GROUND WATER

OPEN FILE REPORT

GROUNDWATER INVESTIGATION OF BONANZA SPRINGS YONNA, POE AND LANGELL VALLEYS KLAMATH COUNTY, OREGON

By
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REPORT 94 -01

STATE OF OREGON

WATER RESOURCES DEPARTMENT

SOUTH CENTRAL REGION

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Glossary

Acre-foot- The amount of water needed to cover one acre of land one foot deep.

Alluvium- Of or pertaining to material deposited by a stream or running water.

Andesite- Fine-grained, gray to black volcanic rock. Similar to Basalt but contains more silica.

Aquifer- A body of rock, soil or earth material that is sufficiently permeable to conduct groundwater and to yield significant quantities of water to wells.

Basalt- Dark gray to black, fine-grained igneous rock. Most commonly called lava, occurs primarily in flows that vary in thickness. Erupts to surface in volcanically active areas.

Breccia- A coarse-grained rock consisting of angular fragments cemented together by fine-grained material.

Cfs- Cubic feet per second. A customary unit of quantifying large stream flow. One cfs equals 449 gallons per minute.

Cone of Depression- Pattern of the decreased head around a pumping well caused by the withdrawal of water.

Confined Aquifer- An aquifer bounded above and below by impermeable strata, or by strata of distinctly lower permeability than that of the water-bearing stratum itself.

Diatomite- Very fine-grained sediment containing the skeletons of silicic colonial algae.

Extensional Faulting- See Normal Faulting.

Fault- A fracture or fracture zone along which there has been movement of the sides relative to one another parallel to the fracture.

Fecal Coliform bacteria- Rod-shaped bacterium usually occurring in chains found in waste of humans and animals.

Fluviolacustrine- River, stream and/or lake sediments.

Groundwater- Any water, except capillary moisture, beneath the land surface or beneath the bed of any stream, lake, reservoir or other body of surface water within the boundaries of this state, whatever may be the geological formation or structure in which such water stands, flows, percolates or otherwise moves.

Groundwater reservoir- See Aquifer

Hydraulic Conductivity- A coefficient used to describe the ease with which water travels through an aquifer.

Hydrology- The study of water emphasizing surface water.

Intrusive Igneous Rock- Rock formed from magma not erupted to the surface. Lava that cooled below the surface does so more slowly than surface-erupted lavas resulting in crystal grains that grow larger in size.

Lahar- A landslide or mudflow of pyroclastic material on the flank of a volcano; also, the deposit so produced.

Lapilli Tuff- Volcanic rock formed when hot volcanic ejecta erupted in the air or flowed over land and cooled to a consolidated condition. Particularly pertaining to grain size 1/2 to 3 cm in diameter.

Lithologic- Pertaining to rock.

Mafic- Pertaining to iron and magnesium minerals assemblages in igneous rocks.

MSL- Mean sea level. Elevation of a point in reference to the average elevation of the ocean, established in 1919.

NOAA- National Oceanic and Atmospheric Association.

Normal Fault- A fault at which the mass of rock above the fault plane (hanging wall) has been depressed, relative to the mass of rock below the fault plane (foot wall).

Olivine- A mineral often found in the dark-colored igneous volcanic rocks.

Permeable Rock- Rock that has sufficient interconnected void space that water can readily move through it.

Plagioclase- Common mineral found in many volcanic rocks primarily composed of sodium, potassium and various accessory elements.

Pleistocene- Geologic epoch in the Quaternary period extending in age from 1.6 million years to 10,000 years ago.

Pliocene- A division of the Tertiary period extending from 5.3 to 1.6 million years before present.

Potassium-Argon age Dating- Use of the ratio of constituent radioactive gasses in a rock to determine age.

Potentiometric Surface- A pressure surface as defined by the level to which water will rise in a well.

Pumice- Light volcanic rock filled with air pockets.

Pyroclastic Rock- Any rock consisting of unreworked solid material of whatever size explosively ejected from a volcanic vent.

Quaternary- The time period from 1.6 million years ago to the present.

Rhyolite- Fine-grained volcanic rock that contains relatively large amounts of silica. Its large grained, chemically-similar rock type is granite.

Scoriaceous Zone- The zone, usually at the upper or lower edges of a lava flow in which the lava has many vesicles, or gas bubbles.

Stratigraphic correlation- Use of geologic age, lithologic characteristics, fossil content, or any other property to relate rock units by age.

Static Water Level- SWL. The level at which water comes to rest in a well bore.

Tertiary- The time period from 65 million to 1.6 million years before present.

Total Dissolved Solids (TDS)- A measure of dissolved mineral matter in water.

Transmissivity- The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Equals the hydraulic conductivity multiplied by the aquifer thickness.

Tuff- A general term for all consolidated pyroclastic rocks.

Vesicular - Referring to the holes resulting from gas bubbles entrained in erupting rock.

INTRODUCTION

ACKNOWLEDGEMENTS

Ken Lite and Fred Lissner of the Groundwater Section of Oregon Water Resources Department assisted in the direction of the study, as did Bob Main, South Central Regional Manager for OWRD. I appreciate the help of Del Sparks, Watermaster, District 17, in well measurements and stream-flow measurements, and Phil Brown of CH2M Hill for data from aquifer tests that his company conducted, and I especially thank all homeowners for allowing me access to their wells. A special thanks goes out to Earl Wiersma for allowing the Water Resources Department to utilize one of his unused wells for an entire year and a half for continuous recorder measurements.

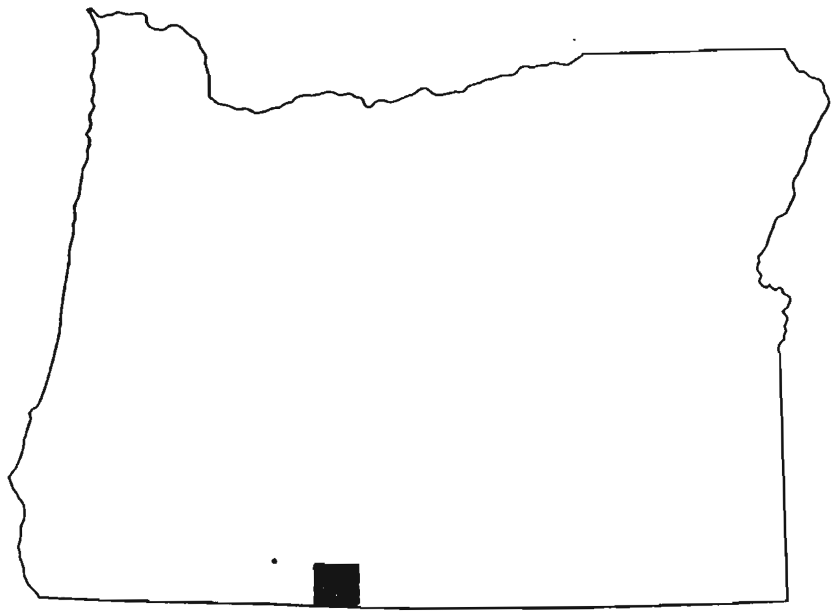
PROBLEM STATEMENT

During the early 1990's, groundwater declines allegedly resulted in water quality problems with wells in the town of Bonanza. At the same time, Oregon Water Resources Department (OWRD) received a large number of applications for increased groundwater use in the same area. These two factors caused OWRD to be concerned about the area. This study was conceived to address the groundwater-surface water inter-relationship.

It is well-documented that groundwater is a major contributor to the flow of the Lost River in the Bonanza Springs area (Meyers and Newcomb, 1952; Newcomb and Hart, 1958; Leonard and Harris, 1974). It has been determined through previous hydrogeological studies (Meyers and Newcomb, 1952; Newcomb and Hart, 1958; Leonard and Harris, 1974) that what the prior investigators termed the regional groundwater system has a water surface whose elevation is coincident with that of he major drainages. This includes the Lost River near Bonanza, Oregon. Water-bearing geologic units in the Bonanza area provide large amounts of water to wells and provide natural base flow for springs and drainages. The principal natural outflows of groundwater occur where drainages have intersected both the regional water table and highly- permeable rocks.

The study area is located approximately 25 miles east of the City of Klamath Falls in South Central Oregon, Klamath County (Figure 1). From mid to late 1991, several events occurred which caused people to examine the hydraulic connection between the groundwater and surface water resources of the Bonanza Springs area: 1. The State Health Division (HD) (Nelson, 1991) concluded that the outbreak of bacterial contamination in a few wells in Bonanza was caused, in part, by the direct hydraulic connection between the Lost River and the shallow permeable zone wherein the wells are developed. 2. The Bonanza Springs were flowing at a reduced rate, as were many springs in the region, probably in response to the well-documented drought. 3. Between early 1991 and June 1992, OWRD received 25 applications for the appropriation of groundwater in Yonna, Langell and Poe Valleys for the purpose of primary and supplemental irrigation. The cumulative appropriation of the applications equaled 97.11 cfs. In addition to those applications, OWRD received 13 emergency drought applications for the appropriation of groundwater in Langell Valley between February and June of 1992. The drought emergency applications sought an additional 39.5 cfs. The cumulative rate of appropriation requested in those 38 applications represented an amount that exceeds the average historic measured flow of Bonanza Springs. The emergency drought permits for groundwater were issued and utilized during the 1992 spring and summer irrigation season. With the reduced rate of flow of the Bonanza Springs the OWRD questioned the effect that these new permits, if issued, would have on the flow of the Lost River.

LOCATION OF STUDY AREA



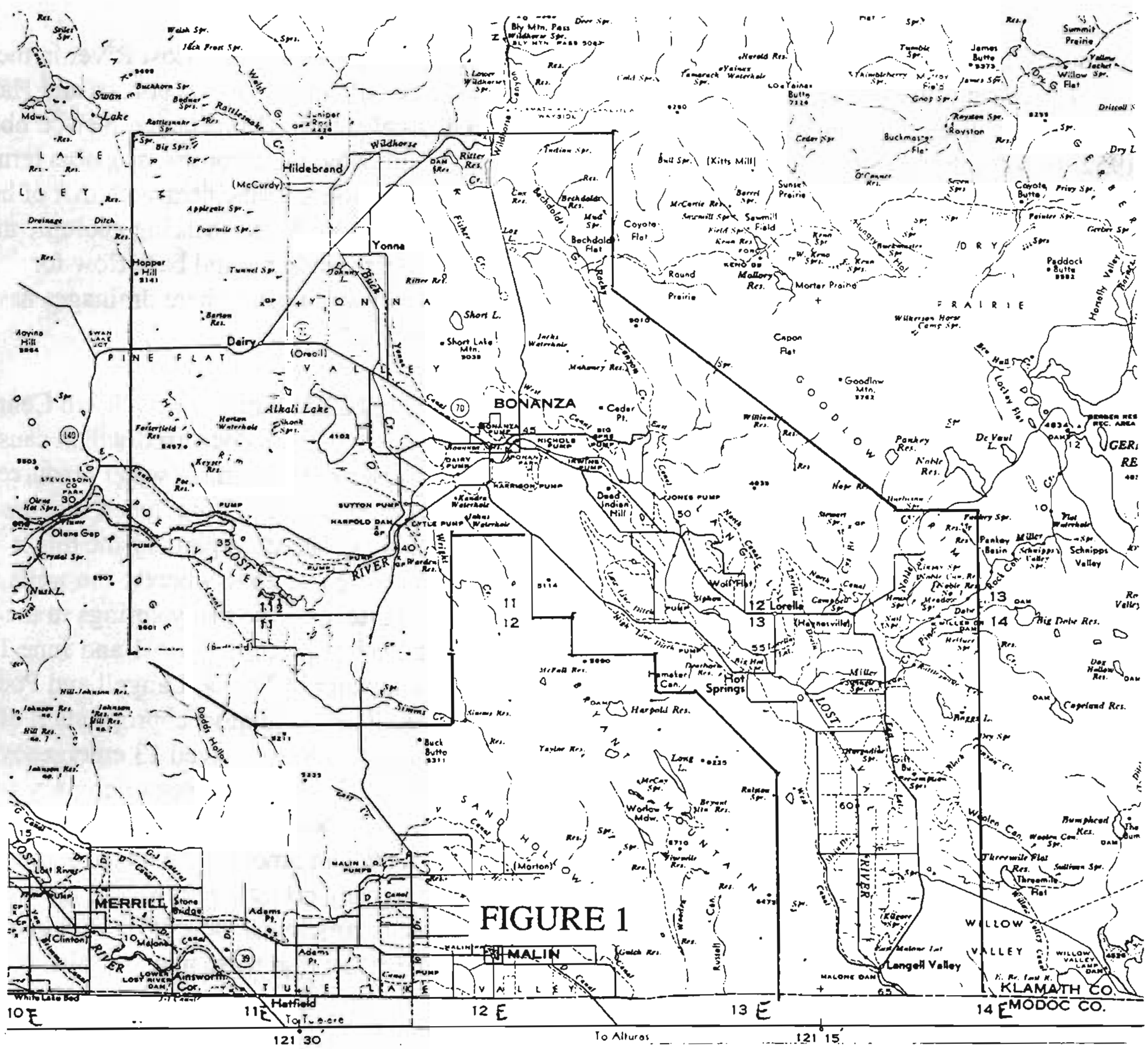


FIGURE 1

The concern was accentuated by the historic low flow measurement of 38 cfs on the Bonanza Springs in January 1992, by the watermaster from the Klamath Falls office. In addition to the low flow measurement, the prominent springs in the north channel of the Bonanza Springs Park ceased to flow during the summer of 1992.

OWRD staff, observing less-than-normal groundwater discharge through springs and a large additional groundwater withdrawal potential occurring in the same area, concluded that the resource could sustain no additional pumping beyond that which was already permitted without significantly affecting the springs. The above mentioned conditions led OWRD to request the Water Resources Commission to initiate a proceeding to withdraw the Lost River Groundwater reservoir from further appropriation on June 5, 1992. The request was denied due to a lack of data that would support the contention that the decreased flow of the springs was, in part, the result of increased pumping of groundwater, rather than a result of the lingering drought.

PURPOSE, SCOPE AND METHODOLOGY

A reconnaissance study was designed to collect, compile, and analyze data to determine if groundwater use would interfere with surface water sources near Big Bonanza Springs. The study was to last one year from July 1992 to June 1993. Periodic water level measurements and stream flow measurements have been made since June 1993, to create a more complete data set.

Water level measurements in selected wells were made periodically to determine groundwater level fluctuations over time. A continuous water level recorder was installed in one well in September 1992 and is currently scheduled to run until spring 1994, when its status will be evaluated. The emphasis on work in the local area around Bonanza included monthly water level measurements, Lost River stream flow measurements, and Bonanza Springs weir measurements. This area has the highest concentration of wells, both domestic and irrigation, and is of particular interest because of the large aggregate discharge of groundwater in a short reach of the Lost River.

To quantify the discharge of the Bonanza Springs, wading stream flow measurements were made above and below the section of the Lost River where groundwater is known to discharge. The difference between the two measurements was assumed to give the discharge of the springs in that reach. To correlate the overall flow of Bonanza Springs to the direct measurement of some of the discharge points, various-sized rectangular weirs were placed in the northern channel of the springs in the Big Bonanza Springs Park. The comparison could then be made by making sets of measurements at all locations in a single day.

The total potential use was determined by summing the number of cubic feet per second (cfs) on the pending applications filed with OWRD for the appropriation of groundwater in the area within the study boundaries. This area coincides with the valley lowland areas.

The total maximum rate of appropriation under terms of existing permits was determined by valley only in Langell Valley for the 1992 irrigation season. This was done by summing the individual rates in permits for irrigation, stock and domestic purposes, if any. This total included all issued permits and emergency drought permits exclusively from groundwater.

