin-fill area in Salt Lake Valley is classified as having Class IA ground water, and 62% is classified as having Class II ground water, Class III ground water comprises about 7% of the Salt Lake basin fill, and Class IV about 12%, typically associated with proximity to Great Salt Lake and affiliated with some mining operations.

REFERENCES

Anderson, P.B., and Susong, D.D., 1995, Hydrogeology of recharge areas of the principal aquifers along the Wasatch Front and adjacent areas, Utah, *in* Lund, W.R., editor, Environmental and engineering geology of the Wasatch Front region: Utah Geological Association Publication 24, p. 249-268.

Anderson, P.B., Susong, D.D., Wold, S.R., Heilweil, V.M., and Baskin, R.L., 1994, Hydrogeology of recharge areas and water quality of the principal aquifers along the Wasatch Front and adjacent areas, Utah: U.S. Geological Survey Water-Resources Investigations Report 93-4221, 74 p.

Arnow, Ted, and Mattick, R.E., 1968, Thickness of valley fill in the Jordan Valley east of Great Salt Lake, Utah, *in* Geological Survey research 1968: U.S. Geological Survey Professional Paper 600-B, p. B79-B82.

Arnow, Ted, Van Horn, Richard, and LaPray, Reed, 1970, The pre-Quaternary surface in the Jordan Valley, Utah, *in* Geological Survey research 1970: U.S. Geological Survey Professional Paper 700-D, p. D257-D261.

Baskin, R.L., 1990, Selected factors related to the potential for contamination of the principal aquifer, Salt Lake Valley, Utah: U.S. Geological Survey Water Resources Investigations Report 90-4110, 35 p.

Bryant, Bruce, 1990, Geologic map of the Salt Lake City 30' x 60' quadrangle, north-central Utah, and Uinta County, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1944, scale 1:100,000.

Burden, C.B., and others, 2005, Ground-water conditions in Utah, spring of 2005: Utah Division of Water Resources, Utah Division of Water Rights, and U.S. Geological Survey Cooperative Investigations Report No. 46, 138 p.

Comley, H.H., 1945, Cyanosis in infants caused by nitrates in well water: Journal of the American Medical Association, v. 129, p. 112.

Cuello, C., Correa, P., Haenszel, W., Cordillo, G., Brown, C., Archer, M., and Tannenbaum, S., 1976, Gastric cancer in Columbia: 1. Cancer risk and suspected environmental agents: Journal National Canadian Institute, v. 57, p. 1015-1020.

Demographic and Economic Analysis Section, 2001, Utah data guide, spring 2001: Salt Lake City, Utah Governor's Office of Planning and Budget, 16 p.

—2005, Utah data guide, summer/fall 2005: Salt Lake City, Utah Governor's Office of Planning and Budget, 12 p.

—2007, Utah data guide, winter 2007, Salt Lake City, Utah Governor's Office of Planning and Budget, 12 p.

Fraser, P., Chilvers, C., Beral, V., and Hill, M.J., 1980, Nitrate and human cancer, a review: International Journal of Epidemiology, v. 9, p. 3-11.

Herbert, L.R., Cruff, R.W., and Waddell, K.M., 1985, Seepage study of six canals in Salt Lake County, Utah, 1982-83: Utah Department of Natural Resources Technical Publication No. 82, 95 p.

Hely, A.G., Mower, R.W., and Harr, C.A., 1971, Water resources of Salt Lake County, Utah: Utah Department of Natural Resources Technical Publication No. 31, 244 p.

Hely, A.G., Mower, R.W., and Horr, C.A., 1967, Hydrologic and climatologic data, 1966, Salt Lake County, Utah: Utah Basic-Data Release No. 13, 85 p.

—1968, Hydrologic and climatologic data, 1967, Salt Lake County, Utah: Utah Basic-Data Release No. 15, 74 p.

—1969, Hydrologic and climatologic data, 1968, Salt Lake County, Utah: Utah Basic-Data Release No. 17, 70 p.

