Deschutes Basin
HABITAT CONSERVATION PLAN

STUDY REPORT

Study 10 – Phase 1: Compilation of Updated Ground Water Withdrawal Data

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Prepared for:

Deschutes Basin Board of Control, and

City of Prineville, Oregon

Prepared by:

Newton Consultants, Inc.

December 9, 2013

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Study 10 – Phase 1: Compilation of Updated Ground Water Withdrawal Data

Prepared for:

Deschutes Basin Board of Control
P. O. Box 919
Madras, Oregon 97741

City of Prineville
387 NE Third Street
Prineville, Oregon 97754

Prepared by:

Newton Consultants, Inc.
P. O. Box 1728
Redmond, Oregon 97756

December 2013

Contents

INTRODUCTION 1
PURPOSE 1
PRIMARY GEOGRAPHIC FOCUS OF STUDY 10 1
REGIONAL GROUND WATER SYSTEM - Upper Basin Study Area 4
Sources of Ground Water 4
Recharge Areas 4
Discharge Areas 5
Ground Water Flow through the Upper Basin Study Area 7
Ground Water Influence on Stream Flows 10
REGIONAL GEOLOGY AND INFLUENCES ON GROUND WATER AVAILABILITY – Upper Basin Study Area .. 11
Deschutes Formation 11
Prineville Basalt 11
John Day Formation 12
GROUND WATER DEPENDENCY; MUNICIPAL, COMMUNITY, RURAL USERS – Upper Basin Study Area ... 12
CITY OF PRINEVILLE – Water Supply 13
Description of City's Water Supply System 13
Description of Geology and Aquifer System Supplying City Water 13
Geology and Aquifer System Supplying City Water-Airport Wells 13
Geology and Aquifer System Supplying City Water-Downtown Wells 14
Summary of City Water Use 14
Summary of Current and Estimated Future City Population Growth 15
Estimated Future Water Needs 15
Sources of Water for Future City of Prineville Needs 16
GROUND WATER WITHDRAWAL DATA - U.S. Geological Survey Estimates; 1994-1995 16
GROUND WATER WITHDRAWAL DATA - Deschutes Water Alliance Studies (2004-2006) 17
Regional Urban Water Suppliers Inside Urban Growth Boundaries 17
Pending Ground Water Permit Applications for Other Uses Outside Urban Growth Boundaries 18
Other Potential Future Ground Water Withdrawals Requiring Permits 18
Exempt Ground Water Withdrawals 18

GROUND WATER WITHDRAWAL DATA - Public Water Supplier and Irrigation Updates by USGS, 1995-2008 19
Summary of Available Data 19
Applicability to the Deschutes Basin HCP 22
Return of Withdrawn Water to the Ground Water System 22
The Role of Ground Water in Future Supply 23
Future Ground Water Withdrawal 24
Data Gaps 25
GROUND WATER WITHDRAWAL DATA – Irrigation Water Rights Updated From OWRD Water Right Data Base 26
Summary of Available Data 26
Applicability to the Deschutes Basin HCP 26
Estimated Future Ground Water Use 26
Data Gaps 28
GROUND WATER WITHDRAWAL DATA – Annual Reports from OWRD Public Agency Water Use Data Base 28
Summary of Available Data 28
Applicability to the Deschutes Basin HCP 28
Data Gaps 28
GROUND WATER WITHDRAWAL DATA – Updated Exempt Wells from OWRD Public Agency Data Base 28
Summary of Available Data 28
Applicability to the Deschutes Basin HCP 29
Estimated Future Ground Water Use 29
Data Gaps 29
OTHER GROUND WATER INFORMATION 30
Ground Water Well Construction Information 30
Ground Water Elevations 30
Ground Water Quality Data 30
DATA GAP SUMMARY 32
FORMAT FOR DATA COMPILATION – Future Potential Modeling Use 32

Table of Figures

Figure 1: Deschutes Basin and its Upper and Lower Components..... 3
Figure 2: Principal Recharge Areas of Deschutes Basin..... 6
Figure 3: Principal Discharge Areas of Deschutes Basin 8
Figure 4: Generalized Contours of Equal Head for the Regional Ground Water System 9
Figure 5: Population of Prineville in July of each year from 1990 to 2011 and Estimated Growth Rates. 15
Figure 6: Annual Irrigation Ground Water Pumpage, Water Years 1995 to 2008 25

Table of Tables

Table 1: City of Prineville Total Annual Ground Water Use, Population and Per Capita Water Use, 2004-2011 14
Table 2: Estimate future water use for the City of Prineville..... 16
Table 3: Annual Municipal Ground Water Withdrawals, Water Years 1995-2008 (Acre-Feet)..... 20
Table 4: Maximum Monthly Municipal Ground Water Pumpage, Water Years 1995-2008 (Acre-Feet). . 21
Table 5: Annual Irrigation Ground Water Pumpage, Water Years 1994-2008 (Acre-Feet)..... 22
Table 6: Estimated Future Municipal Ground Water Pumpage at Various Annual Growth Rates 24
Table 7: Summary of Permitted Ground Water Withdrawals for Irrigation Uses for the Deschutes River Basin for Crook, Deschutes, Jefferson and Klamath Counties. 27
Table 8: List of the Estimated Number of Exempt Wells in the Upper Deschutes River Sub-basin by County and Township. 31

INTRODUCTION

Seven central Oregon irrigation districts (Arnold, Central Oregon, North Unit, Ochoco, Swalley, Three Sisters, and Tumalo) and the City of Prineville, Oregon (City) are seeking Federal Endangered Species Act (ESA) incidental take permits for the Middle Columbia River steelhead (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), and up to 12 other listed and unlisted species inhabiting the Deschutes River Basin. As required by Section 10 of the ESA, the City and the irrigation districts (collectively the Applicants) are preparing the Deschutes Basin Multi-species Habitat Conservation Plan (DBHCP) to minimize and mitigate the effects of the proposed incidental take on the covered species. The DBHCP is being prepared in cooperation with a multi-stakeholder Working Group representing the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), U.S. Bureau of Reclamation (Reclamation), U.S. Bureau of Land Management (BLM), Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Environmental Quality (ODEQ), Oregon Water Resources Department (OWRD), the Confederated Tribes of the Warm Springs, Crook County, and several non-governmental entities.

This study has been completed to support development of the DBHCP. The scope of work for the study was reviewed and approved by the Working Group prior to initiation. Final copies of this report are being provided to the Working Group.

PURPOSE

The primary purpose of Study 10 is to compile ground water withdrawal data for present and future use of the City of Prineville and for other municipalities, other public water suppliers, resorts, agriculture, and domestic (exempt) wells on covered lands. The purpose is to also explain the usefulness of the data to the DBHCP effort and identify remaining ground water withdrawal data gaps.

This report presents the results of Study 10 and, in addition to the study purpose elements, provides available information and resources pertaining to ground water quantity and quality data in the Deschutes River Basin. A general overview of the ground water system in the upper Deschutes Basin is included to help facilitate discussion of the usefulness of the data to the DBHCP. Descriptions in the overview relative to geology and ground water are consistent with U.S. Geological Survey (USGS) Water Resource Investigation Report 00-4162, *Ground-Water Hydrology of the Upper Deschutes Basin, Oregon* (2001).

The report content includes direct information or reference to information sites. In some cases, specific information summaries are presented relative to ground water. In other cases, a website is cited at which specific water quantity or quality data can be accessed. For instance, ODEQ has a website that provides access to water quality data for about 600 specific wells in the Deschutes Basin. The website is cited in this report and the type of data available on the website is also described.

PRIMARY GEOGRAPHIC FOCUS OF STUDY 10

The Deschutes River Basin (the Basin) covers about 10,500 square miles and is the second largest river basin (behind the Willamette River Basin) in the State of Oregon. The High Cascade Mountain Range

bounds the southwest and west sides of the Basin. The Ochoco Mountain Complex bounds much of the easterly side of the Basin. Major tributaries of the Deschutes River include the Crooked, Little Deschutes, Metolius, Warm Springs and White Rivers. Whychus Creek, tributary to the Deschutes River and McKay Creek, tributary to the Crooked River are important relative to fish reintroductions. Tumalo Creek at Bend is a source of relatively cool water. Other tributaries above Bend contribute large amounts of ground water to Deschutes River flow.

The Basin can be divided into upper and lower basin components relative to capacity of the ground water system and dependency thereon for water supply. Figure 1 shows the Deschutes Basin and its upper and lower components.

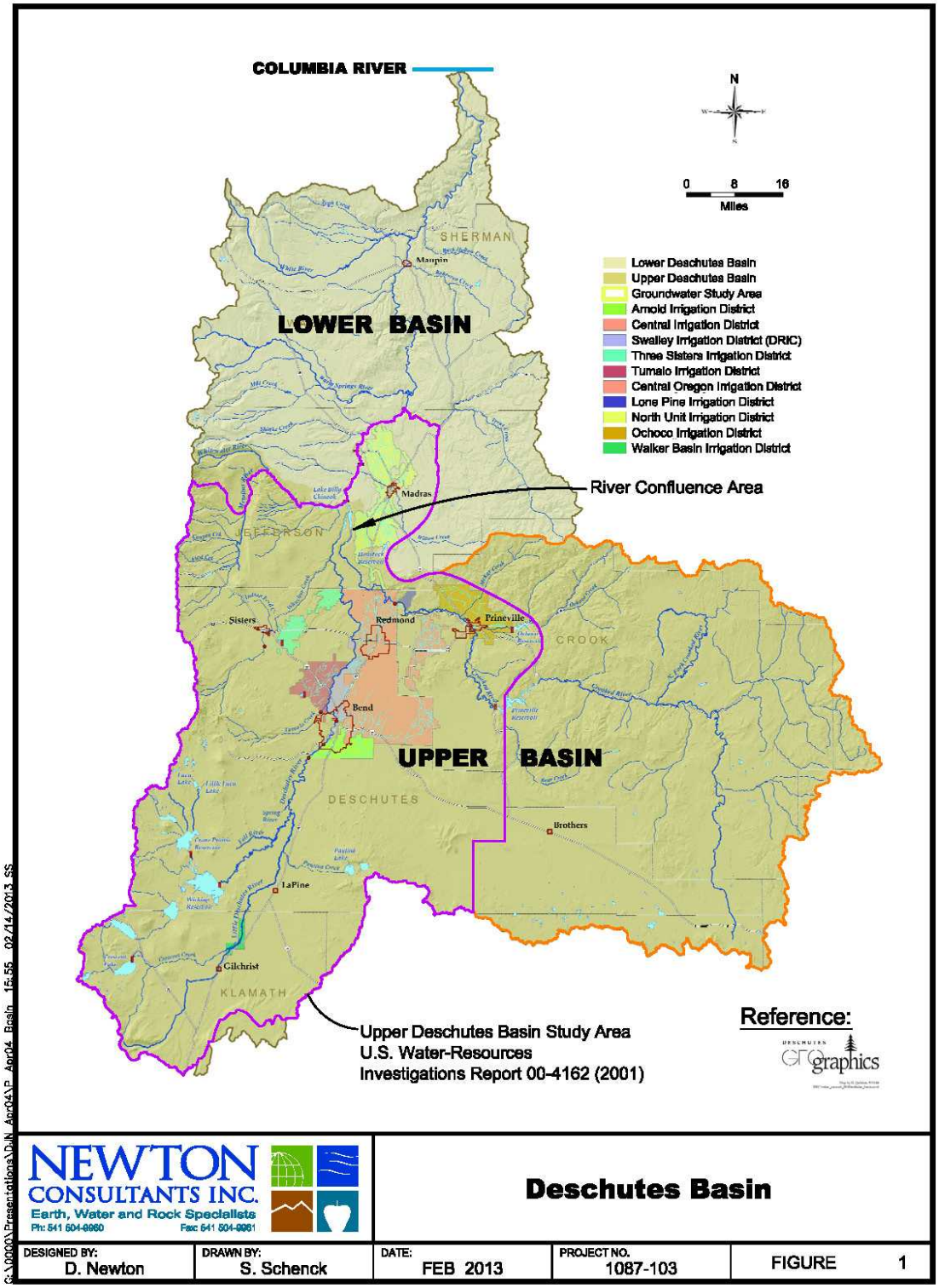
The upper Deschutes Basin covers roughly 8,000 square miles, extending from the headwaters of the Deschutes and Little Deschutes Rivers on the south to an area about 10 miles north of the City of Madras, Oregon (Figure 1). A large portion of the upper Basin comprising about 4,500 square miles was subject to a hydrologic study done jointly by the USGS and OWRDUSGS Water Resource Investigations Report 00-4162, *Ground-Water Hydrology of the Upper Deschutes Basin, Oregon,* 2001). The upper Basin is one of the fastest growing areas in the State of Oregon. Surface waters are all closed by the State of Oregon to additional appropriation such that all new development in the region must rely on ground water as a source of supply. Lack of information on ground water hydrology of the upper Basin made ground water resource management decisions difficult, resulting in high levels of concern about supply reliability for future needs. The study was conducted to respond to the lack of information and provide a comprehensive quantitative description of the regional ground water flow in the upper Basin. The area of study for the USGS Water Investigations Report 00-4162 is shown on Figure 1.