Sample drill cuttings were collected from wells under construction during the study period within the study boundaries. The samples were examined in an effort to correlate geology defined in past studies with present knowledge. They were also used to conceptualize the subsurface geology.

A video log of the well bore in which the continuous water level recorder was installed was done in early October 1992. Since this well was constructed prior to the requirement of a well drilling report, a video log of the rock types throughout the well bore was recorded. This information was important in evaluating static water level information also collected by the recorder.

LOCATION

The study area encompasses three principal valleys in South Central Oregon. Yonna, Langell and Poe valleys all drain to the Lost River (Figure 2.) and are separated by narrow ridges or small mountain ranges. The area includes approximately 110 square miles. The main focus of the study includes a smaller local area around the Town of Bonanza, about 25 miles east of the city of Klamath Falls. The outlying valleys around the Bonanza area are included in the study to provide a better overall understanding of the system and to include some long-term water level information from state observation wells situated in those locations.

PREVIOUS WORK

The first hydrogeological study was done by Meyers and Newcomb (1952). This study involved the geology and groundwater resources of the Swan Lake and Yonna Valleys, which lie to the Northwest of Bonanza. They determined, through water level measurements, that the regional groundwater table slopes gently from the higher portions of the valleys toward the level of the Lost River. The Meyers and Newcomb study identified two basaltic lava rock sequences as containing the principal water-bearing zones and determined the maximum sustainable production rate. Their estimates suggest that the groundwater use in 1952 in Yonna and Swan Lake valleys, including Pine Flats to the South of Swan Lake, equaled 6,000 acre-feet and that the use could safely be doubled without harm to the resource.

Meyers and Newcomb (1952) proposed a conceptual model for the availability and movement of groundwater which consists of three zones: a lower basalt, a fined-grained sedimentary unit, and an upper basalt. The lower basalt zone was thought to be below the water table and capable of high yields; the overlying fine-grained sedimentary unit was thought to confine the lower zone and to be incapable of significant yields; and the upper basalt unit was thought to be capable of significant yields whenever it lay below the water table. Later investigations by Sherrod and Pickthorn (1992), Pickthorn and Sherrod (1990), Mallin and Hart (1991) show that this model is not entirely accurate.

Meyers and Newcomb (1952) determined, based on precipitation and water levels, that the discharge of Bonanza Springs substantially exceeds the recharge to the Swan Lake and Yonna Valleys. These factors suggest that the source is groundwater percolating downstream with the Lost River from Langell Valley and surrounding areas.

Newcomb and Hart (1958) studied the groundwater resources of the Klamath River Basin. Their study included the Yonna and Swan Lake valleys and drainages of the Klamath Marsh, Williamson, Sprague and Klamath Rivers. The main objectives were the mapping and quantification of the

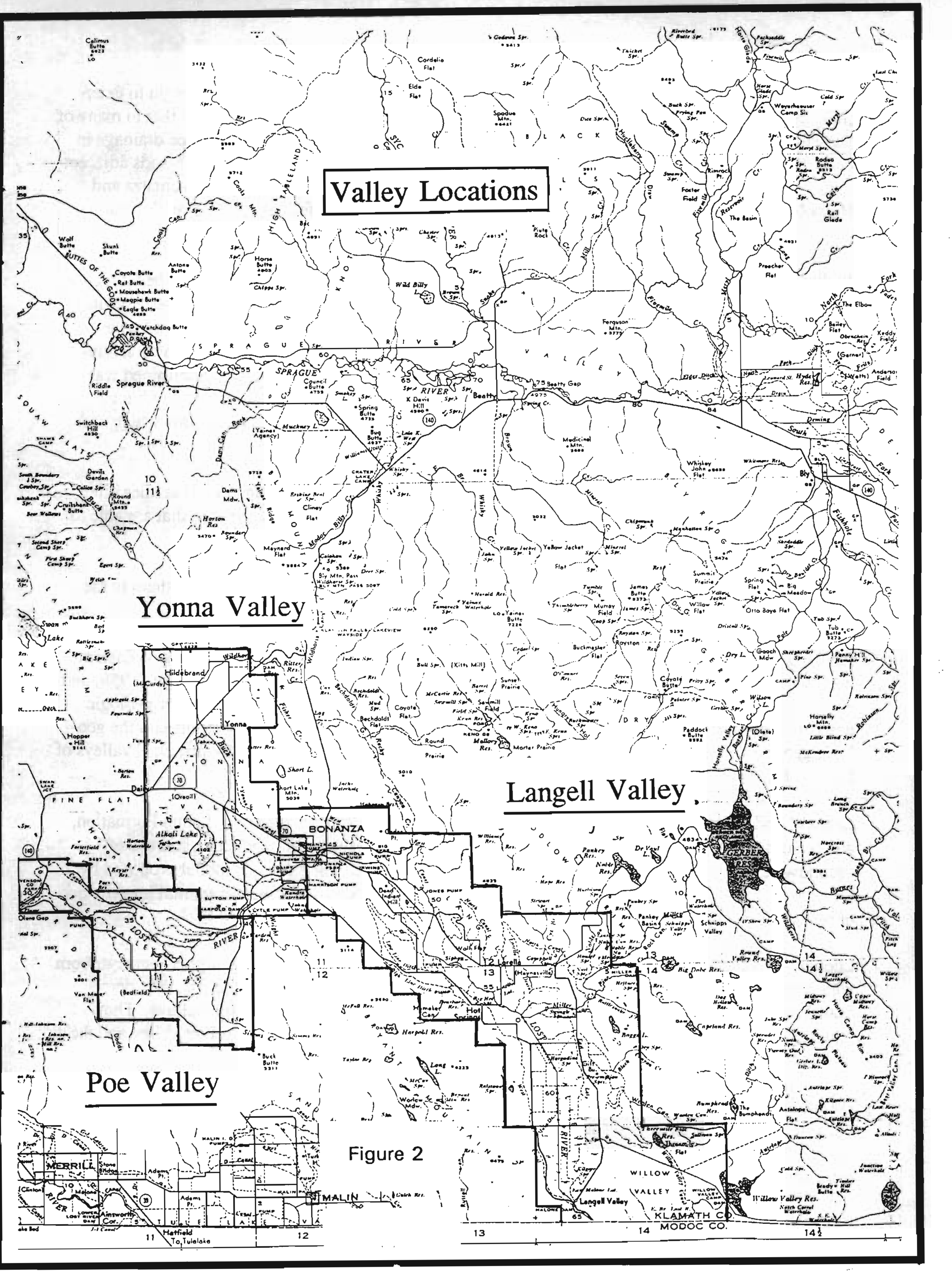

Valley Locations
Yonna Valley
Langell Valley
Poe Valley
BONANZA
MERRILL
MALIN
Sprague River
Beatty
Bly
Langell Valley
KLAMATH CO.
MODOC CO.

Figure 2

groundwater contributions to the surface waters in the Klamath Basin. They also sought to determine the principal factors governing the groundwater system operation. They found that in many of the valleys the regional water table sloped to a level coincident with the major surface drainage in that valley. Groundwater divides exist between the valleys that are separated by highlands adjacent to each valley. Newcomb and Hart measured discharge of the Lost River between Bonanza and Harpold Dam and found that the river had an inflow of 75,000 acre-feet annually directly from groundwater (103 cfs yearly average).

In the same year that Newcomb and Hart released their study, Newcomb (1958) published a report on the Yonna Formation. This was a detailed report on the late Tertiary fluviolacustrine deposits of the Klamath Basin. Newcomb (1958) determined that this formation has two units at the type locality: A lower sedimentary section consisting of fine-grained to medium-grained volcanically-dominant material,and a thick upper unit of basaltic lapilli tuff, part of which he determined was deposited in water. Later mapping by other authors (Sherrod and Pickthorn, 1992) abandon the nomenclature of the Yonna formation and replace it with four different mappable units which are discussed below.

The Yonna Formation of Newcomb (1958) is mentioned quite extensively in several studies after 1958, and has been described as a confining layer for the basalt aquifers of the area that are able to yield substantial quantities of water to wells.

Wells and Peck (1961) described the volcanic rocks of the area in detail and assigned them to the Tertiary and Quaternary periods.

Peterson and McIntyre (1970) published a report on the geology and mineral resources of Eastern Klamath County and Western Lake County. They included much of Newcomb and Hart (1958) and Newcomb (1958) geologic interpretations in their report. This report defined the major geologic units and economically important mineral resources of the two counties. Their report laid the geologic groundwork for Leonard and Harris (1974) study of the groundwater in the principal valleys of Eastern Klamath County.

Leonard and Harris (1974) determined that the sedimentary unit, then called the Yonna Formation, and the thin alluvial deposits of the valleys are poor aquifers. The most productive sources of groundwater come from lava flows beneath the lacustrine beds. The geologic model proposed by Newcomb (1958) was used for the Leonard and Harris (1974) study with no substantial introduction of new concepts on the overall geology of the area.

Leonard and Harris describe the mountains surrounding each valley as areas of higher recharge from which groundwater moves to the lowlands. By observing water level measurements, they determined that groundwater levels normally fluctuate one to four feet annually in the valleys. They noted perennially-declining water levels in two small areas, one in southeastern Poe Valley and the other on the west side of Swan Lake Valley.

Leonard and Harris included seepage measurements along the Lost River in the entire stretch along Langell, Poe and the Southern part of Yonna Valleys. They found that significant groundwater seepage occurs at various points in the river bed. With their seepage measurements, they calculated, somewhat less than Newcomb and Hart (1958), 60,000 acre-feet of groundwater discharges to Lost

River annually. Based on geologic, well, and water-level data, they concluded that 1970 pumpage, 19,500 acre-feet, could be doubled or tripled in most areas without adverse effects on the annual supply. An exception was noted in the southeast corner of Poe Valley where declines were already occurring. In an important conclusion, Leonard and Harris also state: "In addition, the discharge of large quantities of ground water in the (Langell) valley indicates that additional groundwater might be developed at the expense of reducing natural discharge."

In a report by Mckee and others (1983), basaltic rocks similar to the rocks in the Bonanza area were chemically-tested and age-dated to determine their source, volume and areal extent. The study included potassium-argon age-dating and numerous chemical analyses. This study shed new light on the age of the basalt units and their relationship to the mafic lavas of the Cascade volcanic arc and Northwestern margin of the Basin and Range extensional faulting. This new interpretation reduced the uncertainties the previous authors had when mapping the dominantly volcanic geologic units of their study areas.

Pickthorn and Sherrod (1990) published a paper on the age dating of many rocks of the Klamath Falls area. By using the potassium-argon age-dating of selected samples of basalt, andesite and the mineral plagioclase, they were better able to define the time in which the lava units and deposition of the sedimentary units, previously called the Yonna Formation, occurred.

Mallin and Hart (1991) dated lavas by the potassium-argon method to better evaluate the age and distribution of volcanic materials within South Central Oregon and Northern California. They determined by their work that there are two major basalt rock types with one minor rock type showing chemical characteristics of both the other two. Their study helped determine the age and primary source and origin of the basaltic lavas in the Bonanza area.

In August 1991, the State Health Division (HD) conducted a preliminary investigation of an outbreak of bacteria contamination of a few small public water supply systems in the Town of Bonanza. The investigation led to the conclusion that the Bonanza Springs in the park are hydraulically-connected to the shallow permeable rock zone supplying most of the wells in town. The HD's investigation suggested the need of a more thorough study of the area to further characterize the hydraulic connection between surface water and groundwater.

A geologic map of the West half of the Klamath Falls one degree by two degree quadrangle by Sherrod and Pickthorn (1992), reproduced in part in Figure 6, gives a detailed description of the geologic units of the area. They concluded that the Yonna Formation (Newcomb, 1958) is more accurately described as four mappable units and not one large formation. Sherrod and Pickthorn (1992) subdivided the Yonna Formation into older Palagonite Tuff, Younger Palagonite Tuff, Continental Sedimentary Rocks, and Tuff and Lapilli Tuff. Based on age-dating for the development of this geologic map, the Continental Sedimentary unit was more closely age constrained than the previous author's (Newcomb, 1958) work, assigning it to latest late Miocene and Pliocene. The significance of the new geologic work is the conclusion that the Continental Sediments are coeval with the basalt units, and not younger as previously thought.

GEOGRAPHIC SETTING

The Klamath Basin is composed of many NW-SE trending elongate valleys bounded on the east by the western-most Basin and Range extensional faulting. To the west, the Cascade Volcanic arc creates an effective rain shadow and termination of the basin. To the north, the basin is not well-defined, but some authors suggest the Brothers fault zone (Lawrence, 1976) as the northern termination of the Basin and Range faulting. To the south, the basin is bounded by the Modoc Plateau in California.

The Lost River is a major tributary to the Lower Klamath Marsh and Klamath River via a U.S. Department of the Interior (USDA) Bureau of Reclamation canal. The river drains Langell, Yonna and Poe Valleys as well as the eastern edge of the Klamath Lake Basin. During periods of low flow, nearly the entire flow is made up of groundwater discharge from Big Bonanza Springs (Meyers and Newcomb, 1952) and releases from storage reservoirs.

The highland areas surrounding the valleys range in elevation from 4,500 to 6,000 feet with peaks reaching over 7,000 feet. The valleys average 4,100 to 4,300 feet elevation. The highlands are generally assumed to receive more precipitation than the valleys, but all areas tend to be semi-arid, receiving dominantly winter precipitation of approximately 14 to 18 inches. Three graphs showing annual precipitation at Klamath Falls, Malin and Sprague River are given as Figures 3, 4 and 5, respectively. Most of the precipitation falls as snow in the winter. Seventy percent of the precipitation falls during October to March and only nine percent during July through September (Leonard and Harris 1974). At two stations, six of the last eight years have had below normal precipitation, and at the other, precipitation in all of the last eight years has been below normal.

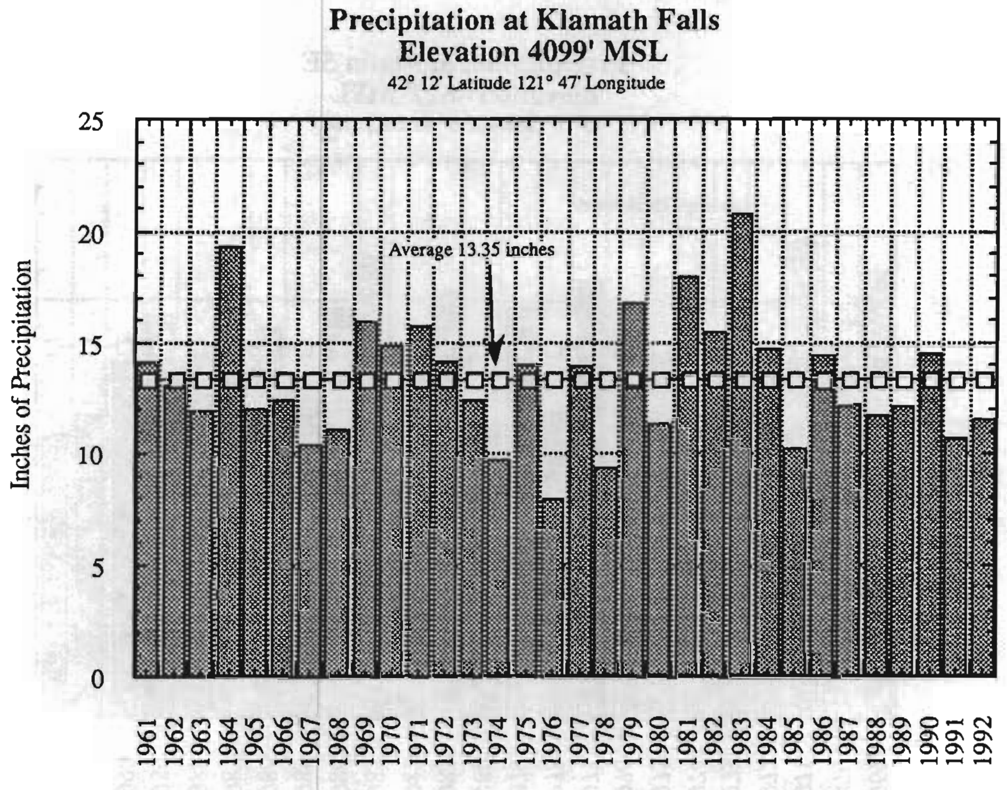
There is a precipitation collection site operated by the USDI Bureau of Land Management (BLM) for forest fire conditions in the area. This site is located near Gerber Reservoir at an approximate elevation of 4,900 feet above mean sea level (msl). Data are available from June 1986, to the present, but they are considered poor in quality. The site is not an official NOAA weather station, and NOAA standards are not followed at the Gerber Reservoir site. In talking with a representative from the BLM about the data collection, BLM staff reported that some of the snow never makes its wayt into the evaporation pan. These data were not included in the report.