Iorns, W.V., Mower, R.W., and Harr, C.A., 1966a, Hydrologic and climatologic data collected through 1964, Salt Lake County, Utah: Utah Basic-Data Release 11, 91 p.

—1966b, Hydrologic and climatologic data, 1965, Salt Lake County, Utah: Utah Basic-Data Release 12, 84 p.

Lambert, P.M., 1995a, Numerical simulation of ground-water flow in basin-fill material in Salt Lake Valley, Utah: Utah Department of Natural Resources Technical Publication 110-B, 58 p.

—1995b, Particle-tracking analysis of time-related capture zones for selected public-supply wells in Salt Lake Valley, Utah: Utah Department of Natural Resources Technical Publication 110-C, 36 p.

—1996, Numerical simulation of the movement of sulfate in ground water in southwestern Salt Lake Valley, Utah: Utah Department of Natural Resources Technical Publication 110-D, 44 p.

Lofgren, B.E., 1952, Jordan Valley, Salt Lake County, *in* Status of development of selected ground-water valleys in Utah: Utah State Engineer Technical Publication No. 7, p. 76-83.

Lowe, Mike, and Snyder, N.P., 1996, Protecting ground water at its source through recharge-area mapping: Utah Geological Survey, Survey Notes, v. 28, no. 1, p. 6-7.

Lowe, Mike, Wallace, Janae, Burk, Neil, Johnson, Anne, Johnson, Justin, and Riding, Rich, 2005, Ground-water sensitivity and vulnerability to pesticides, Salt Lake Valley, Salt Lake County, Utah: Utah Geological Survey Miscellaneous Publication 05-7, 27 p., scale 1:120,000, CD-ROM.

Lowe, Mike, and Wallace, Janae, 2006, Ground water sensitivity and vulnerability to pesticides, northern and central Wasatch Front, Utah, *in* Harty, K.M., and Tabet, D.E, editors, Geology of northwest Utah: Utah Geological Association Publication 34, 49 p.

Marine, I.W., and Price, Don, 1963, Selected hydrologic data, Jordon Valley, Salt Lake County, Utah: Utah Basic-Data Report 4, 30 p.

—1964, Geology and ground-water resources of the Jordan Valley, Utah: Utah Geological and Mineralogical Survey Water Resources Bulletin 7, 68 p.

Marsell, R.E., 1964, Water supply, *in* Crawford, A.L., editor, Geology of Salt Lake County: Utah Geological and Mineralogical Survey Bulletin 69, p. 141-155.

Marsell, R.E., and Threet, R.L., 1964, Geologic map of Salt Lake County, *in* Crawford, A.L., editor, Geology of Salt Lake County: Utah Geological and Mineralogical Survey Bulletin 69, 1 plate, scale 1:63,360.

Mattick, E.R., 1970, Thickness of unconsolidated to semiconsolidated sediments in Jordan Valley, Utah: U.S. Geological Survey Professional Paper 700-C, p. C119-C124.

Moore, W.J., and Sorensen, M.L., 1979, Geologic map of the Tooele 1 x 2 degree quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1132, scale 1:250,000.

Mower, R.W., 1968, Ground-water discharge toward Great Salt Lake through basin fill in the Jordan Valley, Utah, *in* Geological Survey research 1968: U.S. Geological Survey Professional Paper 600-D, p. D71-D74.

—1969a, Groundwater hydrology of the Jordan Valley, Utah, *in* Jensen, M.L., editor, Guidebook of northern Utah: Utah Geological and Mineralogical Survey Bulletin 82, p. 159-173.

—1969b, Ground-water inflow toward Jordan Valley through channel fill in seven canyons in the Wasatch Range near Salt Lake City, Utah, *in* Geological Survey research 1969: U.S. Geological Survey Professional Paper 650-C, p. C174-C176.

—1970, Ground-water inflow toward Jordan Valley from Utah Valley through basin fill near the Jordan Narrows, Utah, *in* Geological Survey research 1970: U.S. Geological Survey Professional Paper 700-B, p. B199-B202.