Ground water is abundant in the USGS study area due to highly permeable geologic materials and is the primary water supply source for the municipalities, other public water suppliers and resorts that are more concentrated in this part of the upper Basin. Ground water is also an important supply source for irrigated agriculture. The largest known ground water contributions to the Crooked River, Deschutes River, Metolius River, and to Whychus Creek occur near the confluence of the three rivers, near Lake Billy Chinook (Figure 1).

The remaining part of the upper Basin, east of the USGS study area, is located in the Crooked River Subbasin. The Crooked River drains water from the Ochoco Mountains. Geologic formations in this area are generally of low permeability with substantially less ground water development and dependency than in the USGS study area to the west.

The lower Deschutes Basin covers roughly 2,000 square miles, extending from an area north of Madras to the Columbia River. Present knowledge suggests that ground water is significantly less abundant than in the upper Basin. The quantity of ground water use is much lower than in the upper Basin according to much lower population, limited and relatively small urban centers (Shaniko, Maupin, Tygh Valley) and generally less permeable geologic materials than are found in the upper Basin Study Area. The Oak Springs Fish Hatchery downstream from Maupin uses water from springs that discharge from the west canyon wall of the Deschutes River.

Figure 1: Deschutes Basin and its Upper and Lower Components.



Although the covered lands under the DBHCP extend from the headwaters of the Deschutes Basin to the mouth of the Deschutes River, the compilation of ground water withdrawal data and discussion in this report are focused on the USGS study area within the upper Basin. This area is referred to as the "upper Basin Study Area" in this report. This focus is based on:

1. The relative abundance of ground water and its very large contribution to flows in the lower Crooked River, Deschutes and Metolius Rivers, and Whychus Creek;
2. The fish reintroduction efforts in these streams;
3. Rapid growth, increasing water demand and the relatively heavy dependency on the ground water system for present and future water supply;
4. Focus of the USGS and OWRD on hydrology of the upper Basin considering rapid growth, increasing demand for water and lack of ground water information for planning and decision-making (Water Resource Investigations Report 00-4162).
5. The existence of eight irrigation districts that are implementing canal piping/lining projects to conserve water, conserve energy, generate power, respond to urbanization issues and respond to water supply needs. Conserved water is used to improve supply reliability for agriculture and to improve stream flows.

REGIONAL GROUND WATER SYSTEM - Upper Basin Study Area

Sources of Ground Water

The sources of ground water in the upper Basin Study Area are direct precipitation and water from melting snow that infiltrates into the ground through permeable soil and rock. Downward infiltrating water ultimately comes to rest upon subsurface formations with low permeability that prevents or impedes continued downward movement. Accumulated ground water moves under gravitational forces through permeable flow paths from high elevation recharge areas to low elevation discharge areas. Recharge areas are where the more significant amounts of direct precipitation and water from melted snow enter the ground to supply the ground water system. Discharge areas are where the ground water escapes the subsurface aquifer system through springs or through streambeds in canyons that have been down cut across the aquifers.

Recharge Areas

The principal ground water recharge areas of the upper Basin Study Area are located in the higher elevations of the Cascade Mountain Range along the west boundary and the relatively high-elevation areas in the south and southeast. Ground water recharge in the Ochoco Mountains to the east is less significant due to generally lower snowpack and precipitation than for the Cascade Mountain Range, and lower permeability of geologic materials. Total precipitation in high elevation areas near the west boundary of the upper Basin can exceed 200 inches per year, mostly as snow during the winter. Annual precipitation rates drop toward the east to less than 10 inches per year in the central part of the upper Basin Study Area. Principal recharge areas are shown on Figure 2.

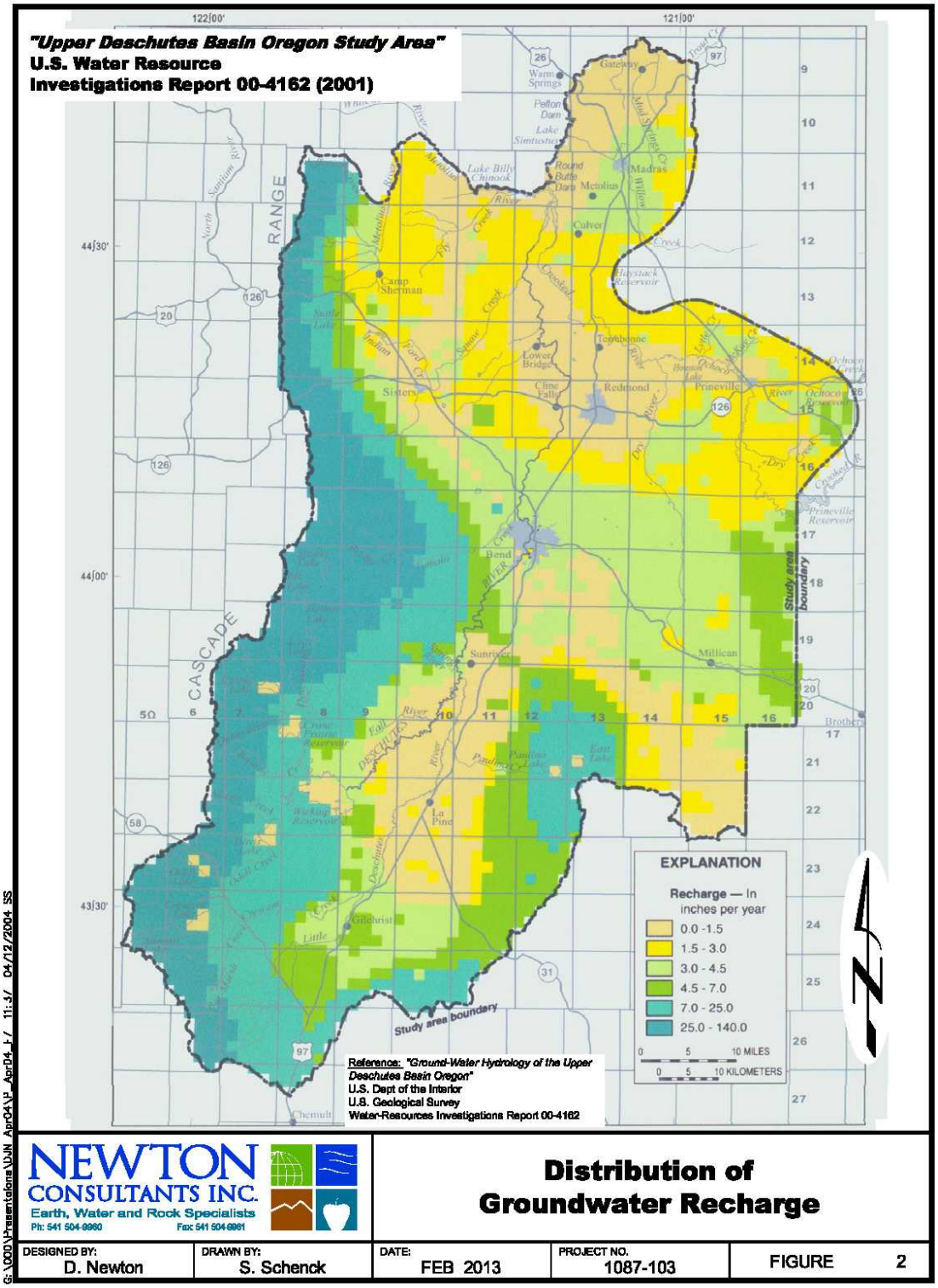
A large amount of direct precipitation and snow pack water infiltrates into the ground, recharging the subsurface ground water systems. The large annual snowpack and highly permeable geologic materials in the principal recharge areas combine to provide a highly efficient recharge system. The lack of well-developed surface drainages in the southerly and westerly parts of the upper Basin Study Area corroborates the high permeability of geologic formations, high rates of infiltration and low surface runoff. Average annual recharge to the ground water system in the upper Basin is estimated by the USGS to be about 3,800 cubic feet per second (cfs), or 2.45 billion gallons per day (gpd), based on historical data for the period 1962 to 1997 (Water Resource Investigations Report 00-4162, Ground-Water Hydrology of the Upper Deschutes Basin, Oregon, 2001*).* This equates to an average annual volume of approximately 2.7 million acre-feet. An average recharge flow rate of 3,500 cfs was estimated by the USGS for the shorter period 1993 to 1995. These years are near the tail end of a period of declining total water-year precipitation at Crater Lake (OWRD).