Short Lake Mountain ridge, trending Northwest from the Town of Bonanza, is the most prominent topographic feature in the area. At the southern termination of this ridge, the visible discharge of Bonanza springs occurs. The valleys surrounding the Bonanza area are separated by the many undulating hills and ridges that rise several hundred feet above the valley floors.

GEOLOGY

GEOLOGIC SETTING

The geologic setting of the Bonanza Springs area is dominated by extensive Basin and Range type extensional faulting and volcanism. The volcanics consist mainly of basalt to basaltic andesite flows and Cascade volcanic arc volcanism underlain and intercalated by mafic lava flows of the Basin and Range volcanism. Older exposed basalt flows occur on the eastern margin of the Klamath graben. Generally, flows become younger toward the west to the present-day Cascades, where recent pumice flows, ejecta and silicic lavas exist. In the Bonanza area, while later flows of the Basin and Range were occurring, lowland areas were probably largely-closed basins where rock and pyroclastic


Precipitation at Klamath Falls
Elevation 4099' MSL
42° 12' Latitude 121° 47' Longitude
Average 13.35 inches
Inches of Precipitation
25
20
15
10
5
0
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
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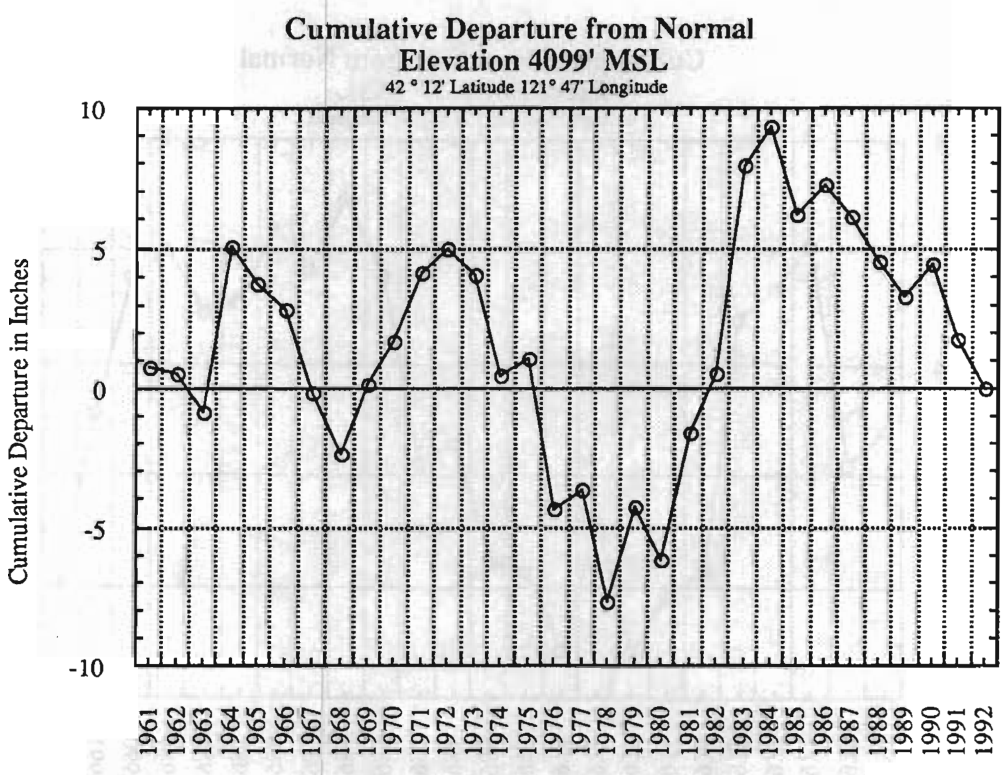
1988
1989
1990
1991
1992


Cumulative Departure from Normal
Elevation 4099' MSL
42 ° 12' Latitude 121° 47' Longitude
Cumulative Departure in Inches
10
5
0
-5
-10
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
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1976
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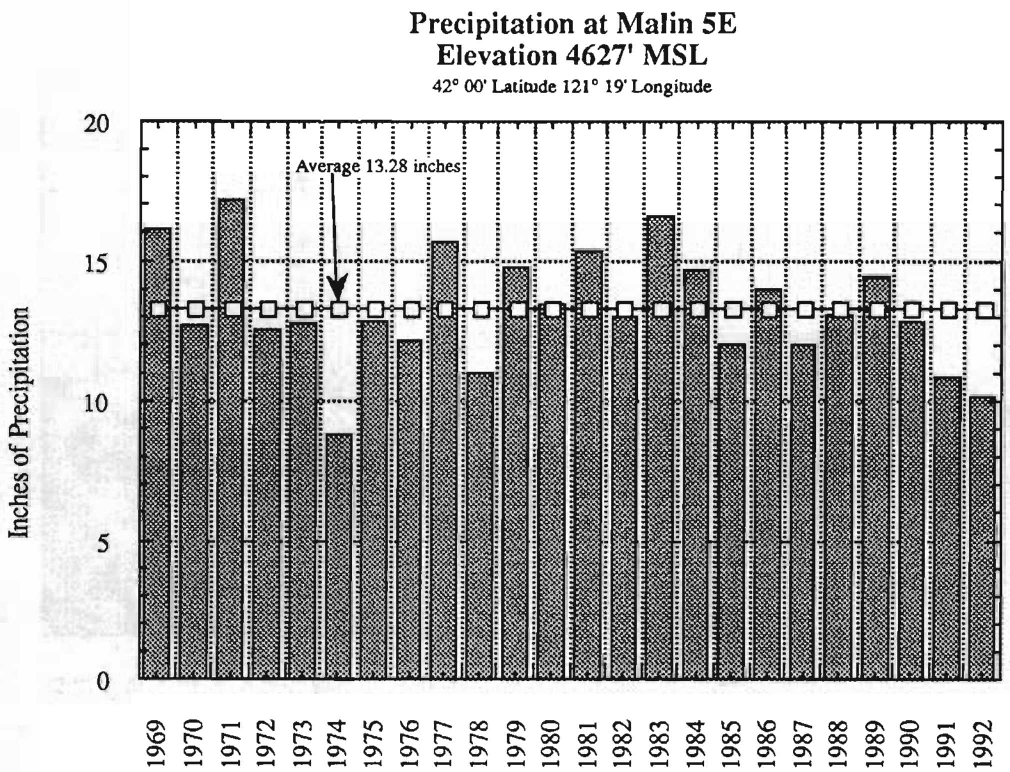
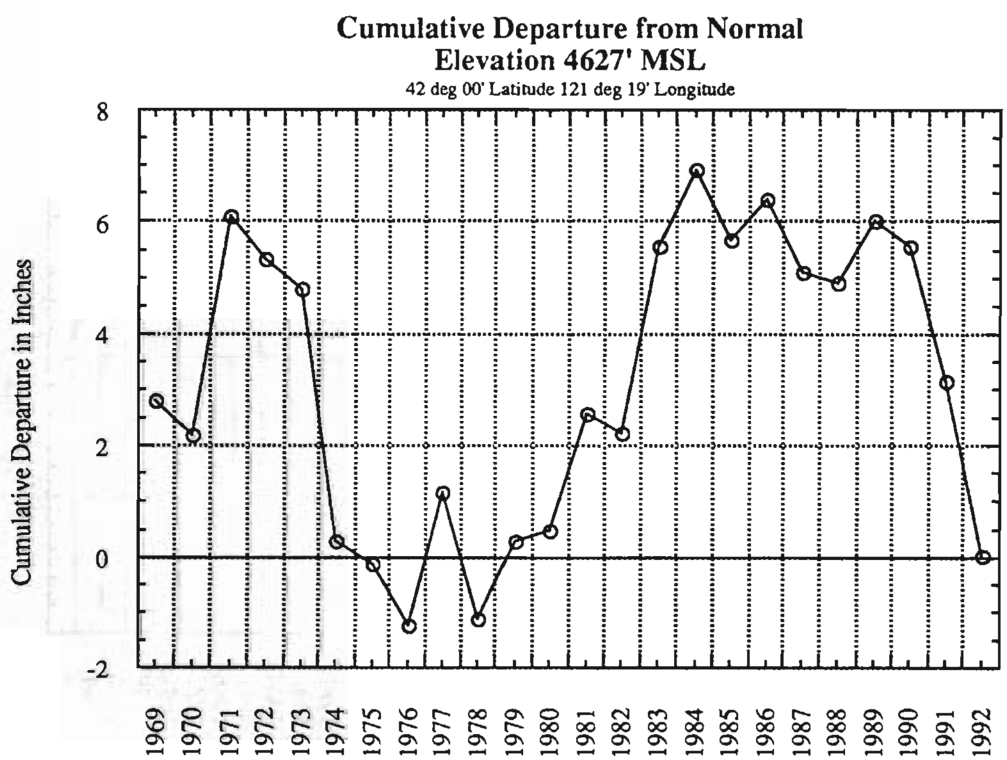
1991
1992

Figure 3

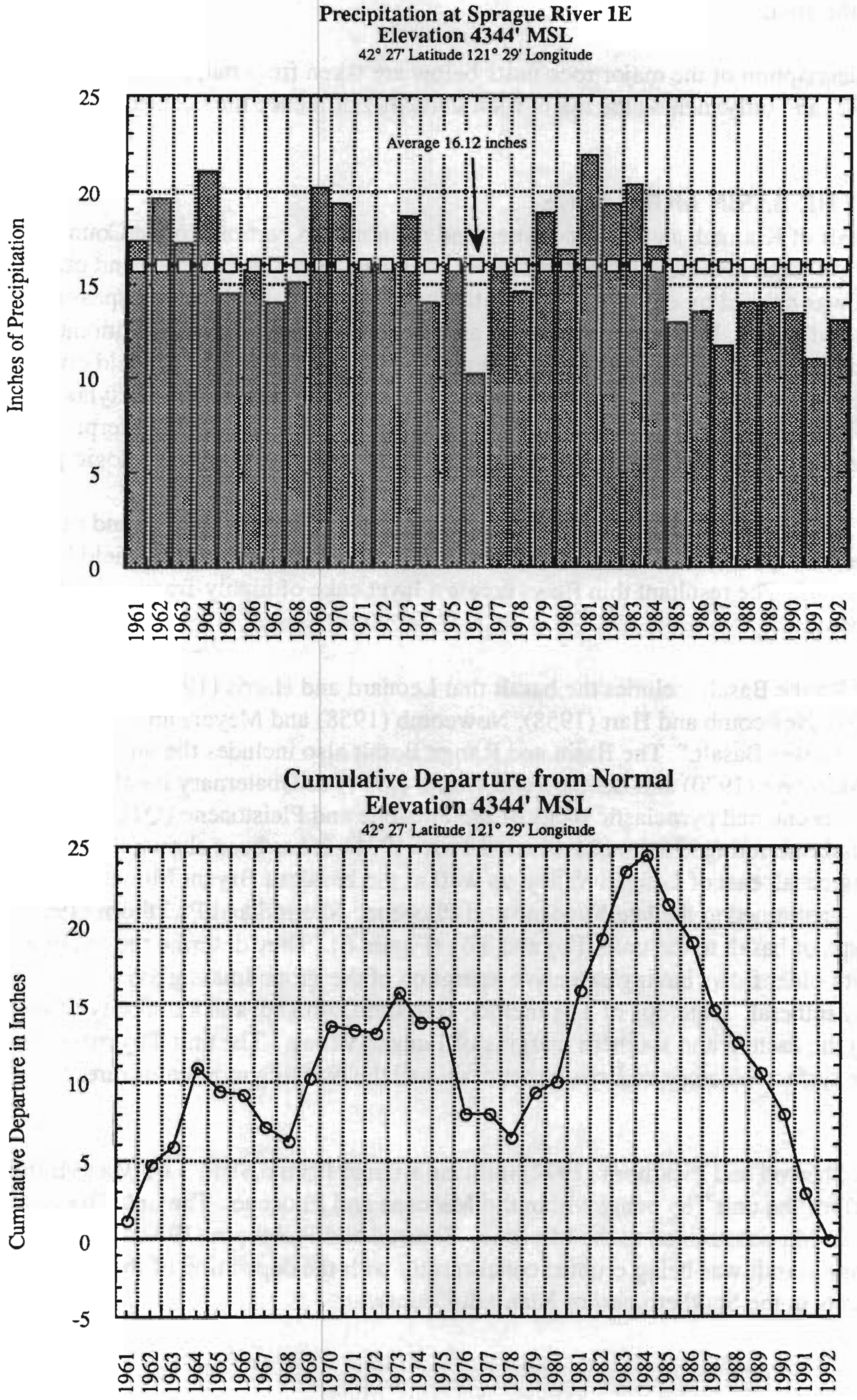


Precipitation at Malin 5E
Elevation 4627' MSL
42° 00' Latitude 121° 19' Longitude
Average 13.28 inches
Inches of Precipitation
20
15
10
5
0
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992



Cumulative Departure from Normal
Elevation 4627' MSL
42 deg 00' Latitude 121 deg 19' Longitude
Cumulative Departure in Inches
8
6
4
2
0
-2
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992

Figure 4


Precipitation at Sprague River 1E
Elevation 4344' MSL
42° 27' Latitude 121° 29' Longitude
Average 16.12 inches
Inches of Precipitation
25
20
15
10
5
0
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
Cumulative Departure from Normal
Elevation 4344' MSL
42° 27' Latitude 121° 29' Longitude
Cumulative Departure in Inches
25
20
15
10
5
0
-5
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
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1991
1992

Figure 5

material from volcanic eruptions were being introduced into shallow lakes and small drainages. These resultant deposits make up the very disconnected, heterogeneous present- day stratigraphic framework of the area.

The geologic description of the major rock units below are taken from mapping done by Sherrod and Pickthorn (1992) and only include the major rock units that influence the occurrence and movement of groundwater.

BASALT OF THE BASIN AND RANGE

The southern half of Klamath and Lake counties and the northern part of Modoc County, California, are underlain by a large lava field termed the Devil's Garden Lava field (Mckee and others, 1983). This lava field was created by eruptions in a relatively brief period, geologically speaking-5 million years, (Mckee and others, 1983)-so it represents a large coherent age and compositional geologic unit. It is estimated by Mckee and others (1983) that the Devil's Garden Lava Field comprises 850 cubic kilometers in a 12,400 square kilometer area. The lava is described as a diktytaxitic olivine tholeiite. The studies by Mckee and others (1983) and Mallin and Hart (1991) interpret this to be the transitional zone between the Cascade Volcanic arc and the Basin and Range geologic province.

Most flows of the Devil's Garden Lava Field are thinner than 10 meters (Mckee and others, 1983). Rhyolitic domes and pyroclastic flows are noted in the Northern half of the lava field but are absent in the southern half. The resultant thin flows create a layer cake of highly-fractured rubble and scoriaceous zones.