Murphy, D.R., 1981, Climatic zones, *in* Greer, D.C., Gurgel, K.D., Walquist, W.L., Christy, H.A., and Peterson, G.B., editors, Atlas of Utah: Provo, Utah, Brigham Young University Press, p. 55-70.

Personius, S.F., and Scott, W.E., 1992, Surficial geologic map of the Salt Lake City segment and parts of adjacent segments of the Wasatch fault zone, Davis, Salt Lake, and Utah Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2106, scale 1:50,000.

Richardson, G.B., 1906, Underground water in the valleys of Utah Lake and Jordan River, Utah: U.S. Geological Survey Water Supply Paper 157, 81 p.

Seiler, R.L., and Waddell, K.M., 1984, Reconnaissance of the shallow-unconfined aquifer in Salt Lake Valley, Utah: U.S. Geological Survey Water-Resources Investigations Report 83-4272, 34 p.

Snyder, N.P, and Lowe, Mike, 1998, Map of recharge areas for the principal valley-fill aquifer, Ogden Valley, Weber County, Utah: Utah Geological Survey Map 176, 16 p., scale 1:75,000.

Stokes, W.L., 1977, Subdivisions of the major physiographic provinces in Utah: Utah Geology, v. 4, no. 1, p. 1-17.

Taylor, G.H., and Leggette, R.H., 1949, Ground water in Jordan Valley, Utah: U.S. Geological Survey Water Supply Paper 1029, 357 p.

Thiros, S.A., 1992, Selected hydrologic data for Salt Lake Valley, Utah, 1990-92, with emphasis on data from the shallow unconfined aquifer and confining layers: U.S. Geological Survey Open-File Report 92-640, duplicated as Utah Hydrologic-Data Report No. 49, 44 p.

—1995, Chemical composition of ground water, hydrologic properties of basin-fill material, and ground-water movement in Salt Lake Valley, Utah: Utah Department of Natural Resources Technical Publication No. 110-A, 59 p.

—2003a, Quality and sources of shallow ground water in areas of recent residential development in Salt Lake Valley, Salt Lake County, Utah: U.S. Geological Survey Water-Resources Investigations Report 03-4028, 74 p.

—2003b, Hydrogeology of shallow basin-fill deposits in areas of Salt Lake Valley, Salt Lake County, Utah: U.S. Geological Survey Water-Resources Investigations Report 03-4029, 23 p.

Thiros, S.A., and Manning, A.H., 2004, Quality and sources of ground-water used for public supply in Salt Lake Valley, Salt Lake County, Utah: U.S. Geological Survey Water-Resources Investigations Report 03-4325, 95 p.

Tooker, E.W., and Roberts, R.J., 1998, Geologic map of the Oquirrh Mountains and adjoining south and western Traverse Mountains, Tooele, Salt Lake, and Utah Counties, Utah: U.S. Geological Survey Open-File Report 98-581, scale 1:50,000.

U.S. Environmental Protection Agency, 2008, Current drinking water standards: Online, http://www.epa.gov/safewater/mcl.html, accessed May 30, 2008.

Utah Department of Technology Services Automated Geographic Reference Center, 2007, accessed online, February 2007: http://gis.utah.gov/sgid-vector-download/utah-sgid-vector-gis-data-layers-by-category#Environmental .

Utah Division of Water Quality, 1998, Aquifer classification guidance document: Salt Lake City, unpublished Utah Division of Water Quality report, 9 p.

Waddell, K.M., Gerner, S.J., Thiros, S.A., Giddings, E.M., Basken, R.L., Cederberg, J.R., and Albano, C.M., 2004, Water quality in the Great Salt Lake Basins, Utah, Idaho, and Wyoming, 1998-2001: U.S. Geological Survey Circular 1236, 36 p.

Waddell, K.M., Seiler, R.L., Santini, Melissa, and Solomon, D.K., 1987a, Ground-water conditions in Salt Lake Valley, Utah, 1969-83, and predicted effects of increased withdrawals from wells: Utah Department of Natural Resources Technical Publication No. 87, 69 p.