Discharge Areas

Ground water discharge from the upper Basin Study Area occurs primarily in Browns, Cultus, and Davis Creeks, the Cultus, Fall, Quinn and Spring Rivers south-southwest of Bend, the Deschutes and Crooked Rivers north of Lower Bridge (northwest of Redmond), and in Whychus Creek and the Metolius River. Principal ground water discharge areas are shown on Figure 3.

The incised canyons of the Deschutes and Crooked Rivers and Whychus Creek are down-cut across aquifer zones in the lower-elevation part of the upper Basin, resulting in ground water discharge into the streams near Lake Billy Chinook. Geologic boundaries between formations of contrasting permeability, as discussed below, also influence the direction of ground water flow to the major discharge areas. The major discharge areas are in the Deschutes and Crooked Rivers near Lake Billy Chinook. The Fall, Metolius, and Spring Rivers flow from large springs located at relatively high elevations in the upper Basin Study Area.

Figure 2: Principal Recharge Areas of Deschutes Basin



Ground Water Flow through the Upper Basin Study Area

Ground water travels from recharge areas to discharge areas in the upper Basin Study Area through permeable subsurface geologic formations (aquifers) over distances of roughly 25 to 80 miles. Figure 4 illustrates generalized contours of equal head for the regional ground water system. The contours represent the estimated static ground water head in elevations above mean sea level (MSL). Ground water flows perpendicular to the contours, from high elevations to low elevations (see arrows on Figure 4). Ground water flow in the southern part of the upper Basin Study Area is from the high elevation recharge areas along the west boundary toward the center of the basin. Ground water flow in the middle part of the upper Basin Study Area is toward the northeast. Ground water flow in the north part of the upper Basin Study Area converges toward the northeast, north and northwest, toward the major discharge areas in the Deschutes and Crooked Rivers, and Whychus Creek, near Lake Billy Chinook.

The shift in ground water flow direction from the northeast to the north-northwest is due to two geologic factors. One is the effect of river down-cutting across the ground water-bearing geologic formations, effectively creating a “drain” to which water will flow naturally (causing the convergence of ground water flow toward the north-northwest). The second factor is the effect of low-permeability geologic formations near the easterly part of the upper Basin Study Area that effectively block eastward flow, deflecting it toward the north-northwest.

The elevation difference between contours in the principal recharge and discharge areas on Figure 4 ranges from about 2,800 feet MSL to 3,000 feet MSL. The elevation differences indicate average hydraulic gradients of 35 to 125 feet per mile.

Figure 3: Principal Discharge Areas of Deschutes Basin

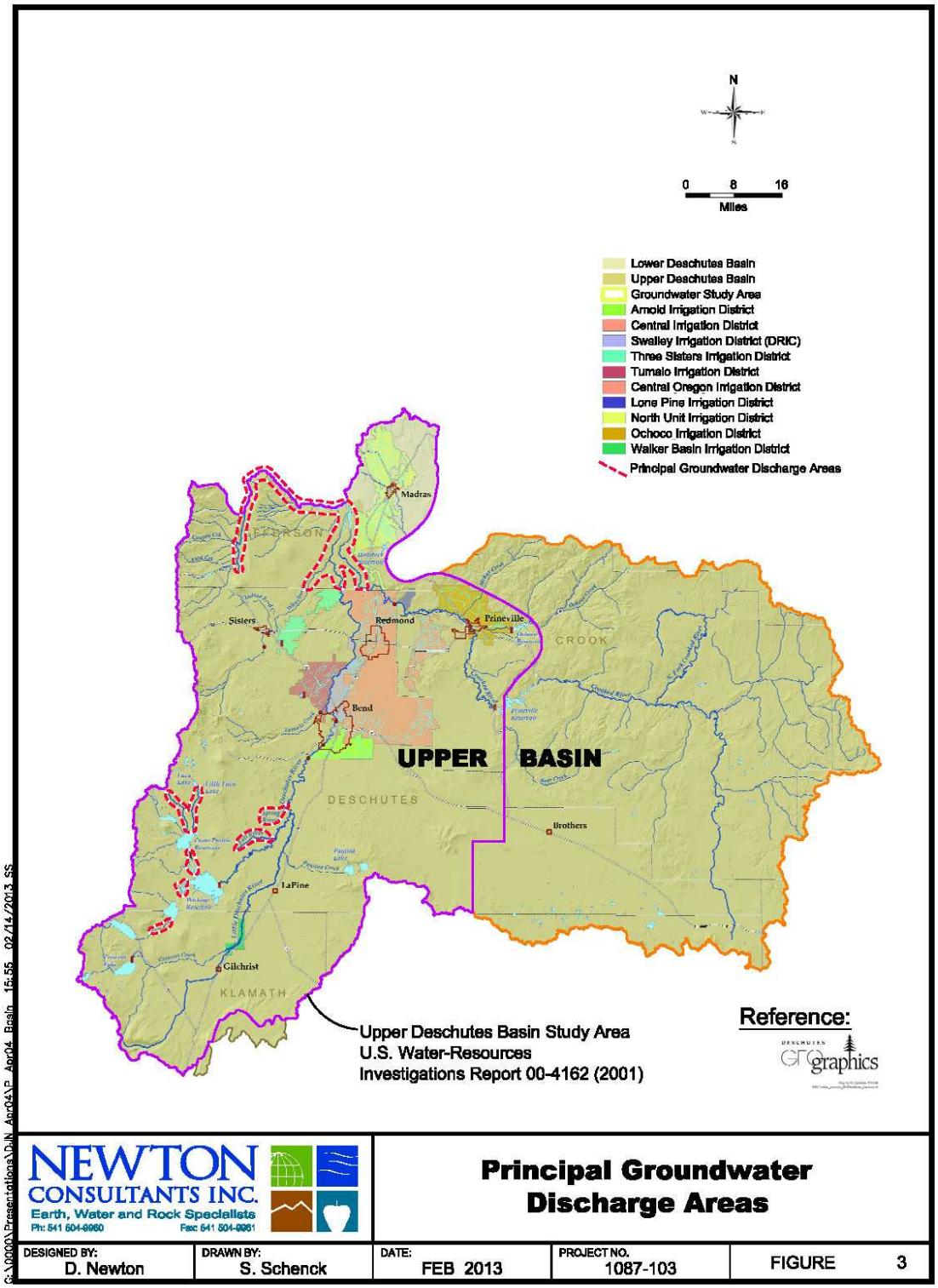
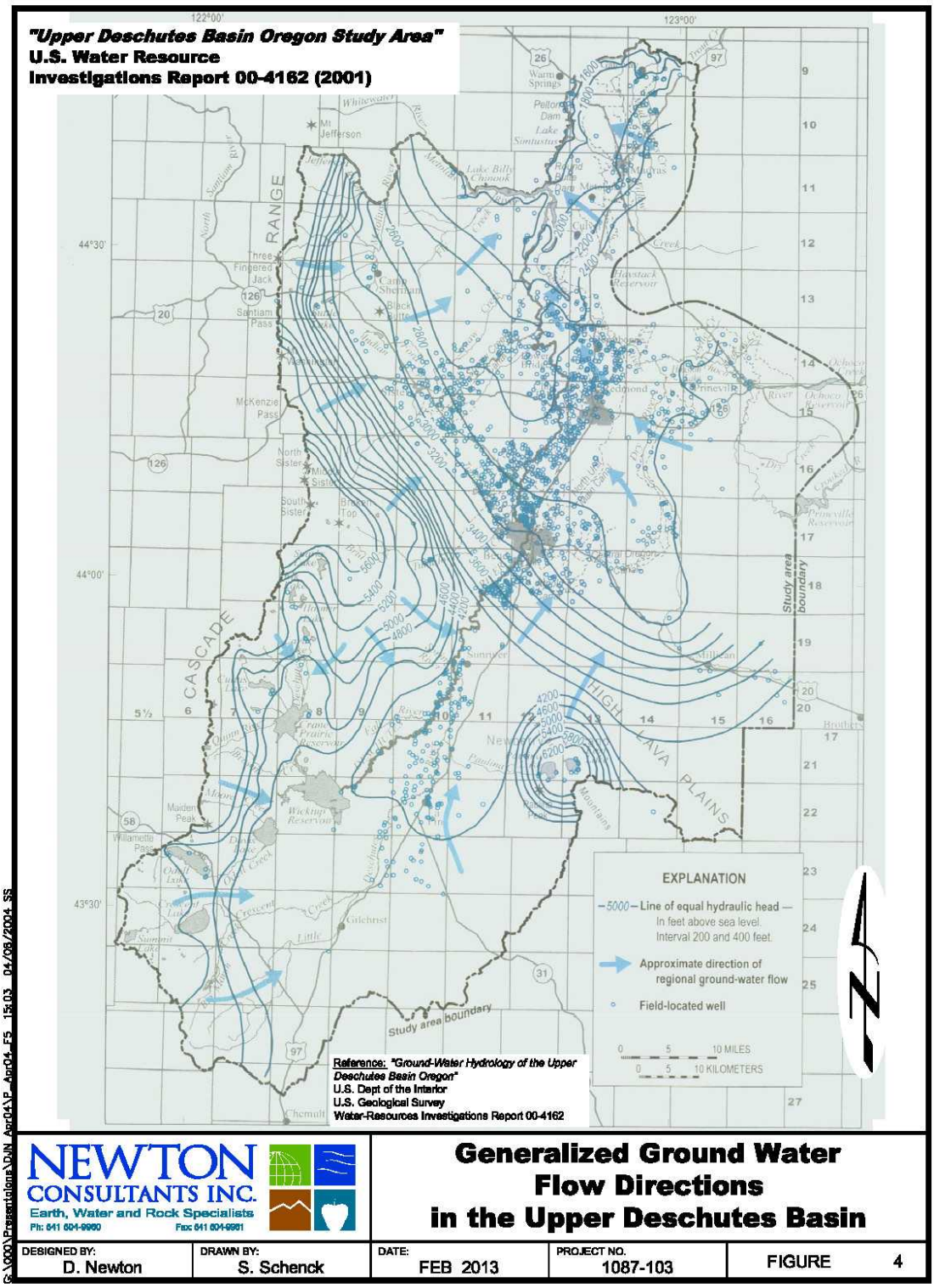


Figure 4: Generalized Contours of Equal Head for the Regional Ground Water System



Ground Water Influence on Stream Flows

The remarkable stability of flow in the Deschutes River across the seasons of the year, relative to other rivers with comparable mean discharges, can be attributed to the substantial fraction of flow that originates as ground water discharge in the upper Basin Study Area.

Ground water discharge from the upper Basin Study Area provides more than three-quarters of the total stream flow for the entire Deschutes River basin. Because of this, in order to consider and evaluate stream flow management strategies for enhancement and protection of habitat for covered fish species, a thorough understanding is necessary of how the stream flow strategies may be affected by the river's interaction with ground water.