The Basin and Range Basalt includes the basalt that Leonard and Harris (1974), Peterson and McIntyre (1970), Newcomb and Hart (1958), Newcomb (1958) and Meyers and Newcomb (1952) all termed the "Lower Basalt." The Basin and Range Basalt also includes the units mapped by Peterson and McIntyre (1970) and Leonard and Harris (1974) as Quaternary basalt flows (Qb) and a unit of basalt, breccia, and pyroclastic rocks of the Pliocene and Pleistocene (QTb). With age-dating by Pickthorn and Sherrod (1990) and Mallin and Hart (1991), it has been shown that the majority of the outcropping basalt east of Langell Valley, as well as the basalt of Bryant Mountain, are in fact older, and are constrained to the late Miocene and Pliocene. Sherrod and Pickthorn (1992) have mapped this type of basalt to the units Tb_2 and Tb_3 (Figure 6). They describe the basalt as diktytaxitic with older flows having extensive alteration of the groundmass glass to greenish smectite, a clay mineral. Outcrops of Tb_3 include Harpold Dam gap, and a majority of the basalt outcrops along the eastern and southern margins of Langell valley. The unit Tb_2 makes up the majority of the surface outcrops of Bryant mountain and the outlying mountains directly east of the study area.

Ages listed by Sherrod and Pickthorn (1992) indicate a range from 6.88 to 3.61 Ma (Million years before present) for the unit Tb_2 being within the Miocene and Pliocene. The unit Tb_3 is dated to 5.78 Ma +/- 0.12 Ma constrained to the Miocene. Sherrod and Pickthorn (1992) have shown that the Basin and Range Basalt was being erupted concurrently with the deposition of the volcaniclastic and sedimentary units in the Southern part of Klamath County.

Geology of the Southern Portion of the West half of the Klamath Falls 1° x 2° Quadrangle, South Central Oregon

from Sherrod and Pickthorn (1992)

Legend

Symbol	Unit
Qs	Surficial deposits (Holocene and Pleistocene)
Qf	Alluvial fan and talus deposits (Pleistocene)
Qls	Landslide debris (Pleistocene)
QTs	Sedimentary deposits and rocks (Pleistocene and Pliocene)

Basalt of Basin and Range

Symbol	Unit
Tb_1	Unit 1 (Pliocene)
Tb_2	Unit 2 (Pliocene and Miocene)
Tb_3	Unit 3 (Miocene)
Tv	Vent deposits (Pliocene and Miocene)
Typt	Younger palagonite tuff (Pliocene and Miocene)
Tcs	Continental sedimentary rocks (Pliocene and Miocene)
Tst	Tuff and sandstone (Pliocene and Miocene)
Tba	Basaltic andesite and andesite (Pliocene and Miocene)
Tad	Andesite and dacite (Pliocene and Miocene)
Tr	Rhyolite and rhyodacite (Pliocene? and Miocene)
Tt	Tuff and Lapilli tuff (Miocene)
Topt	Older palagonite tuff (Miocene)

N

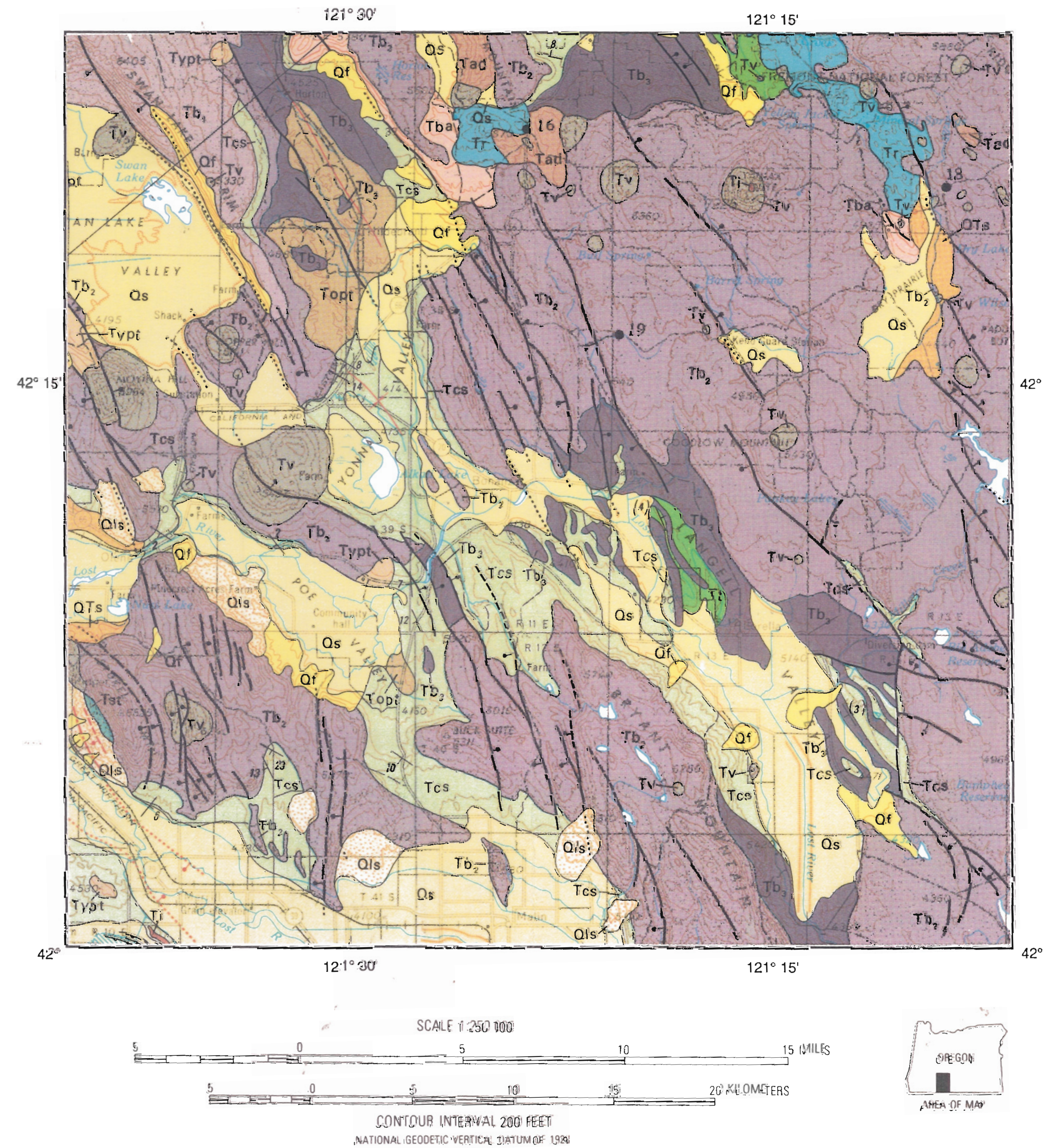


Figure 6.

Geolgy mapped by D.R. Sherrod, July-September 1983. July 1985, Potassium-argon geochronolgy by L.B.G. Pickthorn from samples collected July 1985. Edited by Sean Stone

TUFF AND LAPILLI TUFF

The Tuff and Lapilli Tuff (Tt) unit of Sherrod and Pickthorn (1992) was previously included in the Yonna Formation of Newcomb (1958). The unit outcrops along a narrow band on the eastern margin of Langell Valley (Figure 6). The unit is described by Sherrod and Pickthorn (1992) as a lithic-bearing and pumiceous lapilli tuff, largely of ash-flow or hot avalanche origin. Also included are thin- to medium-bedded fine-grained tuff, coarse pumicite (air fall), and very thick-to thin-bedded pebbly sandstone that were deposited as lahars. The Tt unit chiefly overlies the Tb_3 basalt. The Tt unit, although not widespread in outcrop, probably shows up as chalk or sandstone on well drillers' reports as an overlying bed above the basalt.

CONTINENTAL SEDIMENTARY ROCKS

The largest unit of sedimentary type rocks exposed in the study area is the Continental Sedimentary Rocks (Tcs), named by Sherrod and Pickthorn (1992). The separation of continentally-derived sedimentary rocks from volcanogenic deposits in this area by Sherrod and Pickthorn represents the largest breakthrough in knowledge about the occurrence, age, source and mode of deposition of these rocks since Newcomb first assigned them to the Yonna Formation in 1958. Sherrod and Pickthorn abandon the assignment of these rocks to the Yonna Formation and instead describe them as the Continental Sedimentary rocks of the Pliocene and Miocene. With potassium age- dating by Pickthorn and Sherrod (1990) and Sherrod and Pickthorn (1992) of underlying and overlying basalts, as well as the unit itself, they assign the age of deposition between 6.0 Ma and 3.3 ma. They describe the unit as thick- to thinly-bedded ashy diatomite with thin- to medium- bedded sandstone, siltstone and laminated mudstone; conglomerate and minor tuff and basalt flows. This unit comprises the dominant material encountered in the wells drilled in the area that did not penetrate the basalts.

The intercalated nature of the Tcs unit and the Tb_3 and Tb_2 basalts can be seen on the geologic map (Figure 6). Directly to the south and southeast of the Town of Bonanza, units Tb_3 and Tcs cropout in contact with each other. In other places, the units are also faulted into contact with each other such as along the southern extension of the mapped fault (Sherrod and Pickthorn 1992) that is coincident with Big Bonanza Springs. The intercalated nature of the units can be shown in the southwestern quarter of T39S R11E and the northwestern quarter of T40S R12E. All three units mentioned above were deposited adjacent or nearly adjacent to each other, or are faulted into contact with each other (see the geologic map Figure 6). This closely-structured geologic framework of the units, along with potassium age-dating, indicate that eruption of the basalt flows and deposition of Tcs unit were occurring simultaneously.

QUATERNARY DEPOSITS

A thin veneer of sandy to silty ashy sediments lies on the valley floors of the three principal valleys in this study. These sediments are one to five feet thick, and usually make up part of the soil profile. They are presently being reworked by the Lost River and several small drainages such as Buck and Miller Creeks in Yonna and Langell Valleys respectively. These sediments generally lie above the water table and do not provide water to wells.

STRUCTURE

The dominant structure in the area are the NW trending normal faults related to the regional Basin and Range extensional faulting. The displacements are characterized by many smaller faults rather than the typical large horst and graben faulting one might find in this type of geologic setting (Mckee and other, 1983). Vertical displacement is estimated to be greater than 500 feet in some places, although most is probably less than 300 feet (Sherrod and Pickthorn, 1992). Sherrod and Pickthorn (1992) note that most of the Klamath graben is Pleistocene in age with some faults active in the Holocene. This was substantiated by the earthquake of September 20, 1993 (Wiley and others, 1993).

The town of Bonanza lies mostly on the southern-most visible, upthrown block of the normal fault creating Short Lake Mountain. On several geologic maps the fault is shown extending beneath the valley floor (Walker and Mcleod, 1991 and Sherrod and Pickthorn, 1992). The trace of the fault on the valley floor is hidden by a thin veneer (1 to 5 ft) of sediment from the Lost River. The numerous faults in the Bonanza area can be seen on geologic maps of Leonard and Harris (1974), Walker and Mcleod (1991) and Sherrod and Pickthorn (1992). When it was possible to determine direction of movement, the mappers noted normal displacement on all faults. The pervasive faulting of the area, in addition to the varied stratigraphic units, adds to the complexities in the groundwater flow system.

Two folds are mapped by Sherrod and Pickthorn (1992) in the Yonna Valley and are inferred from the outcrop pattern of map units and dip of bedding. The conditions of the exposures are too poor to resolve with certainty the exact formational processes of the folds.

DRILL CUTTING SAMPLES

A few drilled wells provided cutting samples from depth. These samples were collected by the operators of the drilling machines and were not analyzed until after they were bagged with approximate depths recorded. For the most part, the samples appeared uncontaminated by overlying layers, which can occur when extracting to the surface.

The above-described geologic units were easily-distinguishable in the cuttings. Cuttings from wells along the middle to eastern and southern parts of Langell valley at depths ranging from 100 to 400 feet below land surface show olivine-rich basalt with abundant plagioclase laths 1/10 mm long. The olivine crystals display a pale brown color having been altered to iddingsite. These samples probably represent the Tb_2 unit of Sherrod and Pickthorn (1992) where extensive units have been mapped at these locations. Samples from the Barrett #2 Well, T39S, R12E, sec 34ca, at depths of 275 feet and 335 feet show volcanic glass almost wholly altered to greenish clay indicating the unit Tb_3 of Sherrod and Pickthorn (1992). The largest collective exposures of the unit Tb_3 are mapped by Sherrod and Pickthorn (1992) in this township.

Several drill cutting samples included the Continental Sedimentary Rocks, and generally occurred in the first 100 feet of the samples. This is reasonable because most of the wells in which we have collected samples were drilled on the valley floors which are mapped as Quaternary alluvium or Continental Sediments. Some of the Lapilli Tuff unit (Tt) was apparent in cuttings from a well in T39S, R11E, sec 9ddd, but it is hard to distinguish between drill cutting chips and lapilli. Based on more occurrences of the Tcs unit, it could be likely these lapilli cuttings are an artifact of well drilling. Both of the units, Tcs and Tt described by Sherrod and Pickthorn (1992), have similarities in grain size and texture.

GROUNDWATER

GENERAL OCCURRENCE

When precipitation falls on the ground, some of it evaporates, some is used by vegetation, some runs off and what is left soaks into the ground. The roots of plants use some of that water, but the rest percolates downward under gravity's influence through the pore spaces in the soil and rock. Once this water reaches the point where all pore spaces are filled, it has reached the water table or upper surface of the saturated zone. The area between the ground surface and the saturated zone is called the unsaturated zone.

The saturated zone can exist in two types of conditions: confined and unconfined. The upper surface of the saturated zone in unconfined conditions is called the water table. When groundwater occurs in confined conditions, the pressure within the aquifer is greater than atmospheric pressure. This pressure will cause water in a well that penetrates the confining layer to rise above the elevation at which it was encountered. This type of well is referred to as an artesian well. The surface elevation to which water rises in artesian wells is referred to as the potentiometric surface.

The occurrence of artesian conditions can be found at the southern end of Langell Valley and near Alkali Lake in the southern end of Yonna Valley. In both cases, thick sequences of fine-grained sediments have locally confined the water. In the event that a well is drilled into the water-bearing zone, the water will rise above land surface. This happens provided that the potentiometric surface is above ground surface at the well location.

As water is being drawn from a well completed in a water table aquifer, a depression in the water table surface forms in the shape of a cone pointed down that expands outwardly in all directions from the well. This depression results from water being drawn from the aquifer toward the well. As water withdrawal continues, the cone becomes deeper and larger in diameter, creating an increase in the hydraulic gradient toward the well. The resultant cone of depression in an unconfined system represents water actually being removed from the aquifer.

The cone of depression expands tens to hundreds of times faster in a confined system than an unconfined system. Since the confined aquifer is under pressure, greater than atmospheric, water is not actually being removed from the cone of depression, but a pressure loss or reduction in head pressure is occurring. This head loss is transmitted much more quickly through a confined aquifer than through an unconfined system.

With many production wells penetrating a confined aquifer, there is a greater degree of mutual interference between intersecting cones of depression. The separate cones of depression quickly merge, lowering the water levels over large areas. As long as pumping continues, water levels continue to decline until groundwater discharge is captured in amounts sufficient to offset the pumping or until additional recharge is stimulated to an equivalent degree.

In all groundwater systems, water flows from the recharge area to discharge areas. This flow is controlled by the hydraulic gradients within the aquifer. In very highly-transmissive rock material, groundwater flows relatively freely and will not create a steep hydraulic gradient (the water table elevation difference between two points in the aquifer will be relatively small). This hydraulic gradient in highly-ransmissive rock may only be a few feet per mile. Rock types likely to have high transmissivity values are: basalt inter-flows, bouldery gravels, large gravels and clean sands (Heath 1987). Aquifers that have very low transmissivity values include intrusives, clayey sand, clays or glacial till in which the resultant hydraulic gradient can be tens to hundreds of feet per mile (Heath 1987).