Waddell, K.M., Seiler, R.L., and Solomon, D.K., 1987b, Chemical quality of ground water in Salt Lake Valley, Utah, 1969-85: Utah Department of Natural Resources Technical Publication No. 89, 44 p.

Wallace, Janae, and Lowe, Mike, 2006, Ground-water sensitivity and vulnerability maps for basin-fill aquifers, northern and central Wasatch Front, Utah: Geological Society of America Abstracts with Programs, v. 38, no. 6, p. 5-6.

Woodward, Lowell, Harvey, J.L., Donaldson, K.M., Shiozaki, J.J., Leishman, G.W., and Broderick, J.H., 1974, Soil survey of Salt Lake area, Utah: U.S. Department of Agriculture Soil Conservation Service in cooperation with Utah Agricultural Experiment Station, 132 p., scale 1:20,000.

APPENDIX A: WATER-QUALITY DATA

(Well ID on the following pages corresponds to the ID on plate 2)

Well ID	Data Source	Solids, residue @180°C, dissolved (mg/L)	Sample Date	Nitrate (mg/L)	well depth (feet)
5	**Airport[1]**	**4630**	**2/25/2003**	**-**	**-**
6	**Airport**	**16098**	**2/9/2005**	**-**	**-**
7	**Airport**	**19354**	**2/25/2004**	**-**	**-**
3	**Airport**	**19948**	**2/28/2003**	**-**	**-**
1	**Airport**	**28216**	**2/9/2005**	**-**	**-**
2	**Airport**	**35160**	**2/28/2003**	**-**	**-**
4	**Airport**	**35884**	**2/25/2003**	**-**	**-**
187	**JVWCD[1]**	**288**	**3/10/2005**	**0.16**	**-**
174	**JVWCD**	**294**	**2/28/2005**	**0.047**	**-**
28	**Kennecott[1]**	**888**	**1/12/2005**	**-**	**-**
27	**Kennecott**	**1154**	**1/12/2005**	**-**	**-**
33	**Kennecott**	**1828**	**1/11/2005**	**-**	**-**
19	**Kennecott**	**2082**	**1/10/2005**	**-**	**-**
23	**Kennecott**	**2296**	**4/1/2003**	**-**	**-**
36	**Kennecott**	**2588**	**4/2/2004**	**-**	**-**
24	**Kennecott**	**3134**	**4/1/2003**	**-**	**-**
26	**Kennecott**	**3432**	**1/11/2005**	**-**	**-**
21	**Kennecott**	**4306**	**4/5/2004**	**-**	**-**
22	**Kennecott**	**4842**	**11/1/2005**	**-**	**-**
18	**Kennecott**	**4844**	**1/10/2005**	**-**	**-**
31	**Kennecott**	**5132**	**4/1/2002**	**-**	**-**
20	**Kennecott**	**5224**	**4/2/2002**	**-**	**-**
25	**Kennecott**	**5264**	**1/11/2005**	**-**	**-**
170	**Kennecott**	**5496**	**4/12/2004**	**-**	**-**
11	**Kennecott**	**5814**	**4/1/2003**	**-**	**-**
17	**Kennecott**	**8450**	**1/10/2005**	**-**	**-**
16	**Kennecott**	**9436**	**4/5/2004**	**-**	**-**
15	**Kennecott**	**11196**	**4/2/2003**	**-**	**-**
10	**Kennecott**	**11292**	**4/1/2002**	**-**	**-**
171	**Kennecott**	**19332**	**1/13/2005**	**-**	**-**
9	**Kennecott**	**63556**	**4/2/2003**	**-**	**-**
116	**Publicsupplywell[2]**	**110**	**-**	**-**	**-**
118	**Publicsupplywell**	**116**	**-**	**-**	**-**
104	**Publicsupplywell**	**124**	**-**	**-**	**-**
134	**Publicsupplywell**	**140**	**-**	**-**	**-**
162	**Publicsupplywell**	**140**	**-**	**-**	**-**
110	**Publicsupplywell**	**144**	**-**	**-**	**-**
160	**Publicsupplywell**	**144**	**-**	**-**	**-**
117	**Publicsupplywell**	**150**	**-**	**-**	**-**
120	**Publicsupplywell**	**157**	**05/30/01**	**1.280**	**678**
94	**Publicsupplywell**	**160**	**-**	**-**	**-**
113	**Publicsupplywell**	**160**	**-**	**-**	**-**
122	**Publicsupplywell**	**160**	**-**	**-**	**-**
172	**Publicsupplywell**	**160**	**-**	**-**	**-**
109	**Publicsupplywell**	**164**	**-**	**-**	**-**
74	**Publicsupplywell**	**166**	**-**	**-**	**-**
91	**Publicsupplywell**	**166**	**-**	**-**	**-**