A large proportion of the precipitation in the upper Deschutes Basin falls in the Cascade Range. The amount of precipitation coupled with permeable geologic formations make the Cascade Range the principal ground water recharge area for the upper Basin Study Area. Water-balance calculations indicate that the average annual rate of ground water recharge from precipitation for the period between 1993 and 1995 was about 3,500 cubic feet per second (cfs). For the period between 1962 and 1997, the average annual rate of ground water recharge from precipitation was 3,800 cfs.

Water-budget calculations indicate that in addition to recharge from precipitation, water is reported to enter the ground water system through inter-basin flow (USGS Water Resource Investigation Report 00-4162). Approximately 800 cfs are reported to flow into the Metolius River drainage from the west and about 50 cfs are reported to flow into the southeastern part of the upper Basin Study Area from the Fort Rock Basin. East of the Cascade Range, there is little or no natural ground water recharge from precipitation, but leaking irrigation canals are a significant source of artificial recharge in the area around and north of Bend. The average annual rate of canal leakage during 1994 was estimated to be about 490 cfs (USGS Water Resource Investigations Report 00-4162).

Ground water flows from the Cascade Range through permeable volcanic rocks eastward out into the upper Basin Study Area and then generally northward. About one-half the ground water flowing from the Cascade Range discharges to spring-fed streams along the margins of the range, including the upper Metolius River and its tributaries. Ground water discharge to Browns, Cultus and Davis Creeks, and to the Cultus, Fall, Spring and Quinn Rivers contribute largely to Deschutes River flows above Bend. The remaining ground water flows through the subsurface, primarily through rocks of the Deschutes Formation, and eventually discharges to streams near the confluence of the Deschutes, Crooked, and Metolius Rivers. Substantial ground-water discharge occurs along the lower two miles of Whychus Creek, the Deschutes River between Lower Bridge and Pelton Dam, the lower Crooked River between Osborne Canyon and the mouth, and in Lake Billy Chinook (a reservoir that inundates the confluence of the Deschutes, Crooked, and Metolius Rivers).

REGIONAL GEOLOGY AND INFLUENCES ON GROUND WATER AVAILABILITY – Upper Basin Study Area

Deschutes Formation

The principal ground water system occurs in the Deschutes Formation, which ranges from approximately 7.5 to 4.0 million years in age and covers an extensive area of the upper Basin Study Area. The Deschutes Formation is comprised of interlayered sedimentary and volcanic materials reflecting basin-filling sedimentation combined with episodic volcanic eruptions. Formation materials include sands and gravels, conglomerates, cinder and ash beds, pumice beds, and basalt flows. The Deschutes Formation contains the extensive ground water system described above that is capable of supplying high-capacity wells. Ground water systems in the Deschutes Formation are the most widely used for ground water sources in the area.

Three major depositional environments have been recognized in the Deschutes Formation during previous studies (USGS Water Resources Investigations Report 02-4015). These environments have some hydrogeologic significance to the DBHCP and include: 1) arc-alluvial plain; 2) ancestral Deschutes River; and 3) inactive-basin margin. The arc-alluvial plain is located immediately east of the Cascade Range extending roughly to the Deschutes River and consists of debris flows, ignimbrites (ash flows), fallout material, and lava flows. The ancestral Deschutes River environment is located on an alignment roughly from Terrebonne along the Crooked River to the Gateway area northeast of Madras and consists of sedimentary conglomerates, sandstone, mudstone, and intracanyon lava flows. The inactive-basin margin environment is mapped along the eastern portion of the upper Basin and includes deposits of materials eroded from formations of older rocks such as the John Day Formation. These materials were deposited as recycled beds of angular gravels, sands, pyroclastic debris, and other sediments.

Permeability of Deschutes Formation materials is reported as moderate to very high in the arc-alluvial plain environment and proximal volcanic rock facies. Relatively high permeability in this environment is conducive to high recharge efficiencies and substantial ground water discharge to the Deschutes River system. Permeability is generally lowest in the inactive-margin environment, in easterly areas of the upper Basin Study Area.

The eastern portion of the upper Basin Study Area that includes the inactive-basin margin also includes proximal facies deposits of the Deschutes Formation. These proximal facies consists of thin-bedded lavas and local sediment units in potential contact with the John Day Formation. Large diameter well capacities in this unit can yield from 400 to 2,000 gpm.

Prineville Basalt

The Prineville Basalt is a geologic unit composed of lava flows that has surface exposure in the upper Basin Study Area in the area near Bowman Dam approximately 10 miles southeast of Prineville, and in the Crooked River Canyon and the Deschutes River canyon north of Round Butte Dam near Gateway. This unit produces ground water for areas between the Crooked River and northern side of Powell Butte and near Madras and Gateway.

The Prineville Basalt is approximately 15.7 million years in age and underlies portions of the Deschutes Formation in the northern and northeastern portions of the Deschutes Basin. The Prineville Basalt has moderate permeability and overlies the less permeable John Day Formation.

John Day Formation

The John Day Formation consists of the oldest rock units in the upper Basin Study Area and has surface exposures east and southeast of Prineville; to the north and northeast to the Crooked River canyon and Smith Rock area; and Powell Butte. Rocks of the John Day Formation have very low permeability and wells constructed in this Formation do not generally yield much ground water. The John Day Formation is approximately 22 to 39 million years in age and is generally assumed to underlie much of the upper Basin Study Area and assumed to act as a ground water boundary to downward (and lateral) movement of ground water. The John Day Formation has been encountered in wells installed on the easternmost portion of the upper Basin Study Area based on the drill cuttings retrieved from these onsite well borings. This formation is believed to have a major role in blocking northeasterly flow of ground water across the upper Basin Study Area, resulting in flow redirection toward the northwest.

GROUND WATER DEPENDENCY; MUNICIPAL, COMMUNITY, RURAL USERS – Upper Basin Study Area

The Cities of Bend, Culver, LaPine, Madras, Metolius, Prineville, Redmond, and Sisters, other private and community water suppliers, resorts, and rural homeowners rely on ground water from the upper Basin Study Area ground water system for their various water needs. Present knowledge suggests that the physical capacity of the ground water system, as a whole, is substantially more than present ground water demand. However, potential capacity restriction exists through regulatory conditions (mitigation requirements for new ground water permits). Locally, capacity of the system is subject to specific project needs, geologic conditions, recharge effectiveness and other ground water demands on the aquifer systems.

Although the areas of Bend and Redmond are relatively arid with high desert characteristics, a plentiful ground water supply lies beneath the area due to relatively efficient snow pack recharge in the High Cascade Mountains and flow beneath these communities to major discharge areas in the northern part of the upper Basin Study Area, near Lake Billy Chinook. The ground water system underlying the area of the Prineville Airport includes geologic units similar to those that provide water to Bend and Redmond, along with John Day Formation rocks. Hydrologic investigations for water supply (Newton, 2011) in this area indicate high-yield aquifer conditions occur in apparent ancient stream channels cut through lower-permeability geologic materials. The area of downtown Prineville overlies a geologically different ground water system that tends to produce reduced amounts of ground water.

CITY OF PRINEVILLE – Water Supply

Description of City's Water Supply System

The City of Prineville water supply system consists exclusively of 10 ground water wells and 5 above ground storage reservoirs (tanks). Eight of the wells ("Downtown Wells") are located in the City, on the relatively broad and flat floor of the Crooked River Valley. Two wells (Airport Wells) are located adjacent to the Prineville Municipal Airport, about 2 ½ miles west of the downtown area of the City. These wells are located on top of the relatively flat, basalt-capped mesa, about 400 to 500 feet above the downtown area of Prineville. The Downtown wells pump ground water directly into the City distribution system and into 4 tank reservoirs. Distribution of water through the delivery system is facilitated with booster pumps. The distribution system of the Downtown Wells delivers water supply throughout the City, but do not provide water to the Airport.

The Airport Wells pump ground water into a 1 million gallon tank reservoir, and pressurized distribution is provided by a booster pump station located near the wells. The Airport Wells may convey water to the downtown portion of the City distribution system; the downtown distribution system, however, is not equipped with booster pumps capable of lifting water to the Airport area distribution system.

Description of Geology and Aquifer System Supplying City Water

The City of Prineville lies predominantly within the Crooked River canyon immediately adjacent to the Crooked River at elevations between 2,800 to 2,900 feet MSL. The western portion of the City in the vicinity of the Airport area resides on the basin plateau above the Crooked River Canyon at elevations around 3,200 to 3,300 feet MSL. Based on these two geographically divisive sections of the City, the underlying geologic and aquifer characteristics are much different.

Geology and Aquifer System Supplying City Water-Airport Wells

The Airport Wells are completed in an aquifer that has been identified as part of the Deschutes Formation, the predominant producing aquifer within the Deschutes Basin. The Airport Wells are located in the eastern portion of the upper Basin Study Area that includes the inactive-basin margin and also includes proximal facies deposits of the Deschutes Formation, as described above in section ***Deschutes Formation***.

The Airport Wells produce ground water from a fine to coarse sand and gravel deposit with localized areas of cementation. This sand and gravel deposit is interpreted to be stream bed sediments of paleo-channels (ancient river channels), likely remnant river courses of what is the present day Crooked River (Newton, 2011).

The Deschutes Formation overlies the Prineville Basalt, Simtustus Formation and low permeability John Day Formation, which are exposed to the east of the Airport area in the valley and canyon walls of the Crooked River and Ochoco Range.

Wells completed in the Airport area that produce ground water from this sand and gravel deposit range in capacity from 300 to 2,000 gpm.

Geology and Aquifer System Supplying City Water-Downtown Wells

The downtown portion of the City resides in an alluvial valley of the Crooked River, Ochoco Creek and McKay Creek. The geology and aquifer system of the downtown area of the City are comprised of alluvial deposits (deposited by streams or running water) of sand, gravel, silt and glacial outwash materials resulting from erosion of the watersheds of the current day Crooked River, Ochoco Creek and McKay Creek drainages.

The source of the alluvial deposits is a composite of weathered volcanic materials and volcanic esediments of the Deschutes, Simtustus John Day and Clarno Formations and Prineville Basalt from the Cascade and Ochoco Ranges. The episodic depositional environment of the alluvial valley in the Prineville area was created in response to volcanic events that changed the course of the Crooked River from paleo-channels underlying the Airport area to its present day location in the downtown area of the City.

City wells are completed in the alluvial materials, producing groundwater from interbeds of silty sandy gravels. These silty sandy gravels are interbedded with clayey deposits that limit the vertical conductivity and areal extent of water producing zones within aquifers. These conditions appear to limit s production rates from the wells to an approximate range of 100 to 400 gpm.

Summary of City Water Use

Table 1 shows the City of Prineville's total annual water use, population and per capita water use for the years 2004 through 2011 and the average per capita water use over those 8 years.