Hydraulic gradients can be affected by several different conditions. A well pumping water from an aquifer can reduce the gradient in the direction of normal flow and sometimes actually reverse the gradient in cases of large withdrawals. A stream that normally is fed by the discharge of groundwater becomes a source of groundwater recharge when the direction of the hydraulic gradient is reversed.

Newcomb and Hart (1958) found groundwater in the Klamath Basin to occur largely in an unconfined or water table condition, though areas of local confinement exist. Conceptually, the groundwater flow system in the Klamath Basin can be thought of as a three part flow system. It can be divided into local, intermediate and regional flow systems (Illian, 1970). The local flow system has the shortest travel path between recharge and discharge areas, whereas the intermediate and regional systems have longer and longest flow paths, respectively. The deepest and longest flow paths occur in the regional flow system of the Klamath Basin as described by Illian (1970).

The local flow systems as described by Illian (1970) represent recharge and discharge being adjacent to each other. A small ridge several hundred feet high with a coinciding stream valley running parallel might represent a local flow system typical of the study area.

The regional flow system of the Bonanza area or Klamath Basin as conceptualized by Illian (1970) represents recharge occurring in the mountainous areas of the Cascades, Goodlow Mountain, Quartz Mountain, Gerber Rim and Yainax Butte, all of which receive two to three times the precipitation the valley lowlands receive. Discharge areas could be 10 to 15 miles away where large streams represent the lowest relative elevation. Regional flow paths may reach depths of up to 10,000 feet (Illian, 1970) in the Klamath Basin.

GROUNDWATER OCCURRENCE IN THE BONANZA AREA

The stratigraphic and structural juxtaposition of the Continental Sediments and the Basalt of the Basin and Range has resulted in a groundwater system that is characterized by abrupt vertical and horizontal changes in aquifer properties. Due to the interfingering and overlapping of interflow zones intercalated with sedimentary units, local areas of confined water can be found. These fine-grained, low-permeability strata form low- to non-producing zones which may locally confine the groundwater within the lava flows below. In a regional system with geologic units which have greatly different hydraulic properties, local areas can be confined but overall the entire system may act as an unconfined groundwater body.

Occurrences of apparent artesian conditions are found when drilling wells in the Bonanza area. When a well is drilled through a thick sequence of the Tcs unit and then penetrates into the underlying vesicular basalt, the water level rises rapidly in the well. The water level will come to rest at a position within the overlying sediments.

Some of the drillers' reports in the Bonanza area indicate that once water is encountered while drilling, the water level remains constant throughout depth. The strata in the upper part of the bore-hole are sandstones and finer-grained rock, part of the Tcs unit. Once the well bore penetrates the basalt, the SWL remains as it was in the upper zones. This constant head while drilling indicates unconfined conditions in which both differing rock units are saturated and hydraulically-interconnected but yield significantly different amounts of water to wells, because of their different hydraulic properties.

The groundwater flow system in the Bonanza area has been characterized as a deeper zone (Leonard and Harris 1974), an intermediate zone (Illian 1970), and a regional groundwater system (Newcomb and Hart 1958 and Meyers and Newcomb 1952). Regardless of these apparent disagreements, groundwater, based on water well drilling reports and water level measurements taken for this and other studies, resides in and flows through both the basalt layers and the continental sediments. Because of the stratigraphic relationship of these units as discovered by Mallin and Hart (1991) and Sherrod and Pickthorn (1992), it is apparent that the rock units are hydraulically-connected, a fact which is borne out by the coincidence of head within these units. The groundwater system occurs within sedimentary and basalt units in the Bonanza area. The Basalt units supply most of the large withdrawals of water due to their hydraulic conductivity characteristics and areal extent.

HYDROLOGIC PROPERTIES

Leonard and Harris (1974) report very high transmissivity values in the aquifer near the center of Yonna Valley. They found through aquifer tests that the saturated basalt zone has a transmissivity of 2.0×10^6 gpd/foot (reported as 270,000 ft^2/day). Tests run by CH2M Hill in 1992 also show very high transmissivity ($T = 1.4 \times 10^5$ to 1.8×10^5 gpd/foot) and low storativity (4.4 to 4.5×10^{-4}) values, indicating the possibility of confined conditions (Heath, 1987) in the southern end of Yonna Valley. Two tests run by CH2M Hill consisted of one 12-hour constant rate and one 2.33-hour variable rate discharge test.

The most productive water-bearing zone found in the Bonanza area is in flows of the Basin and Range Basalt of Mckee and others (1983) and Mallin and Hart (1991). The basalt was noted by Newcomb and Hart (1958) to provide up to 3,000 gpm with one or two feet of drawdown in wells. The water chiefly flows through fractures and scoriaceous interflow zones within the basalt flows (Meyers and Newcomb, 1952; Newcomb and Hart, 1958; and Leonard and Harris, 1974). In addition to the fractured and scoriaceous interflow zones, water can move vertically through fault fracture zones (Newcomb and Hart, 1958). Newcomb and Hart (1958) go on to say that porous interflow zones interfinger and overlap sufficiently to allow free movement of water vertically across layers.

In contrast, the wells completed in the Tcs unit of the Bonanza area do not yield large quantities of water. Although this author knows of no aquifer tests completed in the Tcs unit, there are specific capacity figures reported on well drillers' reports. Of 15 well logs in T39S, R11E, completed in only the Tcs unit, the average specific capacity is 1.6 gpm/foot of drawdown.

The different specific capacity of wells is not an indicator of different aquifers but only of the diverse hydraulic conductivity of the various rock units. The significance of the variability of rock units is demonstrated by the two Earl Wiersma wells drilled in T39S, R11E, sec 15, NW quarter.

One reportedly yields 1,900 gpm at 186 feet deep and the other yields 30 gpm at 207 feet deep. Both wells are on the valley floor and are only 900 feet apart. (See attached well driller's reports in Appendix 1.) In spite of the different specific capacity of these wells, the heads reported by the driller are within two feet of being the same.

Faulting is described by Leonard and Harris (1974) to cause compartmentization of the groundwater resource. They conclude that the presence of compartmentization creates areas of elevated potentiometric surface specifically on the northeastern end of Bryant Mountain. The elevated surface is found to be over 100 feet higher than the water table on the valley floor of Langell Valley one mile to the east.

Conversely, the local fault projecting northward from Bonanza shows no evidence of compartmentization. The water levels on either side of this fault are essentially the same (Figure 7A hydrograph of Ballfield and Don Manning wells). The general elevation of the water table does not vary across this fault. Throughout the study area there is pervasive faulting, and no other compartmentization is obvious.

Another theory suggests varying hydrologic properties in the rock are creating local steeper hydraulic gradients. In the area of elevated static water levels on Northeastern Bryant Mountain (plate 5, Leonard and Harris [1974]), Sherrod and Pickthorn (1992) have mapped the Tcs unit extensively. This unit is generally fine-grained and does not allow water to flow as freely as the Basin and Range Basalt. On the eastern side of Langell Valley, Leonard and Harris (1974) show contour intervals more closely-spaced and rising significantly above those of the Valley. This may be the result of the Tuff and Lapilli tuff (Tt) unit that Sherrod and Pickthorn (1992) have mapped in this precise location. This Tt unit is also fine-grained and will not allow the water to flow as freely as in the Basin and Range Basalt.

In all lowland areas where permeable rock intersects both the groundwater and the land surface, there is significant groundwater discharge. This is exemplified by Big Bonanza Springs. Here, there is an intersection of groundwater and the Basalt of the Basin and Range at land surface. Leonard and Harris (1974) found that most irrigation wells, as well as the large springs, are in discharge areas.

WATER LEVEL MEASUREMENTS

Water level measurements in wells are used to distinguish aquifer units, determine groundwater flow directions, analyze long-term and seasonal changes in the groundwater system, and analyze groundwater/surface water relationships. Water level measurements used in this study include measurements reported on drillers' logs, measurements reported in previous groundwater reports, and periodic measurements made by OWRD staff (Map 1).

WATER LEVEL SURFACE

Most water level surface information comes from plates 4 and 5 of Leonard and Harris (1974). In general, the water level surface of the groundwater in the three principal valleys is very flat. A gradient of a few feet per mile exists in the central part of the valleys. Water level measurements by Leonard and Harris (1974) generally indicate steeper, higher gradients on the margins of Langell

Bonanza Area Observation Wells Showing Similar Head Relationship Across Short Lake Mountain Fault

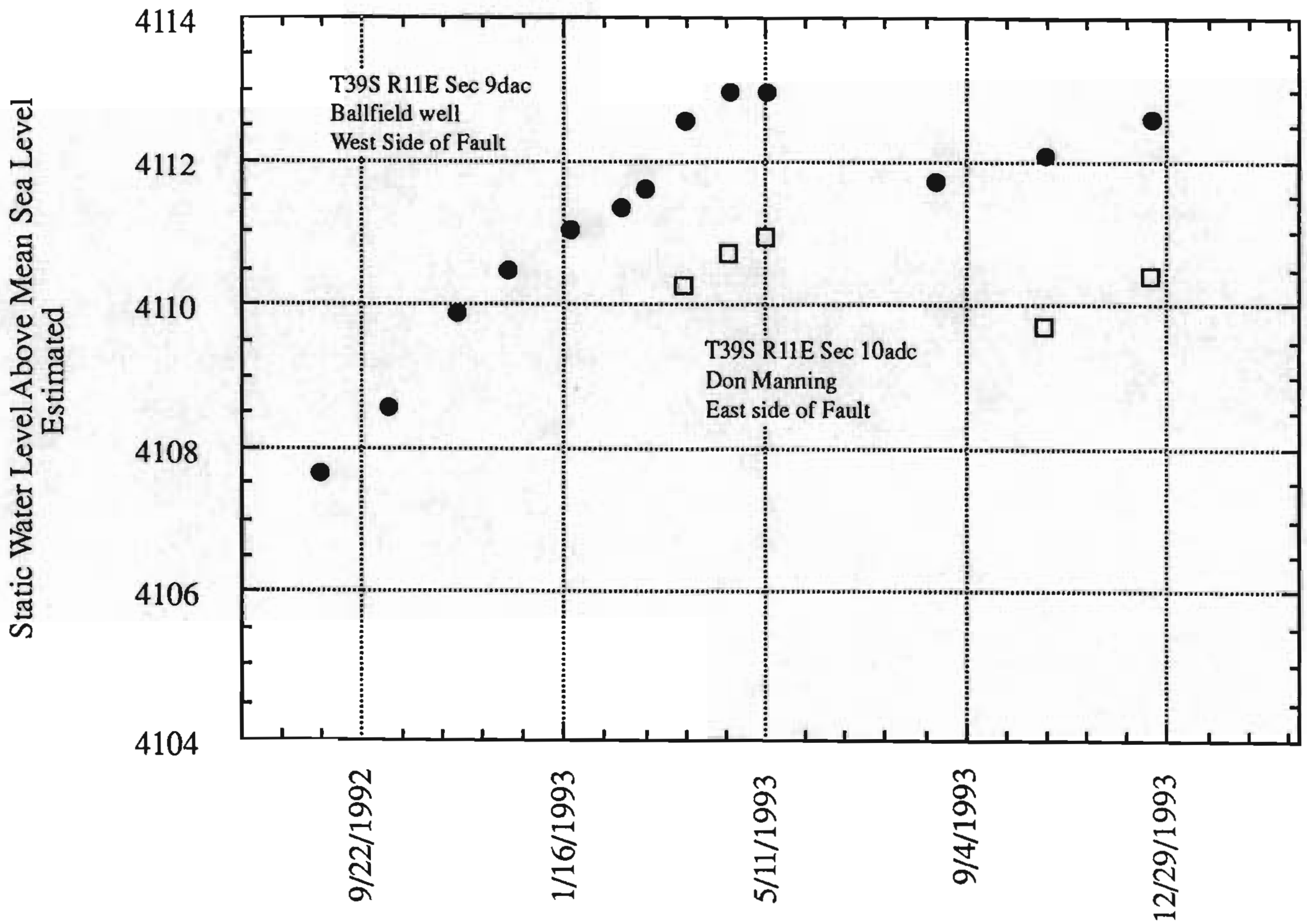
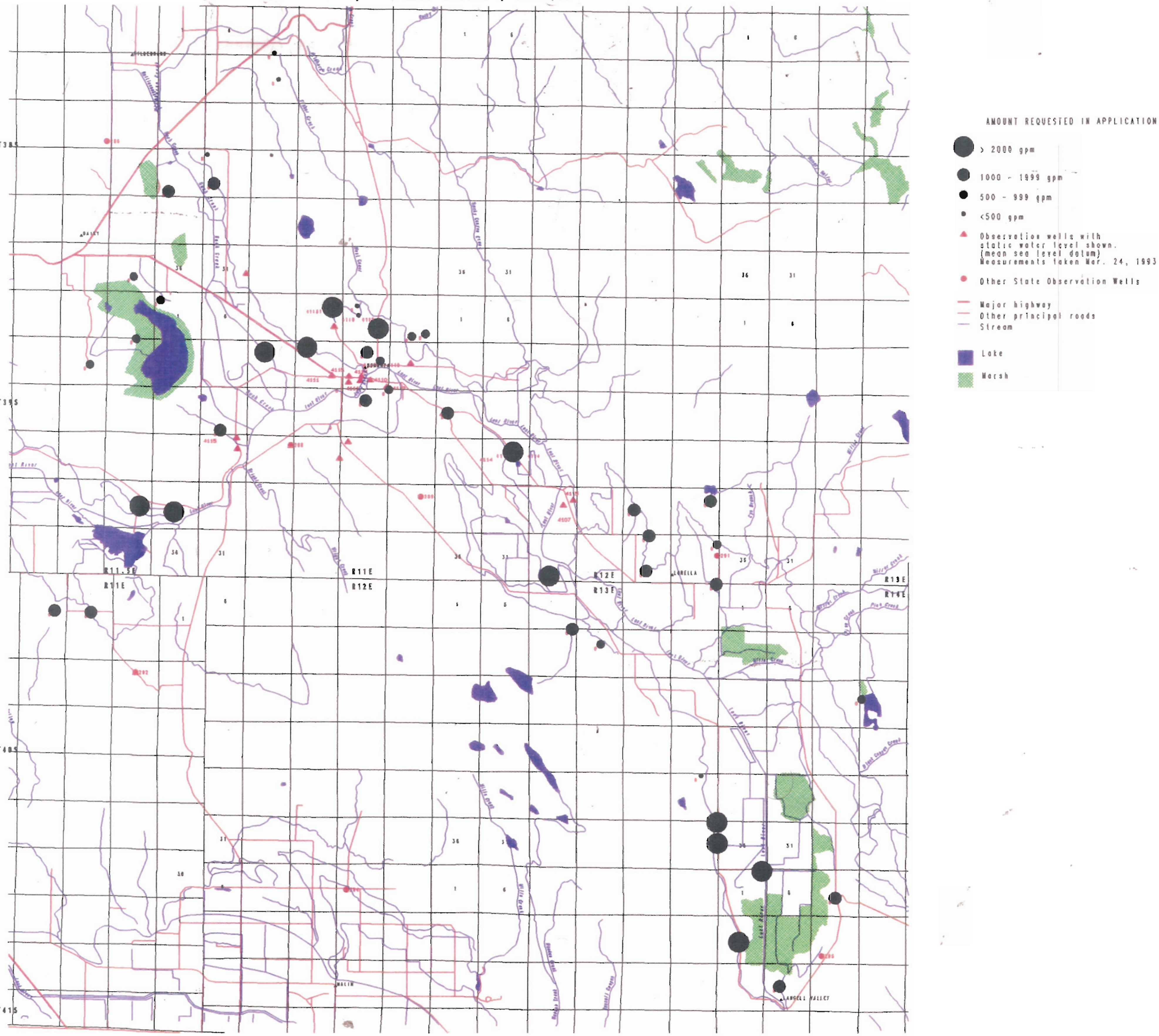


Figure 7A

WELL LOCATIONS OF APPLICATIONS FOR GROUNDWATER PERMITS WITH WATER LEVEL INFORMATION

BONANZA AREA, KLAMATH COUNTY, OREGON

Map 1.
Open File Report 94-01
Oregon Water Resources Department



Valley where local precipitation recharges the water-bearing zones. With recharge occurring nearby, the ground surface somewhat elevated, and the strata made up mostly of fine-grained rocks (Tcs and Tt of Sherrod and Pickthorn 1992) having lower hydraulic conductivity (K) characteristics, one would expect that water level contours will be more closely-spaced at the valley margins.