155	Publicsupplywell	167	-	-	-
95	Publicsupplywell	168	-	-	-
145	Publicsupplywell	171	05/09/01	0.686	544
88	Publicsupplywell	178	-	-	-
63	Publicsupplywell	180	-	-	-
167	Publicsupplywell	180	-	-	-
92	Publicsupplywell	188	-	-	-
139	Publicsupplywell	192	-	-	-
124	Publicsupplywell	194	-	-	-
144	Publicsupplywell	195	-	-	-
136	Publicsupplywell	196	-	-	-
150	Publicsupplywell	200	-	-	-
163	Publicsupplywell	200	-	-	-
130	Publicsupplywell	204	-	-	-
138	Publicsupplywell	204	-	-	-
107	Publicsupplywell	208	-	-	-
126	Publicsupplywell	208	-	-	-
164	Publicsupplywell	208	-	-	-
158	Publicsupplywell	210	06/25/01	2.640	935
168	Publicsupplywell	216	-	-	-
133	Publicsupplywell	220	-	-	-
121	Publicsupplywell	222	-	-	-
72	Publicsupplywell	224	-	-	-
147	Publicsupplywell	224	-	-	-
108	Publicsupplywell	228	05/10/01	1.760	650
67	Publicsupplywell	232	-	-	-
128	Publicsupplywell	240	-	-	-
129	Publicsupplywell	241	06/12/01	1.110	861
151	Publicsupplywell	244	-	-	-
173	Publicsupplywell	250	-	-	-
71	Publicsupplywell	256	-	-	-
68	Publicsupplywell	258	-	-	-
98	Publicsupplywell	260	-	-	-
135	Publicsupplywell	264	-	-	-
86	Publicsupplywell	266	06/11/01	0.890	590
47	Publicsupplywell	272	-	-	-
127	Publicsupplywell	280	-	-	-
69	Publicsupplywell	286	-	-	-
60	Publicsupplywell	288	-	-	-
123	Publicsupplywell	288	-	-	-
103	Publicsupplywell	292	-	-	-
159	Publicsupplywell	292	-	-	-
165	Publicsupplywell	292	-	-	-
157	Publicsupplywell	296	-	-	-
131	Publicsupplywell	300	-	-	-
77	Publicsupplywell	304	-	-	-
143	Publicsupplywell	304	-	-	-
48	Publicsupplywell	321	05/16/01	0.026	500
90	Publicsupplywell	327	05/23/01	1.200	950
101	Publicsupplywell	330	-	-	-
105	Publicsupplywell	337	05/14/01	2.840	965
125	Publicsupplywell	341	06/07/01	1.430	250
102	Publicsupplywell	344	-	-	-