Table 1: City of Prineville Total Annual Ground Water Use, Population and Per Capita Water Use, 2004-2011

	2004	2005	2006	2007	2008	2009	2010	2011	Average
Water Withdrawal, gallons*	539,128,639	568,830,586	606,607,861	618,928,536	615,255,806	568,842,500	495,327,074	507,331,264	
Water Withdrawal, acre-feet	1,655	1,746	1,862	1,900	1,888	1,746	1,520	1,557	
Population as of July 1st**	8640	9080	9990	10190	10370	10370	10370	9260	
Per Capita Water Use, gal/year	62,399	62,647	60,722	60,739	59,330	54,855	47,765	54,787	57,905
Per Capita Water Use, gal/day	170	172	166	166	162	150	131	150	**159**

*Source: City of Prineville Water Usage Records

**Source: Portland State University, College of Urban and Public Affairs, Population Research Center

Summary of Current and Estimated Future City Population Growth

Figure 5 shows the population of Prineville in July of each year from 1990 to 2011. As can be seen, from 1990 through 1999, the growth rate was relatively small at 1.6 percent per year. Beginning in 2000, however, the growth rate increased dramatically to 2.2 percent per year. Then, beginning in 2008 through 2011, the population decreased, likely as a result of the economic down turn. It is reasonable to expect that population growth will again resume; however, the timing and rate of growth are uncertain. For the purpose of this report, the two growth rates shown in the graph were used to bracket the estimated future growth rate. In other words, future water use will be estimated based both on a lower and a higher growth rate as displayed on the graph.

Estimated Future Water Needs

Based upon the data in Table 2 and the two growth rates shown in Figure 5, Table 3 below shows the estimated amount of water to be required by the City of Prineville at 10-year increments from 2011 to 2061, a total of 50 years.

Figure 5: Population of Prineville in July of each year from 1990 to 2011 and Estimated Growth Rates

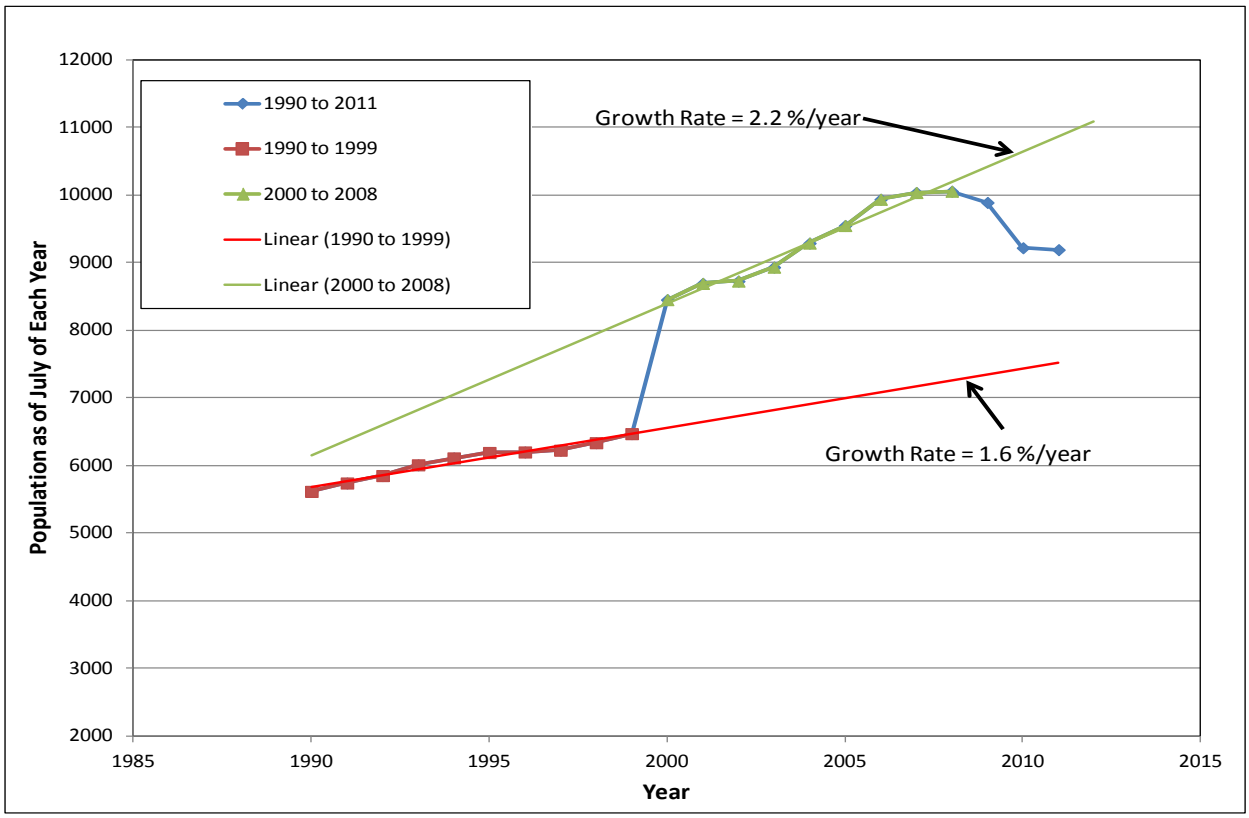


Table 2: Estimate future water use for the City of Prineville.

Year	Annual Water Use @ 1.6% Growth Rate, Acre-Feet/Year	Annual Water Use @ 1.6% Growth Rate, Gallons/Year	Annual Water Use @ 2.2% Growth Rate, Acre-Feet/Year	Annual Water Use @ 2.2% Growth Rate, Gallons/Year
2011 (actual)	1,557	507,300,000	1,557	507,300,000
2021	1,825	594,600,000	1,936	630,800,000
2031	2,139	696,900,000	2,406	783,900,000
2041	2,506	816,500,000	2,991	974,600,000
2051	2,938	957,300,000	3,718	1,211,400,000
2061	3,443	1,121,800,000	4,322	1,408,200,000

Sources of Water for Future City of Prineville Needs

Based on a review of the City of Prineville *Draft Water Management and Conservation Plan,* dated June 2008 (DWMCP), the City of Prineville is planning to meet future water demands with ground water from the Deschutes aquifer, identified in areas of the Prineville Airport and further west. Ground water needs are intended to be met with new water right permits that require mitigation as an offset to ground water pumping effects on surface waters (mitigation is described on page 23). Currently, the City has water rights, as identified in the 2008 DWMCP, to meet demand to 2017, with additional water right permit(s) pending with OWRD. The additional water right permits for ground water withdrawal at a rate of up to 5,589 gpm could meet projected City water supply until 2027. No surface water is planned as a direct supply source. Legislation currently before the U.S. Congress and Senate seeks to authorize approximately 5,000 acre-feet of water in the Crooked River from Prineville Reservoir to be used for mitigation by the City of Prineville.

GROUND WATER WITHDRAWAL DATA - U.S. Geological Survey Estimates; 1994-1995

Estimates of annual ground water withdrawals in the upper Basin Study Area are presented in the USGS Water Resource Investigations Report 00-4162 for public water supply wells, irrigation and exempt wells. Estimated annual withdrawals for these uses are summarized below.

Public Water Supply Wells (1995; 19 suppliers):	15,100 Acre-Feet
Irrigation (1994):	14,800 Acre-Feet
Exempt Wells (1995, 34,000 persons, 100 gpd/person, 5.3 cfs avg):	3,830 Acre-Feet

GROUND WATER WITHDRAWAL DATA - Deschutes Water Alliance Studies (2004-2006)

The Deschutes Water Alliance (DWA) was initially formed in 2004 to administer a Water 2025 Challenge Grant awarded by Reclamation. The DWA was formed by four major Deschutes Basin partners to develop and implement integrated water resources management programs in the upper Deschutes Basin (upper Basin Study Area). The partners at this time included: 1) Deschutes Basin Board of Control (DBBC); 2) Central Oregon Cities Organization (COCO); 3) Deschutes River Conservancy; and 4) Confederated Tribes of Warm Springs.

Five planning studies were conducted by the DWA in the upper Basin Study Area under the Water 2025 Challenge Grant. These included:

1. Irrigation District Water Conservation Cost Analysis and Prioritization.
2. Growth, Urbanization and Land Use Change: Impacts on Agriculture and Irrigation Districts in Central Oregon.
3. Reservoir Management.
4. Future Ground Water Demand in the Deschutes Basin.
5. In-stream Flow in the Deschutes Basin: Monitoring, Status and Restoration Needs.

The study on future ground water demand in the upper Deschutes Basin focused on the upper Basin Study Area and estimated future ground water demand to the year 2025. Future demand estimates were made for: 1) Regional Urban Water Suppliers (future uses within Urban Growth Boundaries); 2) Pending Ground Water Permit Applications for Other Uses Outside Urban Growth Boundaries; 3) Other Potential Future Ground Water Uses Requiring Permits; and 4) Exempt Ground Water Use. Estimated ground water withdrawals for these uses are summarized below.

Regional Urban Water Suppliers Inside Urban Growth Boundaries

Regional urban water suppliers considered in the DWA study included the Avion Water Company, cities of Bend, Prineville, Redmond and Sisters, and the Deschutes Valley Water District (supplying Culver, Madras and Metolius). The total estimated annual ground water withdrawal data based on information provided by the suppliers is summarized below for the years 2005 and 2025.

Total Estimated Withdrawal Volume – 2005:	39,800 Acre-Feet
Total Estimated Withdrawal Volume – 2025:	62,000 Acre-Feet

Pending Ground Water Permit Applications for Other Uses Outside Urban Growth Boundaries

Ground water uses outside the Urban Growth Boundaries considered in the DWA study included irrigation, industrial, group domestic (i.e., rural developments), pond maintenance and quasi-municipal. Ground water permit applications were on file with OWRD in 2006 for these uses. Estimated annual ground water withdrawal data based on permit application data for these uses in 2006 are summarized below.

Irrigation Use:	3,299 Acre-Feet
Industrial Use:	811 Acre-Feet
Group Domestic Use:	90 Acre-Feet
Pond Maintenance:	22 Acre-Feet
Quasi-Municipal Use:	13,844 Acre-Feet
TOTAL	18,066 Acre-Feet

Other Potential Future Ground Water Withdrawals Requiring Permits

The pending water right permit applications summarized above did not necessarily reflect the full extent of ground water demand out to the year 2025. Accordingly, the DWA study considered additional demand for other potential needs, including destination resorts. Several destination resorts were in the development and planning stages in the upper Basin at the time of the DWA study (2004-2006). Estimated annual ground water withdrawal data for other potential uses out to the year 2025 are summarized below.

Destination Resorts (5 assumed):	6,630 Acre-Feet
Additional Irrigation (120 Acres):	360 Acre-Feet
Additional Group Domestic:	900 Acre-Feet
TOTAL	7,890 Acre-Feet

Exempt Ground Water Withdrawals

Ground water is also used for domestic water needs in rural areas without municipal or other water utility service. OWRD records indicated that approximately 20,000 exempt wells existed in Crook, Deschutes and Jefferson Counties at the time of the DWA study (2004-2006). It was estimated that the number of exempt wells could grow to 32,000 by the year 2025. Estimated annual ground water withdrawal data based on an estimated daily usage rate of 1,000 gallons per well are summarized below.