In the extreme southern end of Langell Valley, Leonard and Harris (1974) show water levels ranging from 4,130 to 4,150 feet above msl. This is 20 to 40 feet higher than water levels in the Bonanza Springs area. The water level surface is sloped gently to the north to the vicinity of Lorella, Oregon, where it makes a gentle curve to the northwest. The surface also takes on a trough shape having the vertex coincident with the Lost River.

In the Yonna, Poe and Swan Lake Valleys the water level surface is so flat that very few water level contours were drawn by Leonard and Harris (1974). This is most likely the result of uncertainty in estimating well head elevations from topographic maps. The water level surface near the Town of Bonanza ranges from 4,108 to 4,120 feet above msl as indicated by Leonard and Harris (1974).

Leonard and Harris (1974) found that local areas contain perched water table conditions at higher altitudes outside the valley floors. They found that perched groundwater conditions are not common in lowland areas.

The general direction of groundwater flow in the study area is from the highlands to the valleys and then downstream with the major drainages in each valley (Newcomb and Hart, 1958, Leonard and Harris, 1974). Meyers and Newcomb (1952) describe a regional water table occurring beneath both Swan Lake and Yonna Valleys that slopes gently down from higher levels beneath the upper parts of the valleys to the elevation equal to the Lost River to the south where discharge occurs. Leonard and Harris (1974) also indicate that groundwater flows from highlands to lowlands where discharge occurs by upward seepage from confined aquifers and springs. Occurrence of seepage was found at marshy areas, such as those that are common in Langell Valley.

LONG-TERM WATER LEVEL TRENDS

Static water levels are strongly affected by decreased precipitation. This is readily apparent in some of the State Observation Well (SOW) hydrographs (Appendix 2). During the winter of 1976-1977, the state experienced one of the worst droughts on record (Pacific Northwest Water Resources Summary, Annual Summary 1977 prepared by Northwest Water Resources Data Center, U.S. Geological Survey, with National Weather Service and U. S. Soil Conservation Service., out of print). This drought is reflected in some SOW hydrographs as lowered static water levels. The reduced precipitation of the last 7 to 8 years (Figures 3, 4 and 5) is readily apparent in all SOW hydrographs. This indicates that continuing droughts have a significant impact. During times of drought, surface water is not as available and more groundwater is pumped. In addition, less water is available to infiltrate into the aquifers to recharge it. Both of these factors contribute to lowering water levels.

OWRD maintains a network of observation wells around the state. Eight of these wells were selected to show long-term history of water levels in the study area. All but one well, number 329, are currently monitored. The significance of each well in this particular study is discussed in detail, referring to each by number. The hydrographs of these wells can be found in Appendix 2.

Table 1 shows the change in static water levels of state observation wells during the period 1990 through 1993. The table shows that there were greater decreases in SWL's between November 1991 and November 1992, than between February 1991 and February 1992, suggesting that pumping effects were greater than drought effects.

Table 1.

State Observation Wells measured near Bonanza, Oregon. Figures given are in static water level elevation.

November measurements

SOW Well	Nov 90	Nov 91	change 90-91	Nov 92	change 91-92	Nov 93	change 92-93
281	4150.77	4150.50	-0.27	4147.95	-2.55	4149.59	1.64
286	4115.91	4116.33	0.42	4113.20	-3.13	4116.42	3.22
288	4110.44	4111.08	0.64	4108.76	-2.32	4111.09	2.33
289	4223.44	4220.59	-2.85	4215.89	-4.70	4222.02	6.13
291	4118.37	4114.23	-4.14	4106.62	-7.61	4117.37	10.75
292	4129.38	4127.92	-1.46	4118.11	-9.81	4108.12	-9.99
295	4130.24	4128.78	-1.46	4121.52	-7.26	4129.41	7.89
AVERAGE CHANGE			-1.30		-5.34		3.14

February Measurements

SOW Well	Feb 90	Feb 91	change 90-91	Feb 92	change 91-92	Feb 93	change 92-93
281	4153.48	4151.87	-1.61	4150.42	-1.45	4148.83	-1.59
286	4117.25	4117.52	0.27	4117.07	-0.45	4115.74	-1.33
288	4112.72	4111.98	-0.74	4111.62	-0.36	4110.68	-0.94
289	4224.13	4222.98	-1.15	N/A		4215.99	N/A
291	4118.29	4117.39	-0.90	4114.51	-2.88	4110.14	-4.37
292	4131.96	4130.22	-1.74	4128.75	-1.47	4121.97	-6.78
295	4131.83	4130.97	-0.86	4129.87	-1.10	4127.99	-1.88
AVERAGE CHANGE			-0.96		-1.29		-2.82

There was a greater decrease in SWL's after pumping rather than after winter recharge. The February 1992, measurements were made prior to the pumping of the drought emergency wells. The November 1992 measurements were made after a season of increased pumping. Figure 7B displays the February and November measurements showing the increased drawdown in the November 1992 measurements after the 1992 pumping season.

State Observation well #281 is located in Swan Lake Valley T37S, R10E, sec 29ddb(2). This valley area is not included in the study boundary but has been investigated in the past and is thought to exist in the same groundwater flow regime as the other valleys of the Lost River sub-basin. This

STATE OBSERVATION WELL MEASUREMENTS FEBRUARY, 1990 TO NOVEMBER, 1993 AVERAGED CHANGE

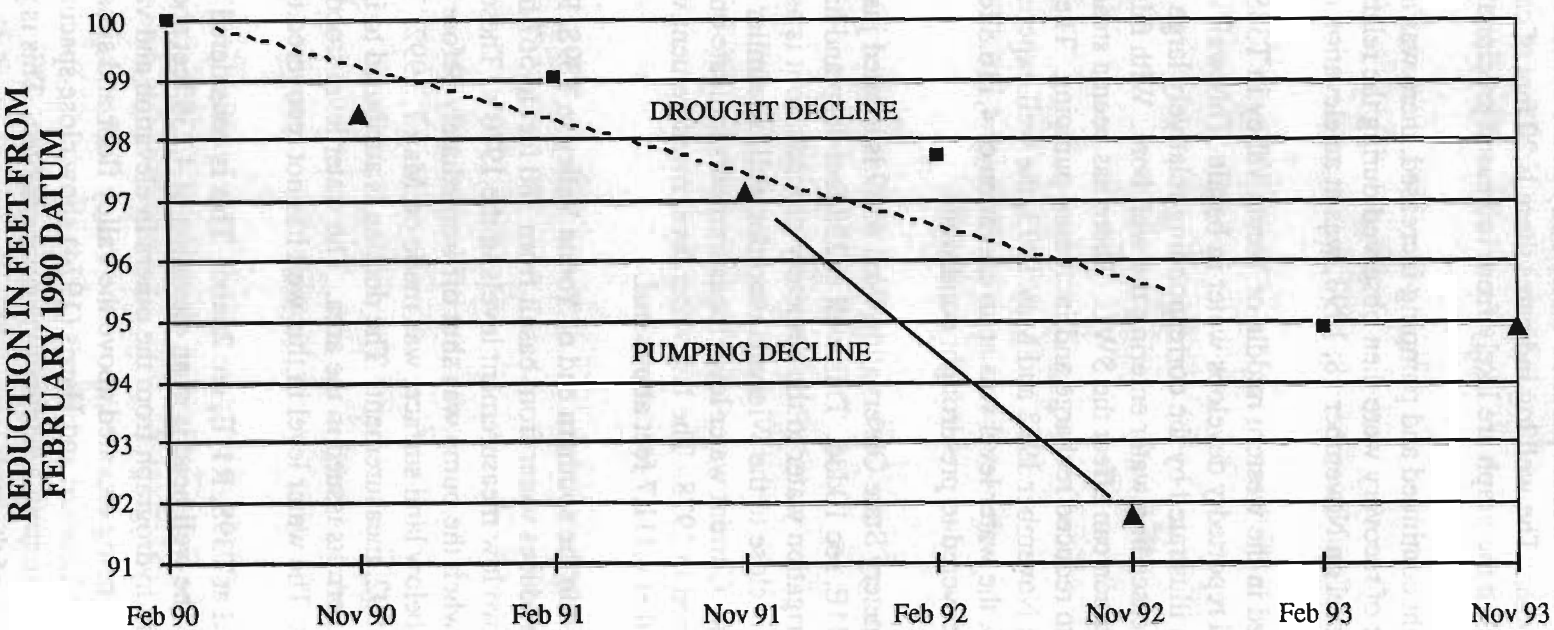


Figure 7B

well experiences erratic water level fluctuations of five to 10 feet. It is 800 feet deep and when drilled indicated a water-bearing zone at 135 to 155 feet in depth. The area as described by Meyers and Newcomb (1952) has a local perched water body in the center of the valley that is elevated from the regional water table. The well log indicates there is 20 feet of casing with 780 feet of open hole. The observed spikes in the graph are likely from increased precipitation recharging the perched zone.

As the recent drought continued and pumping increased, there was a steady water level decline to late 1992. Two feet of recovery were then observed during the relatively wet winter of 1992 to 1993. The water level on November 18, 1993, was at an elevation of 4,149.6 feet above msl.

SOW #286 is located in the western middle of Yonna Valley in T38S, R11.5E, sec 15dda. This well is 495 feet deep and reportedly develops water in basalt. This well is affected strongly by heavy winter precipitation illustrated by the corresponding relatively large increases in SWL. This well has been noted to have cascading water entering the well bore. With this fact in mind, it is evident that winter time precipitation can affect the SWL. There has been a steady decline in SWL since the mid 1980's due largely to reduced recharge and increased pumping. The lowest recorded level was in late 1992. Between November 1992 and May 1993, the well experienced four feet of recovery. On December 20, 1993, the water level was at an elevation of 4,116.8 feet above msl. As of that date, this well had not recovered to pre-drought conditions.

The Lost River Cemetery State Observation Well #329 is located just east of the Town of Bonanza, Oregon in T39S, R11E, sec 10ddd. This well is 238 feet deep and has no report of the water-bearing zone. It provides irrigation water to the cemetery grounds, so it is assumed to be sufficient for that purpose. This well is close to the Wiersma recorder well, so similar changes in static water levels are believed to occur. Current water level measurements indicate one to two feet of decline since the well was last measured in 1978. The last water level measurement was made on October 20, 1993, when the SWL stood at 4,111.7 feet above msl.

SOW #288 is located in the southern end of Yonna Valley in T39S, R11E, sec 20aad. This well is 567 feet deep and produces water from basalt from 380 feet to 567 feet below land surface. The hydrograph shows two low measurement levels in the 1970's. These are recovering levels made during the summer when the pump was shut off immediately before measuring. The lowest measurement, 71.8 feet below land surface, was made on May 7, 1992. This is a decline of five feet from the February 1992, measurement. The decline is attributed to increased pumping from the emergency drought permits issued in the area. The water level stood at 4,111.4 feet above msl on December 20, 1993. The water level in this well has not recovered to pre-drought conditions.

SOW #289 is located at T39S, R11E, sec 26abd. This is considered to be in Langell Valley but is not on the valley floor. The well head is at an elevation of 4,238 feet above msl. This well displays a significantly different hydrograph from the others in elevation and variability of SWL. This is primarily the result of being elevated above the valley floor and situated near a local recharge zone. Water level maps from Leonard and Harris (1974) show close spacing of water level contours near the well to the east, illustrating a steeper hydraulic gradient. This is probably the result of lower hydraulic conductivity of the rock strata within the upper part of the bore-hole. This well is 1,225 feet deep and uncased in all but 63 feet. The casing is perforated at 50 to 62 feet where brown and black clay, boulders, and cinders make up the strata. This clearly indicates a situation in which local groundwater circulation influences the water level behavior of deeper zones. Four measurements made on this well in late 1992 to early 1993 show nearly identical static water levels. This is a direct result of all recharge being precipitated as snow and not infiltrating until the spring thaw. After snow melt, infiltration occurred resulting in a rise of nearly 12 feet in SWL. Leonard and Harris (1974) describe this water bearing-zone as being compartmentized by faulting. The lowest recorded level, 4,201.5 feet msl, was during the drought of 1976 to 1977. The water level measurement of November 18, 1993, shows the level to be at 4,222 feet above msl.

SOW #291 located just east of Lorella in Langell Valley, T39S, R12E, sec 35add, shows the dramatic effects of pumping in Langell Valley during 1992. This well is 360 feet deep and develops water from basalt. The hydrograph shows consistent water levels until 1988, when the effects of the drought show up as a general decline in SWL. This well clearly shows the effects of increased pumping in Langell Valley in 1992. On December 20, 1993, the water level was at 4,116.7 feet above msl. This well is used as a domestic source of water for Mr. Charles Cheyne.

SOW #292 located in the southeastern part of Poe Valley in T40S, R11E, sec 11bad, is in the area where Leonard and Harris (1974) noted perennially-declining water levels. The hydrograph in Appendix 2, showing data beginning in 1955, clearly illustrates the effects of water use under terms of permit G-2210 on water levels in that area. Since the permit was issued on October 10, 1962, the water level has never been measured at or above the prior levels. The well is 992 feet deep and produces water from basalt. After a general increase during the 1980's, the well experienced a severe decline that persisted through late 1993. This severe decline suggests that pumping has exceeded recharge and the permeable zone in the area is being drained. The December 20, 1993, water level measurement indicates the SWL to be at 4,111.2 feet above msl.

SOW #295 is located in the extreme southern end of Langell Valley in T41S R14E sec 18 cca. This well is 210 feet deep and develops water from basalt breccia. The hydrograph shows that the water level in late winter 1992, after increased pumping during the summer, was five feet lower than any other previous summer measurement. This low static water level resulted from increased pumping and low recharge. The well had six feet of recovery between November 1992 and February 1993. At least some of this recovery was the result of the cones of depression filling in from the increased 1992 summer pumping as shown by a similar recovery during the same period in the Wiersma well. The measurement on December 20, 1993, indicates a SWL of 4,129.9 feet above msl, about 18 feet higher than water levels near Big Bonanza Springs.

SEASONAL WATER LEVEL TRENDS

Recharge

As stated earlier, some precipitation that occurs runs off, some evaporates and some infiltrates into the ground. To some extent, which of these occurs depends on the timing of precipitation events. If most of the precipitation falls in the winter, and falls as snow, then the timing of recharge is significantly changed. During the Winter of 1992 and 1993, up to 150 percent of normal precipitation occurred as snow in the Klamath Basin. With the significant snowpack in the mountains and on the valley floors, this area was destined for significant run-off, in addition to recharge. Had the precipitation been rain instead of snow, and had that rain been distributed evenly throughout the winter, groundwater recharge during the winter would have been greater.