186	Publicsupplywell	348	-	-	-
64	Publicsupplywell	356	-	-	-
132	Publicsupplywell	356	-	-	-
56	Publicsupplywell	370	05/15/01	0.066	1004
55	Publicsupplywell	374	-	-	-
89	Publicsupplywell	374	-	-	-
42	Publicsupplywell	377	06/06/01	0.031	453
161	Publicsupplywell	384	-	-	-
115	Publicsupplywell	388	-	-	-
58	Publicsupplywell	392	-	-	-
57	Publicsupplywell	396	-	-	-
46	Publicsupplywell	400	-	-	-
112	Publicsupplywell	407	06/13/01	2.890	700
61	Publicsupplywell	408	-	-	-
81	Publicsupplywell	410	-	-	-
97	Publicsupplywell	420	-	-	-
83	Publicsupplywell	426	-	-	-
85	Publicsupplywell	431	-	-	-
29	Publicsupplywell	435	-	-	-
148	Publicsupplywell	448	-	-	-
54	Publicsupplywell	450	-	-	-
44	Publicsupplywell	452	-	-	-
76	Publicsupplywell	452	-	-	-
65	Publicsupplywell	480	-	-	-
73	Publicsupplywell	488	05/15/01	1.200	560
99	Publicsupplywell	496	05/01/01	0.921	464
149	Publicsupplywell	512	-	-	-
82	Publicsupplywell	523	06/12/01	2.880	510
52	Publicsupplywell	532	-	-	-
142	Publicsupplywell	532	-	-	-
43	Publicsupplywell	540	-	-	-
153	Publicsupplywell	540	-	-	-
152	Publicsupplywell	544	-	-	-
114	Publicsupplywell	550	-	-	-
13	Publicsupplywell	562	05/29/01	3.340	177
106	Publicsupplywell	566	05/14/01	1.380	502
78	Publicsupplywell	578	-	-	-
34	Publicsupplywell	599	-	-	-
70	Publicsupplywell	608	-	-	-
35	Publicsupplywell	610	-	-	-
8	Publicsupplywell	616	06/25/01	5.270	657
80	Publicsupplywell	626	-	-	-
140	Publicsupplywell	626	-	-	-
37	Publicsupplywell	628	-	-	-
39	Publicsupplywell	632	05/24/01	1.210	391
119	Publicsupplywell	632	-	-	-
188	Publicsupplywell	636	-	-	-
12	Publicsupplywell	656	-	-	-
32	Publicsupplywell	660	05/16/01	0.041	701
53	Publicsupplywell	661	05/23/01	0.899	410
184	Publicsupplywell	666	-	-	-
87	Publicsupplywell	668	-	-	-
154	Publicsupplywell	678	06/05/01	1.330	620

45	Publicsupplywell	680	-	-	-
169	Publicsupplywell	684	05/07/01	0.199	900
14	Publicsupplywell	696	06/05/01	5.990	468
146	Publicsupplywell	712	-	-	-
50	Publicsupplywell	716	-	-	-
183	Publicsupplywell	716	-	-	-
41	Publicsupplywell	720	-	-	-
137	Publicsupplywell	734	06/26/01	3.230	1212
62	Publicsupplywell	742	-	-	-
141	Publicsupplywell	744	-	-	-
100	Publicsupplywell	760	-	-	-
177	Publicsupplywell	768	-	-	-
189	Publicsupplywell	770	-	-	-
96	Publicsupplywell	780	-	-	-
156	Publicsupplywell	800	-	-	-
185	Publicsupplywell	818	-	-	-
66	Publicsupplywell	834	05/21/01	0.421	590
175	Publicsupplywell	850	-	-	-
180	Publicsupplywell	854	05/08/01	3.010	840
59	Publicsupplywell	860	-	-	-
75	Publicsupplywell	912	-	-	-
166	Publicsupplywell	948	-	-	-
181	Publicsupplywell	978	-	-	-
111	Publicsupplywell	980	-	-	-
182	Publicsupplywell	986	05/22/01	3.760	515
51	Publicsupplywell	1000	-	-	-
176	Publicsupplywell	1010	-	-	-
40	Publicsupplywell	1200	05/02/01	3.410	130
179	Publicsupplywell	1240	-	-	-
38	Publicsupplywell	1280	05/03/01	3.470	496
178	Publicsupplywell	1280	-	-	-
79	Publicsupplywell	1360	-	-	-
49	Publicsupplywell	1430	-	-	-
30	Publicsupplywell	1480	-	-	-
84	Publicsupplywell	1680	-	-	-
93	Publicsupplywell	1940	-	-	-

1-data from EPA STORET website

2-data from USGS (Thiros and Manning, 2004) and personal communication, 2007.

APPENDIX B: POTENTIAL CONTAMINANT SOURCE DATA

(Information is located on CD)