Estimated Annual Withdrawals – 2006:	22,400 Acre-Feet
Estimated Annual Withdrawals – 2025:	35,800 Acre-Feet

GROUND WATER WITHDRAWAL DATA - Public Water Supplier and Irrigation Updates by USGS, 1995-2008

Updated ground water withdrawal data for 1994-2008 were compiled by the USGS (Marshall Gannett, Personal Communication). These data were retrieved and included in this Study 10 report to provide more current information on ground water withdrawals for public water suppliers and irrigation. Exempt ground water use was not compiled by the USGS and updated withdrawal data for this use were generated by Newton through research of the OWRD data base.

Summary of Available Data

The updated ground water withdrawal data compiled by the USGS are for irrigation and municipal uses only. Municipal uses considered in the update include cities and other private water suppliers. The updated data are available in acre feet per month for water years 1995 through 2008.

Table 3 is a summary of total annual ground water withdrawals for the municipalities included in the updated data, plus that for Deschutes Valley Water District. It should be noted that the data update did not include Deschutes Valley Water District water withdrawals. Table 4 is a summary of the maximum monthly withdrawals for each year for each municipality included in the update. Table 5 is a summary, by county, of the updated ground water withdrawals for irrigation in the covered lands.

Table 3: Annual Municipal Ground Water Withdrawals, Water Years 1995-2008 (Acre-Feet).

Owner	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change per Year
Avion				3434	3548	4291	4143	4804	4662	5133	5314	5946	6395	6846	9%
BLACK BUTTE RANCH	508	474	474	480	486	492	503	435	457	422	436	408	372	352	-2%
City of Bend	1092	2020	2020	1938	1961	1997	2297	3086	2014	4538	3452	6242	6676	3829	18%
CITY OF MADRAS	164	25	21	18	11	5	2	1	1	1	0	2	1	1	-7%
City of Redmond	3313	3703	3523	3648	4053	4181	4517	4438	4992	5334	5125	5592	6282	6075	6%
CITY OF SISTERS	267	275	283	330	449	509	538	611	670	833	709	712	681	652	10%
Crooked River Ranch	297	435	435	435	435	435	435	435	435	435	435	435	435	435	3%
EAGLE CREST INC.	121	113	113	157	201	245	288	332	376	420	550	603	603	603	28%
LA CASA MIA ASSOCIATION IMPROVEMENT DISTRICT	4	5	4	4	4	5	4	4	3	3	3	3	3	3	-2%
LAPINE WATER DISTRICT	0	0	0	0	0	0	0	0	0	132	185	227	285	271	21%
RIVER MEADOWS IMPROVEMENT DISTRICT	20	21	21	22	22	21	30	39	38	39	41	40	39	39	7%
ROATS WATER SYSTEMS INC.	563	548	604	562	615	742	772	801	791	895	805	775	745	494	-1%
SUNRIVER LP	0	0	0	419	413	408	251	296	932	952	802	1128	871	615	4%
SUNRIVER WATER LLC	1464	1516	1516	1077	1062	1048	745	807	556	370	458	569	539	509	-5%
TERREBONNE DOMESTIC WATER DISTRICT	115	128	128	136	136	149	137	137	137	157	219	209	218	209	6%
Tollgate	198	252	252	252	252	252	252	252	252	252	252	252	252	252	2%
Deschutes Valley Water District*	3548		3285	3021	2187	3190	3141	2916	3014	2709	2718	2600		2576	-2%
TOTAL	**11,674**	**9,515**	**12,679**	**15,933**	**15,836**	**17,970**	**18,055**	**19,397**	**19,330**	**22,627**	**21,506**	**25,744**	**24,398**	**23,761**	7%

* Deschutes Valley Water District was not included in USGS data base; these data were derived directly from OWRD website.

Table 4: Maximum Monthly Municipal Ground Water Pumpage, Water Years 1995-2008 (Acre-Feet).

Owner	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Avion				676	627	729	679	992	817	828	1179	1137	1147	1300
BLACK BUTTE RANCH CORP.	80	75	75	86	87	94	155	70	89	54	58	55	58	45
City of Bend	257	476	476	369	296	302	531	509	421	1181	757	1625	1737	739
CITY OF MADRAS	156	7	11	9	5	1	1	0	0	0	0	1	0	1
City of Redmond	551	659	562	630	706	663	827	740	914	914	927	972	1048	1075
CITY OF SISTERS	59	62	64	77	78	104	88	113	133	206	128	138	126	122
Crooked River Ranch	45	65	65	65	65	65	65	65	65	65	65	65	65	65
EAGLE CREST INC.	23	22	22	30	38	46	55	63	71	80	109	112	112	112
LA CASA MIA ASSOCIATION IMPROVEMENT DISTRICT	1	1	1	1	1	1	1	1	1	1	1	0	1	1
LAPINE WATER DISTRICT	0	0	0	0	0	0	0	0	0	30	29	47	39	44
RIVER MEADOWS IMPROVEMENT DISTRICT	4	4	4	4	4	4	5	8	7	7	8	7	7	8
ROATS WATER SYSTEMS INC.	107	98	103	115	105	137	135	133	130	152	156	133	164	108
SUNRIVER LP	0	0	0	179	177	174	84	85	173	156	148	272	196	122
SUNRIVER WATER LLC	352	364	364	336	331	327	186	178	176	125	169	200	170	179
TERREBONNE DOMESTIC WATER DISTRICT	16	20	20	27	19	20	21	23	23	26	31	31	34	37
Tollgate	30	38	38	38	38	38	38	38	38	38	38	38	38	38
Deschutes Valley Water District*	598		547	562	501	573	549	468	527	420	399	403		421

* Deschutes Valley Water District was not included in USGS data base; these data were derived directly from OWRD website.

Table 5: Annual Irrigation Ground Water Pumpage, Water Years 1994-2008 (Acre-Feet).

County	1994	1995	1996	1997	1998	1999	2000	2001
Crook County	1,352	1,820	2,165	2,165	2,437	2,981	3,367	3,367
Deschutes County	13,924	15,481	15,807	16,619	16,893	17,542	17,985	18,785
Jefferson County	2,152	2,152	2,152	2,152	2,170	2,170	2,170	2,170
Klamath County	78	78	78	78	78	78	78	78
Total	17,506	19,531	20,203	21,015	21,579	22,772	23,601	24,401
County	2002	2003	2004	2005	2006	2007	2008	
Crook County	3,367	3,367	3,367	3,367	3,367	3,384	3,396	
Deschutes County	18,849	18,867	19,183	19,340	19,432	19,491	19,640	
Jefferson County	2,170	2,170	2,170	2,170	2,170	2,170	2,170	
Klamath County	78	78	78	78	78	78	78	
Total	24,464	24,483	24,798	24,956	25,048	25,124	25,285	

Applicability to the Deschutes Basin HCP

As stated in the background component of this report, flow in the Deschutes River and its tributaries is highly dependent on ground water discharge. Wells that withdraw water from ground water are, therefore, potentially reducing the amount of ground water discharge to river system. Not all of the withdrawn ground water is lost, however. In the case of municipal withdrawal, a substantial proportion is returned to ground water after treatment and disposal. In the case of irrigation, only a portion of the irrigated water is consumed either by evaporation and crop uptake.

Return of Withdrawn Water to the Ground Water System

When ground water is withdrawn for beneficial use, part of the water returns to the ground water system through seepage from wastewater ponds, leakage from water supply pipelines, infiltration from septic drainfield systems, and deep percolation during irrigation (USGS Water Resources Investigations Report 00-4162, 2001). The fraction of the withdrawn water that is not returned to the ground water system is water that is consumptively used. The percentage of consumptive water use varies according to season and type of use. For public water suppliers, consumptive use generally ranges from approximately 10 percent of total withdrawal during winter to 50 to 60 percent in summer. In general, consumptive use of ground water in urban areas is probably somewhat less than 50 percent of the gross annual withdrawal (USGS Water Resources Investigations Report 00-4162, 2001). Guideline consumptive use provided by OWRD for municipal and quasi-municipal ground water use is 40 percent for year-round use. Consumptive use of 47 to 60 percent has been applied to ground water permits restricted to summer periods of withdrawal. The average consumptive fraction of irrigation water is generally taken at 60 percent in the upper Basin Study area; however, consumption can be much higher for highly efficient irrigation systems such as for golf courses.

The Role of Ground Water in Future Supply

In the Deschutes Basin, as previously stated in this report, all available surface water has already been appropriated and is not available for additional appropriations. In other words, there is no surface water that is available for appropriation. Water for all future growth must come from ground water.

Current water management regulations applicable to the upper Deschutes Basin Study Area require that any new ground water withdrawals must be offset with a reduced amount of water withdrawal for other prior-existing uses. The intended net effect is no increase in consumptive water use as new ground water permits are developed. These regulations are referred to as the "Mitigation Program for the Deschutes Basin." Although ground water is physically available in the regional ground water system of the upper Basin Study Area, certainty in its availability at the present time as a supply source depends largely on whether suppliers can satisfy the mitigation requirements for new ground water permits under Oregon Administrative Rules 690-505.

Mitigation for new ground water uses is intended to offset the impacts of ground water pumping on surface waters and other senior water rights. This requirement is based on hydrologic connectivity between the aquifer system and surface waters. Mitigation is required for the volume of ground water use that is actually consumed and does not return to the hydrologic system. This volume is in the general range of 40 to 60 percent (OWRD guidelines) of the total annual volume of ground water withdrawn for municipal and quasi-municipal use. This volume can be much higher or lower depending on the type and efficiency of water use.

Presently, mitigation is achieved by retiring an existing, valid surface water right and transferring the right back to its source stream where it is then protected as an instream water right. In general, 1.8 acre-feet of water or 1.8 mitigation credits are issued for one acre of irrigation water right in the upper Basin Study Area. The number of water right acres needed for a given mitigation obligation depend on the amount of the proposed ground water use and consumption volume. This situation means that a new ground water use can be allowed if an existing out of stream water use of equal consumptive volume is discontinued. A new ground water use can also be allowed if an existing ground water use in equal consumption volume is discontinued.

The ability to satisfy a mitigation obligation for a new ground water permit depends on the availability of valid water rights for this purpose relative to volume, timing and location. Ground water pumping effects can apply to different streams or stream reaches in the upper Deschutes Basin, depending on the location of the pumped well relative to streams or stream reaches. For example, well pumping in the upper Deschutes River subbasin requires mitigation in the Upper Deschutes Zone of Influence. Well pumping in the Bend-Redmond area requires mitigation in the General Zone of Influence (general Central Oregon area). Well pumping east of Redmond, in the Powell Butte and Terrebonne areas, and in Prineville requires mitigation in the Crooked River Zone of Influence.