In observation wells measured in the Bonanza area (Figures 8, 9A and 9B), static water levels rose gently from the end of the 1992 irrigation season to the initial snow melt in March 1993. The curve of the Wiersma well hydrograph (Figure 10) demonstrates the water level recovery. Nearly two feet of recovery occurred during the dry period, from early September through October 1992. This recovery in the Wiersma well is a direct result of the groundwater table filling in the cones of depression caused by pumping that occurred in the previous irrigation season. The well recovered two additional feet from November 1992, through early March 1993, while significant snow was accumulating. During this time, freezing conditions prevented any significant infiltration. These four feet of recovery following the 1992 irrigation season without any recharge events occurring are evidence that water levels in the aquifer had been depressed by pumping.

The well recorded nearly two more feet of recovery from March 3, 1993, to May 10, 1993. On that date, pumping began and the hydrograph recorded a reversal of the recovery trend. This early spring recharge resulted when the winter snow quickly melted and infiltrated the permeable zones.

Leonard and Harris (1974) included hydrographs of selected wells on which they installed continuous water level recorders (Figure 11). The well in T39S, R11E, sec 22bba2, experienced the same pattern of recharge from March to May 1971, as the Wiersma well did in 1993. However, it displays a significantly different water level response during the preceding winter. The hydrograph of the water level is nearly horizontal, indicating no discharge or recharge that is out of balance within the aquifer. There was no recovery, suggesting there was no water level depression to fill in. This suggests there was little or no groundwater pumping in the preceding irrigation season.

Water levels in wells in the study area responded similarly during the study period. The park well with a shallow casing and seal is compared to four observation wells in town (figures 9A and 9B) and all show similar water level responses. Two of these are known to have short casings and seals while construction of the other two wells is unknown. The Manning well is sealed more deeply to 198 feet. Its water level responses are similar to the wells with shallow casings and seals. The water level elevations in the observation wells are also similar. Figure 9C shows that deep wells respond the same and have similar heads. The State Observation Well #288 is 567 feet deep and is over one mile from the Lost River. These five hydrographs demonstrate that shallow wells (100 feet or less), deep wells (greater than 500 feet), wells with deep seals (198 feet) all have similar heads and water level responses.

Wiersma Hydrograph

A water level recorder was installed in the Wiersma well located 1/4 mile east of the Town of Bonanza. The hydrograph produced by the recorder is shown in Figure 10. This well is located in sec 10dcb, T39S, R11E and is 180 feet deep. A float and counterweight-driven shaft encoder connected to a data collection module takes water level readings every two hours. The system was installed on September 3, 1992, and continues in operation as of this writing. The static water level on September 3, 1992, was 9.85 feet below land surface.

On October 13, 1992, a video log was made of the well bore to investigate the geologic formations the well penetrates and to note any easily-recognizable water-bearing zones. The geologic information gathered indicates that the first 20 feet of the well has a steel casing installed. From 20 to 175 feet there is medium to coarse grain tuffaceous sediment, bedding planes and fractures, with

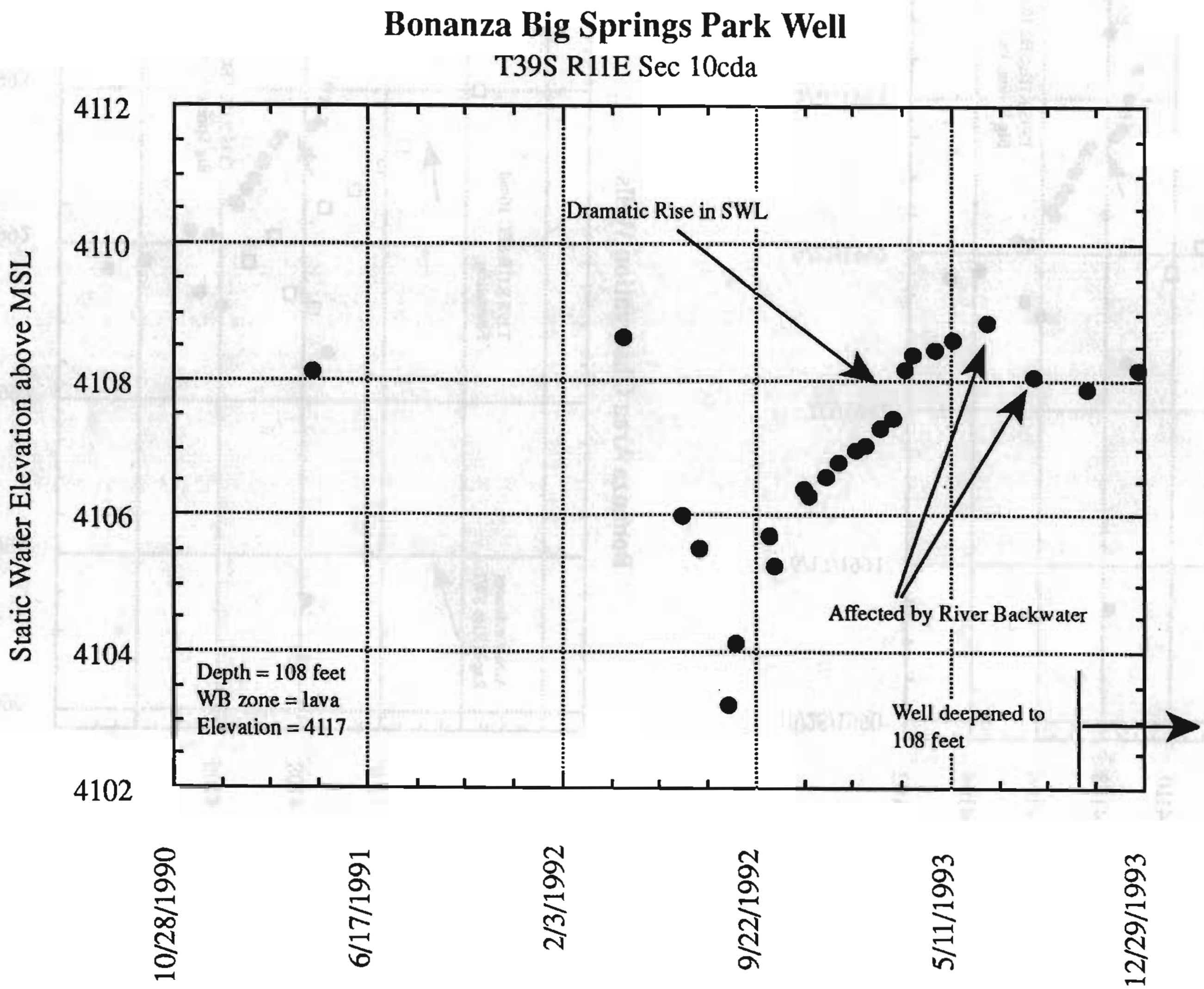
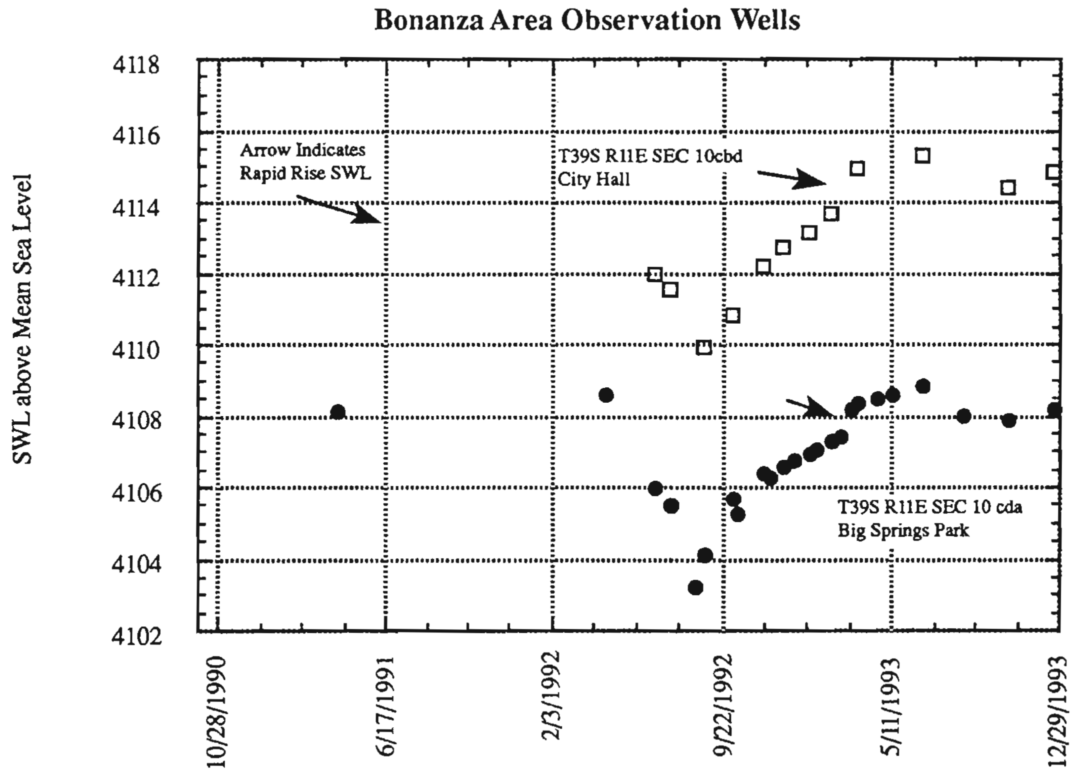

Bonanza Big Springs Park Well
T39S R11E Sec 10cda
Static Water Elevation above MSL
4112
4110
4108
4106
4104
4102
10/28/1990
6/17/1991
2/3/1992
9/22/1992
5/11/1993
12/29/1993
Dramatic Rise in SWL
Affected by River Backwater
Depth = 108 feet
WB zone = lava
Elevation = 4117
Well deepened to
108 feet

Figure 8


Bonanza Area Observation Wells
SWL above Mean Sea Level
4118
4116
4114
4112
4110
4108
4106
4104
4102
Arrow Indicates
Rapid Rise SWL
T39S R11E SEC 10cbd
City Hall
T39S R11E SEC 10 cda
Big Springs Park
10/28/1990
6/17/1991
2/3/1992
9/22/1992
5/11/1993
12/29/1993

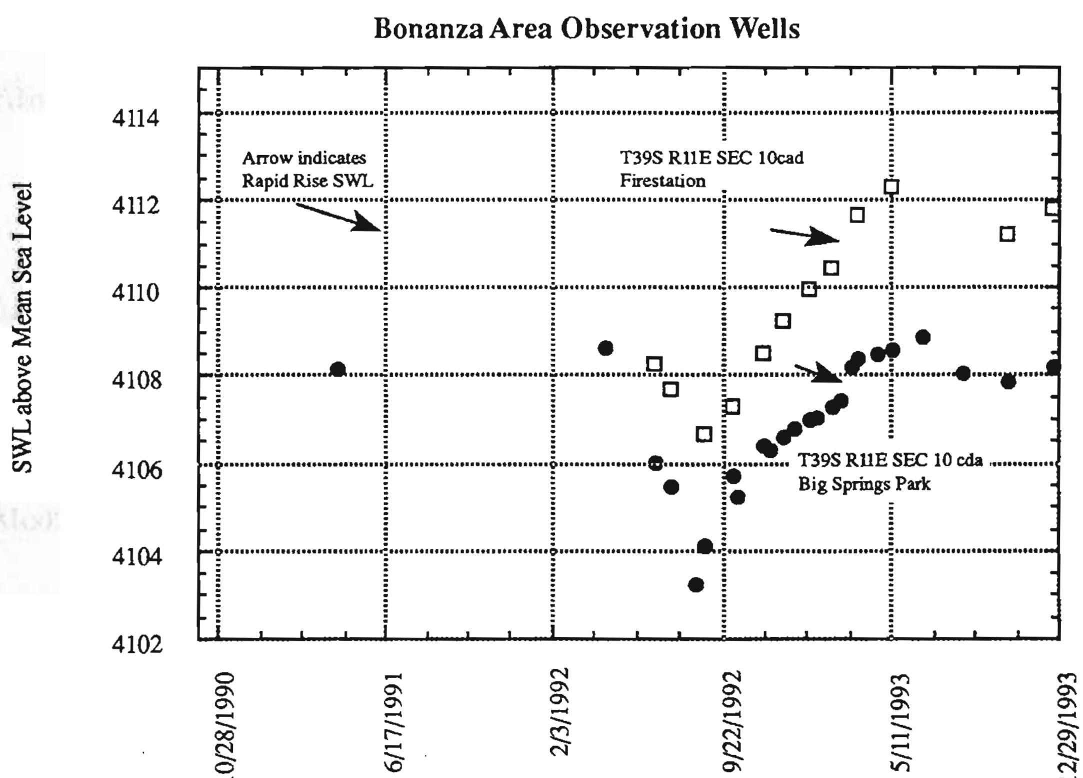
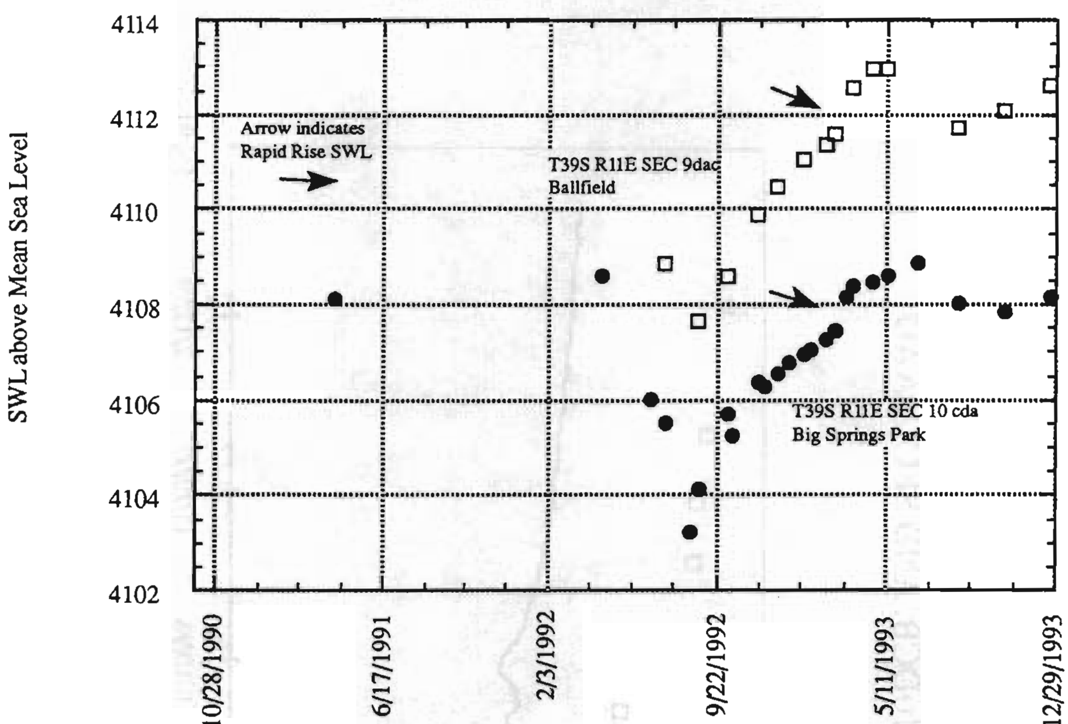

Bonanza Area Observation Wells
SWL above Mean Sea Level
4114
4112
4110
4108
4106
4104
4102
Arrow indicates
Rapid Rise SWL
T39S R11E SEC 10cad
Firestation
T39S R11E SEC 10 cda
Big Springs Park
10/28/1990
6/17/1991
2/3/1992
9/22/1992
5/11/1993
12/29/1993