A critical challenge to municipal and urban community suppliers using ground water is being able to satisfy its mitigation obligation and maintain its required certainty in supply for 20 years into the future, considering the constraints on water availability for mitigation, timing of availability, and location of the mitigation water relative to zone of influence. These factors result in increased uncertainty relative to future water supplies. An additional challenge is the 200-cfs cap on new ground water permits

established by the OWRD. This cap has been reached in the past; however, the cumulative total of requested ground water withdrawal rates on file with the OWRD are presently below the cap.

Future Ground Water Withdrawal

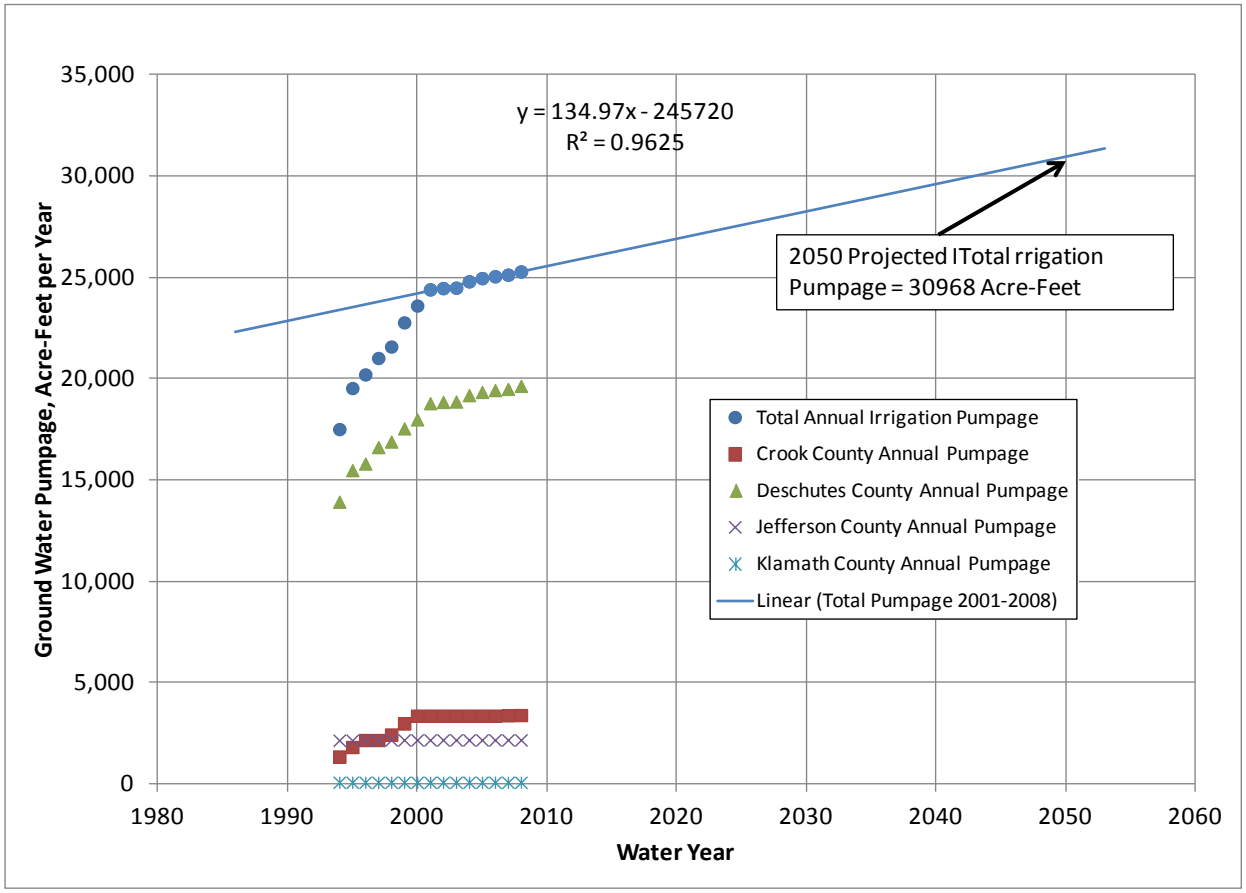
Projected additional ground water withdrawals for future needs out to the year 2030 are estimated at approximately 13,000 acre-feet for the major urban suppliers including cities of Bend, LaPine, Redmond and Sisters, and Avion Water Company and the Deschutes Valley Water District. The projected future ground water withdrawals of roughly 14,000 to 15,000 acre-feet for these major urban suppliers are subject to mitigation requirements. Some of the required mitigation has or is in the process of being satisfied. The remaining mitigation obligation is approximately 4,396 acre-feet based on a consumptive use range between 47 and 60 percent. This remaining mitigation obligation will require transfer of approximately 2,400 acres of surface water rights to instream use in the appropriate zone of influence.

Predicting ground water withdrawal for municipalities is dependent upon the expected growth rate. From 2000 to 2008, the growth rate in central Oregon was quite high, but was sharply reduced in late 2008 and 2009 due to the recession. Rather than trying to predict an overall growth rate, Table 6 shows the potential increase in ground water withdrawal for municipalities for growth rates from 1 percent to 7 percent. Figure 6 displays the annual estimated irrigation ground water withdrawal in the covered lands for Crook, Deschutes, Jefferson, and Klamath Counties for water years 1995 through 2008. The growth rate in irrigation ground water withdrawals slowed beginning in 2001, possibly due to the start of the mitigation program requirements. A possible trend in future irrigation ground water withdrawals is reflected by the trend line on Figure 6, drawn through the 2001 to 2008 water years. This trend line estimates that future irrigation ground water withdrawals could be about 31,000 acre-feet per year by 2050.

Table 6: Estimated Future Municipal Ground Water Pumpage at Various Annual Growth Rates

Annual Growth Rate	Estimated 2025 Muncipal Ground Water Pumpage, Acre Feet/Year	Estimated 2050 Muncipal Ground Water Pumpage, Acre Feet/Year
1%	28,140	36,088
2%	33,271	54,585
3%	39,273	82,230
4%	44,912	109,662
5%	51,350	154,764
6%	58,637	217,704
7%	66,875	305,261

Figure 6: Annual Irrigation Ground Water Pumpage, Water Years 1995 to 2008



Data Gaps

The data provided by Marshall Gannett with the USGS (personal communication) only includes selected actual withdrawal numbers for municipal and irrigation for the water years 1995 through 2008. For instance, the data base does not include figures for the City of Prineville. In addition, it does not include ground water withdrawals for other uses: agriculture, domestic, fish, industrial, irrigation, in-stream, livestock, mining, miscellaneous, municipal, power, recreational, storage and wildlife. Nor does it include information about exempt wells.

GROUND WATER WITHDRAWAL DATA – Irrigation Water Rights Updated From OWRD Water Right Data Base

Summary of Available Data

Specific information about the sources of ground water withdrawals is available by county and use at the following OWRD website: http://apps.wrd.state.or.us/apps/wr/wrinfo/wr_summary_pod.aspx.

Types of ground water uses that require permits include: agriculture, domestic, fish, industrial, irrigation, in-stream, livestock, mining, miscellaneous, municipal, power, recreational, storage and wildlife. At the OWRD website, a summary of permitted sources by county, use, and month of the year can be obtained. In addition, the entire list of sources that was used to obtain the summary can be downloaded.

Table 7 is a summary of irrigation uses for the Deschutes River Basin for Crook, Deschutes, Jefferson, and Klamath counties, and is included in this report as an example of the information that can be obtained from this website.

Applicability to the Deschutes Basin HCP

The data available at this website show the amount of water that could legally be pumped pursuant to either a permit or certificated water right issued by the State of Oregon. It indicates a much larger amount of ground water that could be withdrawn than reflected in the data provided by Marshall Gannett (personal communication) for 1994 – 2008. The volume of ground water withdrawal authorized on existing water rights is much larger than the volume of use reflected in the data.

Estimated Future Ground Water Use

The number of new ground water withdrawal permits will likely parallel the growth in municipal and industrial ground water use. As stated in the USGS data base section, the growth rate is tempered significantly by the need to mitigate the ground water withdrawals with replacement surface water.

Table 7: Summary of Permitted Ground Water Withdrawals for Irrigation Uses for the Deschutes River Basin for Crook, Deschutes, Jefferson and Klamath Counties.

		January	February	March	April	May	June	July	August	September	October	November	December
Deschutes County	# of Water Rights	5	3	309	360	367	369	369	369	369	363	21	5
	# of Points of Diversion	6	4	389	455	469	471	471	471	471	460	28	6
	Average Rate, cfs	5.554	4.284	222.230	251.985	282.266	282.343	282.343	282.343	282.343	264.628	12.999	5.554
	Total Amount for Year, ac-ft		**131,453**										
Crook County	# of Water Rights	5	12	162	170	177	177	177	178	178	173	13	12
	# of Points of Diversion	5	15	248	258	266	266	266	269	269	261	16	15
	Average Rate, cfs	1.810	5.582	183.704	191.980	206.218	206.218	206.218	211.454	211.454	198.340	10.082	5.582
	Total Amount for Year, ac-ft		**98,860**										
Jefferson County	# of Water Rights	2	2	51	53	53	53	53	53	52	52	2	2
	# of Points of Diversion	4	4	67	69	69	69	69	69	68	68	4	4
	Average Rate, cfs	1.260	1.260	57.184	59.734	59.734	59.734	59.734	59.734	58.064	58.064	1.260	1.260
	Total Amount for Year, ac-ft		**28,779**										
Klamath County	# of Water Rights	0	0	3	3	3	3	3	3	3	3	0	0
	# of Points of Diversion	0	0	4	4	4	4	4	4	4	4	0	0
	Average Rate, cfs			1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6		
	Total Amount for Year, ac-ft		**772**										

Data Gaps

The major data gap with regards to this data compilation is that it does not include the exempt wells, which do not require a permit or water right certificate.

GROUND WATER WITHDRAWAL DATA – Annual Reports from OWRD Public Agency Water Use Data Base

Summary of Available Data

While OWRD does not require all water right holders to report their annual water use, it does require public agencies to report their water use on an annual basis. ORS 537.099 requires federal and state agencies, cities, counties, schools, irrigation districts and other special districts to report water use on an annual basis. Procedures and requirements for the annual reporting of water use have been established in OAR Chapter 690 Division 85. These water use reports can be viewed at the following website:

http://apps.wrd.state.or.us/apps/wr/wateruse_report/

It should be noted that this website includes water use separately from both ground and surface water sources.

Applicability to the Deschutes Basin HCP

This data compilation includes information from smaller users than those considered by USGS (Marshall Gannett, personal communication) to be significant ground water pumpers, providing a more comprehensive compilation of ground water withdrawal data

Data Gaps

As indicated, the data provided in this data base only includes public agencies; it does not include private ground water users.

GROUND WATER WITHDRAWAL DATA – Updated Exempt Wells from OWRD Public Agency Data Base

Summary of Available Data

Not all ground water withdrawals require a water right. Water use not subject to a water right is referred to as "exempt use" and includes group or single domestic uses, up to 15,000 gpd; irrigation of a lawn and/or non-commercial garden of ½ acre or less; single industrial or a commercial purpose not to exceed 5,000 gpd; irrigation of school property up to 10 acres in critical ground water areas; stock water; and down-hole heat exchangers. Wells used to supply water for exempt uses are "exempt wells".

Table 8 is a list, by county and township, of the number of domestic wells, assumed to be exempt, in the upper Deschutes River Basin. Listed wells can include those located in upper Basin areas outside the upper Basin Study Area. This list was obtained by accessing the following website operated by OWRD.

The website lists all of the well logs that have been filed in the State of Oregon and are accessible by township, range, and section. The website also indicates what type of use for which the well was constructed. This information can be accessed on the OWRD website at http://apps.wrd.state.or.us/apps/gw/well_log/Default.aspx.

Table 8 shows there are 21,271 exempt wells recorded in the upper Basin. The annual volume of ground water withdrawals from exempt wells is uncertain and can vary over a wide range. The DWA studies (2004-2006) included an estimate based on an average withdrawal rate of 1,000 gallons per day per well and an estimated 20,000 exempt wells. The estimated annual volume of ground water withdrawal was about 22,400 acre-feet. Input from some reviewers suggested that this estimate was too high. For this data compilation, a basis for an estimate of exempt well withdrawals is based on average number of persons per home and consideration of average per capita water demand from public water supplier sources. From U.S. Census records, there are an average of 2.44 people per dwelling in the counties of Crook, Deschutes, Jefferson, and Klamath. Average per capita water demand for a number of public water suppliers is about 245 gallons per day per person. Assuming potential for increased water use for exempt wells in rural settings with no water service payments to a supplier, the average per capita rate is increased by 10 percent to 270 gallons per day per capita. Assuming that each exempt well serves a single family home and that the per capita water use is 270 gpd, the total annual ground water withdrawal from the exempt wells would be about 15,670 acre-feet.

Applicability to the Deschutes Basin HCP

An annual ground water withdrawal on the order of 15,000 acre-feet per year is a significant component of total ground water withdrawal in the upper Basin. The DWA studies (2004-2006) estimated that the number of exempt wells could reach 32,000 in 2025. If this is the case, annual ground water withdrawals from such wells could be about 21,000 acre-feet.

Estimated Future Ground Water Use

The growth of water use from exempt wells is difficult to predict. Many, if not most, of the exempt wells serve rural lots that were created before Oregon's current land use statutes were adopted. The creation of new rural lots outside urban growth boundaries will be restricted under current land use requirements. Future growth of exempt wells will depend on the creation of new lots and the installation of exempt wells on existing, undeveloped lots. Because of these unknowns, future ground water use by exempt wells cannot be reliably predicted.

Data Gaps

Data gaps are significant. There is no reliable information on how may exempt wells serve development other than single family residences. Also, if a well serves a single family residence, is it occupied year around or just seasonally? As a result, the amount of ground water withdrawn from the wells cannot be accurately determined.

OTHER GROUND WATER INFORMATION

Ground Water Well Construction Information

OWRD requires well constructors to file a well log for every well that is constructed. Logs are required for water production wells, monitoring wells, and geotechnical holes. These logs can be accessed on the OWRD website at http://apps.wrd.state.or.us/apps/gw/well_log/Default.aspx. The logs can be accessed on the basis of county, legal description, type of use, or other means.

Ground Water Elevations

OWRD has ground water elevation data available at its website. This data can be access at this website: http://www.oregon.gov/owrd/pages/gw/well_data.aspx. Enquiries for information can be via county or well log.

Ground Water Quality Data

ODEQ has a ground water quality data base system that can accessed at their website. The data base is called "Laboratory Analytical Storage and Retrieval" and can be accessed at http://deq12.deq.state.or.us/lasar2. This site also has surface water quality data.

Ground water quality data can also be accessed from the Oregon Drinking Water Data Online website that is operated by the Oregon Drinking Water Program of the Oregon Public Health Division. This website includes ground water quality data from publicly-accessible drinking water systems, but also includes data from surface water systems. The website to obtain data is: http://170.104.63.9/.

Table 8: List of the Estimated Number of Exempt Wells in the Upper Deschutes River Sub-basin by County and Township.

Township South	Range East	County	No. of Operational Domestic Wells	Township South	Range East	County	No. of Operational Domestic Wells	Township South	Range East	County	No. of Operational Domestic Wells	Township South	Range East	County	No. of Operational Domestic Wells	Township South	Range East	County	No. of Operational Domestic Wells
9	13	Jefferson	17	13	15	Crook	113	16	17	Crook	106	20	7	Deschutes	0	23	5	Klamath	0
9	14	Jefferson	20	14	8	Deschutes	1	17	8	Deschutes	0	20	8	Deschutes	2	23	6	Klamath	21
9	15	Jefferson	16	14	9	Deschutes	12	17	9	Deschutes	0	20	9	Deschutes	0	23	7	Klamath	6
10	10	Jefferson	1	14	10	Deschutes	402	17	10	Deschutes	2	20	10	Deschutes	1113	23	8	Klamath	0
10	12	Jefferson	32	14	11	Deschutes	243	17	11	Deschutes	126	20	11	Deschutes	553	23	9	Klamath	463
10	13	Jefferson	9	14	12	Deschutes	511	17	12	Deschutes	501	20	12	Deschutes	0	23	10	Klamath	481
10	14	Jefferson	62	14	13	Deschutes	1224	17	13	Deschutes	131	20	13	Deschutes	3	23	11	Klamath	12
10	15	Jefferson	2	14	14	Crook	94	17	14	Deschutes	270	20	14	Deschutes	0	23	12	Lake	0
11	8	Jefferson	0	14	15	Crook	569	17	15	Crook	24	20	15	Deschutes	8	24	5	Klamath	0
11	9	Jefferson	0	14	16	Crook	604	17	16	Crook	15	20	16	Deschutes	10	24	6	Klamath	85
11	10	Jefferson	0	14	17	Crook	170	18	8	Deschutes	1	21	6	Deschutes	1	24	7	Klamath	146
11	11	Jefferson	37	15	8	Deschutes	0	18	9	Deschutes	3	21	7	Deschutes	2	24	8	Klamath	21
11	12	Jefferson	10	15	9	Deschutes	242	18	10	Deschutes	52	21	8	Deschutes	8	24	9	Klamath	33
11	13	Jefferson	27	15	10	Deschutes	510	18	11	Deschutes	466	21	9	Deschutes	3	24	10	Klamath	7
11	14	Jefferson	10	15	11	Deschutes	439	18	12	Deschutes	159	21	10	Deschutes	3434	24	11	Klamath	0
11	15	Jefferson	3	15	12	Deschutes	473	18	13	Deschutes	109	21	11	Deschutes	333	24	12	Lake	0
12	8	Jefferson	0	15	13	Deschutes	493	18	14	Deschutes	17	21	12	Deschutes	1	25	5	Klamath	3
12	9	Jefferson	14	15	14	Crook	358	18	15	Crook	1	21	13	Deschutes	9	25	6	Klamath	0
12	10	Jefferson	1	15	15	Crook	264	18	16	Crook	6	21	14	Deschutes	0	25	7	Klamath	25
12	11	Jefferson	34	15	16	Crook	669	19	7	Deschutes	0	21	15	Deschutes	0	25	8	Klamath	76
12	12	Jefferson	29	15	17	Crook	48	19	8	Deschutes	4	22	6	Deschutes	0	25	9	Klamath	2
12	13	Jefferson	14	16	8	Deschutes	2	19	9	Deschutes	0	22	7	Deschutes	0	25	10	Klamath	0
12	14	Jefferson	22	16	9	Deschutes	0	19	10	Deschutes	1	22	8	Deschutes	0	25	11	Klamath	1
13	8	Jefferson	8	16	10	Deschutes	17	19	11	Deschutes	6	22	9	Deschutes	143	26	6	Klamath	0
13	9	Jefferson	96	16	11	Deschutes	485	19	12	Deschutes	1	22	10	Deschutes	1284	26	7	Klamath	109
13	10	Jefferson	0	16	12	Deschutes	815	19	13	Deschutes	0	22	11	Deschutes	10	26	8	Klamath	0
13	11	Jefferson	14	16	13	Deschutes	19	19	14	Deschutes	6	22	12	Deschutes	0	26	9	Klamath	0
13	12	Jefferson	486	16	14	Crook	150	19	15	Deschutes	6	22	13	Deschutes	0	26	10	Klamath	1
13	13	Jefferson	94	16	15	Crook	8	19	16	Deschutes	3	22	14	Deschutes	3	27	7	Klamath	0
13	14	Jefferson	10	16	16	Crook	813	20	6	Deschutes	0	22	15	Deschutes	0	27	8	Klamath	27

DATA GAP SUMMARY

Compilation of ground water withdrawal data revealed some data gaps that are summarized below for clarity:

1. The uncertainty in estimating exempt well withdrawals. The number of existing exempt wells is available on the OWRD data base. Uncertainty in the estimates presented in this report is believed primarily due to the rate of ground water use, which ranges between 100 and just over 400 gallons per person per day. There is no reliable information on how many exempt wells serve development other than single family residences. Also, if a well serves a single family residence, there is uncertainty in whether the residence is occupied year-round or just seasonally.
2. The degree of uncertainty for irrigation withdrawals. The updated withdrawal data compiled by the USGS for 1994-2008 (Marshall Gannett, personal communication) are based on estimates for 293 irrigation wells, considering water rights (OWRD water rights data base) and information on crop types and irrigation methods.
3. Uncertainty in population trends which drive ground water withdrawals for municipal suppliers, resorts and exempt well users in the future.

The difference between ground water withdrawals in data generated by the USGS for 1994-2008 (Marshall Gannett personal communication) and estimated withdrawals reported by the DWA (2006) is noteworthy and warrants consideration moving forward. The difference in annual withdrawal values is about 18,000 acre-feet.

FORMAT FOR DATA COMPILATION – Future Potential Modeling Use

An objective of Study 10 is to organize ground water withdrawal data and forecasts in a format suitable to support basin hydrologic modeling. Updated data compiled by the USGS (Marshall Gannett, USGS) are being used for modeling purposes. The data are compiled in a very large excel spreadsheet system. Data are formatted according to the following categories:

Municipal Withdrawals

Well Log Identification Number

Well Owner

Year (1994-2008)

Withdrawal for Each Year, Acre-Feet (1994-2008)

Irrigation Withdrawals

Well Log Identification Number

Year (1994-2008)

Withdrawal for Each Year, Acre-Feet (1994-2008)

Well Locations

Well Log Identification Number

County within Which Well is Located

Well Identification Number

Well Log Number

Type of Water Use

UTM X and Y Coordinates

The size of the data files is prohibitive for incorporation into this Study 10 report. It is suggested that the data is set up on a website for those who wish to view it. This is being done.