Figure 9A

Bonanza Area Observation Wells



Bonanza Area Observation Wells

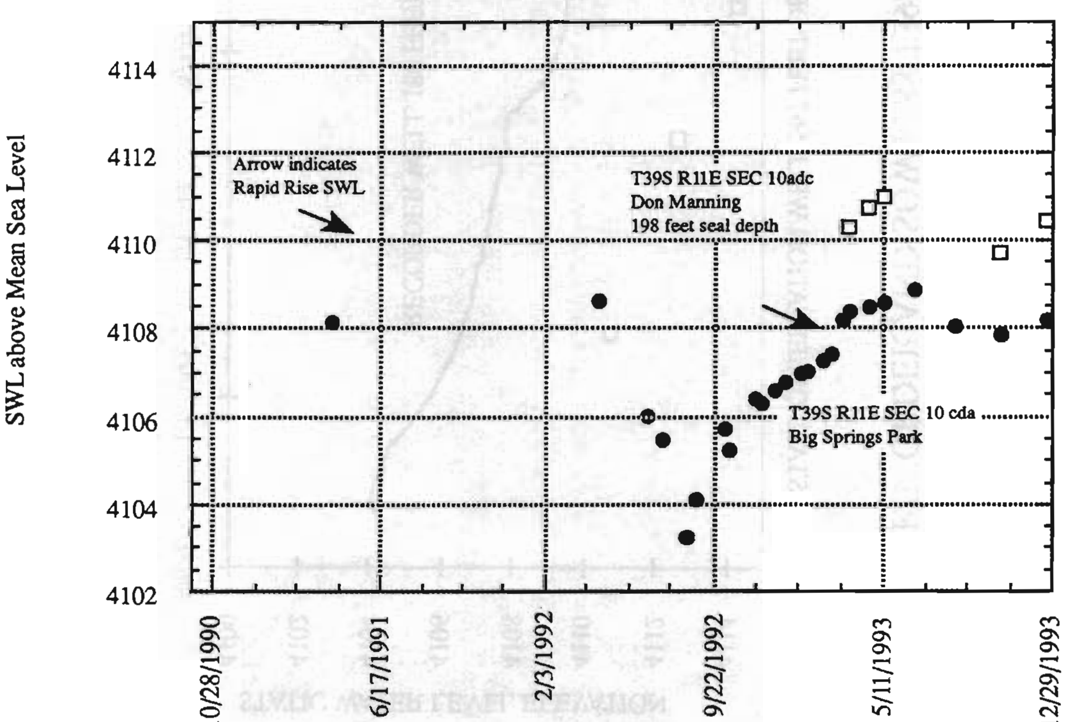


Figure 9B

RECORDER AND SOW #288 T39S, R11E, SEC 10DCB, AND SEC 20AAD

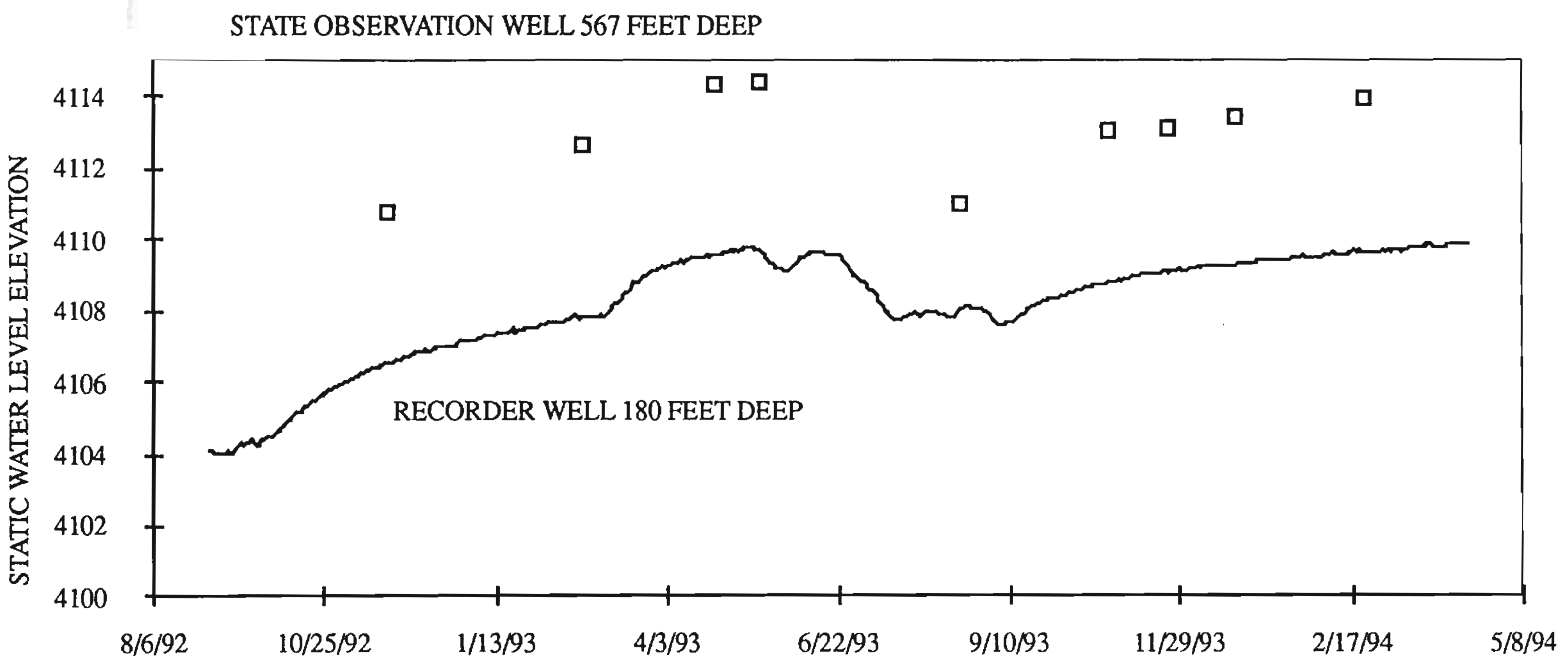


Figure 9C

Wiersma Hydrograph

T39S R11E sec 10 dcb

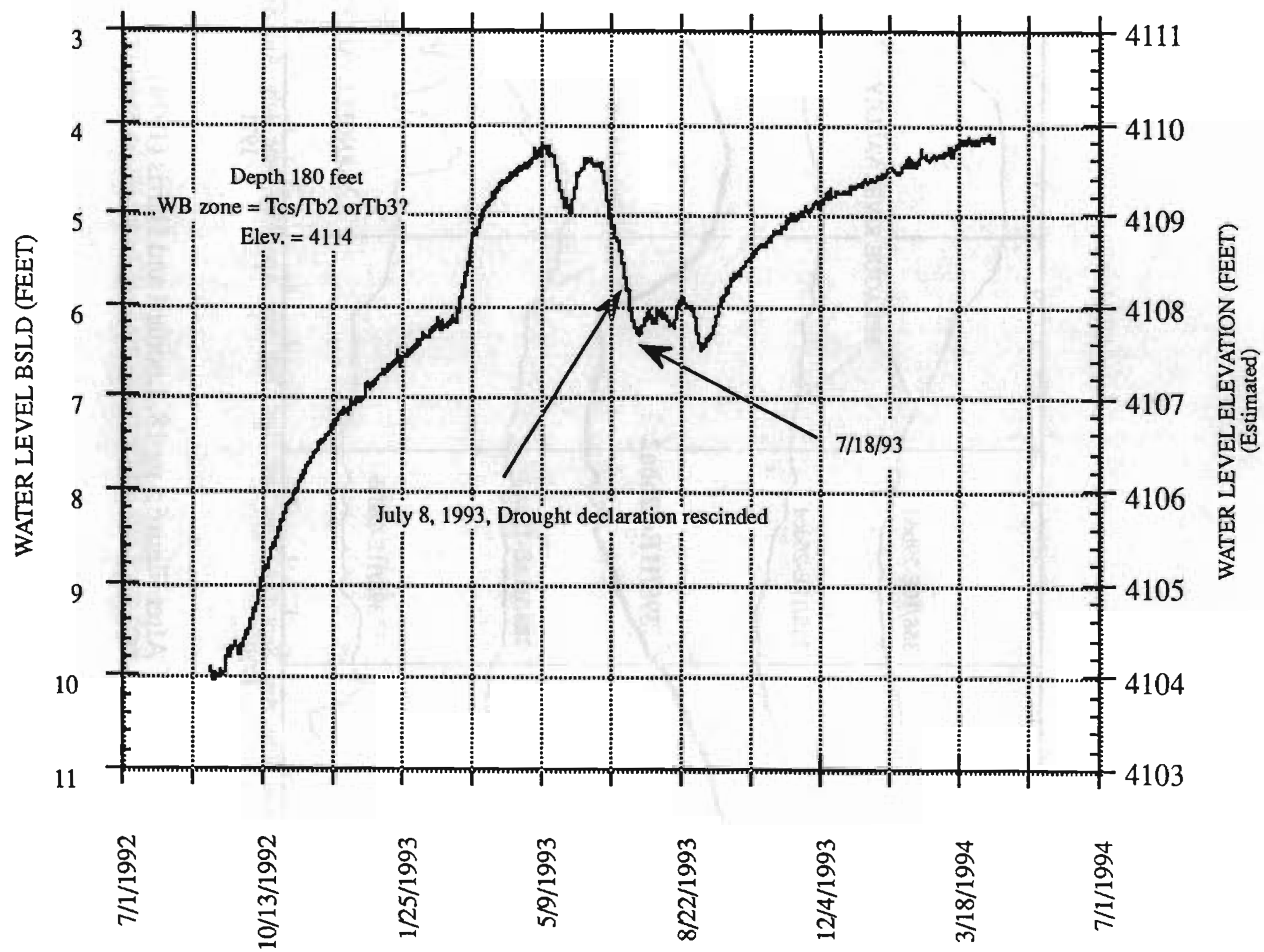
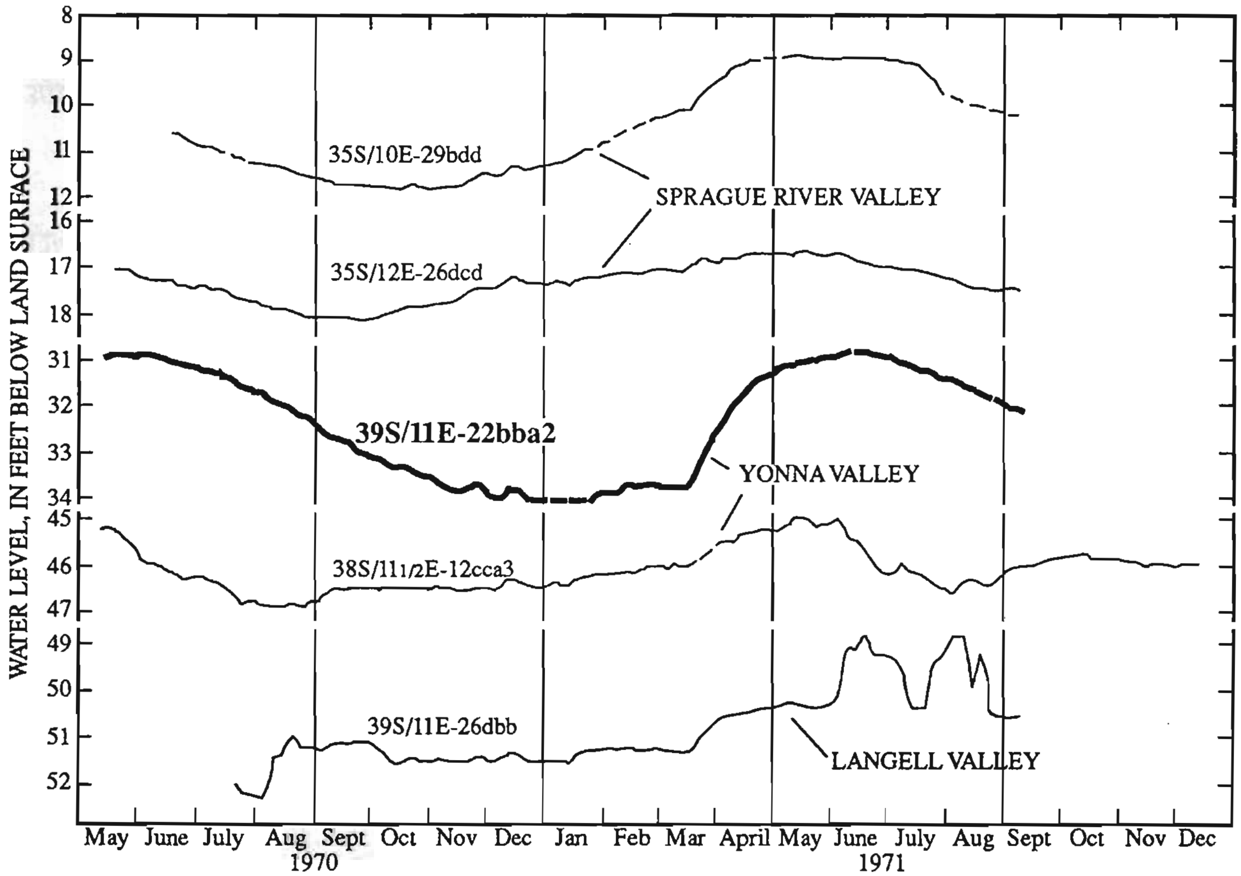


Figure 10



After Figure 5 pg 18, Leonard and Harris (1974)
"Groundwater in Selected Areas in Klamath Basin"

Figure 11

interbeds of dark gray to black medium-grained sandstone. From 175 feet to the bottom of the well (180 feet), there is vesicular basalt with openings up to one cm in diameter. The contact between the sediments and the basalt was seen as irregular, indicating a flow top or an erosional surface. The precise location of water-bearing zones was not determined by the video log.

Between September 3, 1992, and March 3, 1993, the Wiersma well recovered by nearly four feet. When the Lost River flow increased dramatically (figure 12), a site visit was made to the recorder well to check on the equipment. Lost River was at such a high stage that the ground immediately surrounding the well casing was submerged to nearly one foot. A visual inspection of the well casing showed that the surface seal was functioning properly. The water level in the well was below the elevation of the surface water standing around the casing. This shows that infiltration into the low-permeability, continental sediments, at least at the recorder well site, is not instantaneous. If infiltration of the river were immediate and direct, then the water level inside and outside of the well casing would have been the same, and the response on the recorder well would have shown a spike in the water level trend.

The hydrograph shows a slight water level decline and rise between May 10, 1993, and June 15, 1993. During this short time period, pumps were in use. Although pumping records are not available, pumping was likely discontinued for another short time period because of wet weather conditions as documented in the NOAA publication of weather data at the Klamath Falls site. After June 18, 1993, there is again a significant drawdown until July 18, 1993, 10 days after the drought declaration was rescinded which made it illegal to pump drought emergency permit wells. After the wells with drought permits were shut off, the water level remained nearly the same for the rest of the summer. When all pumping ceased for the season, the water level began its recovery. The 1993-1994 recovery period started at a level nearly three and one-half feet above the previous summer water level due to increased recharge and reduced pumping in 1993. As of April 12, 1994, the hydrograph shows a trend indicative of recovery from pumping. Absent from the hydrograph is any indication of a spring recharge event. This is consistent given that there was no significant run off in the spring of 1994 because of the low winter precipitation.

GROUNDWATER DISCHARGE

NATURAL GROUNDWATER DISCHARGE

To quantify total groundwater discharge to the reach of the Lost River where Big Bonanza Springs discharge, U.S. Geological Survey wading stream flow measurement methods were used. The quantity of flow was determined by taking the difference in flow between the Lost River at Keller Bridge, T39S, R12E, sec 29ab and the flow at Harpold Dam SE1/4 of section 19, T39S, R11E. The difference was used as the overall discharge of the Springs, but it is recognized that some of that difference is reasonably-attributed to other groundwater discharge. Measurements were not made whenever significant surface run off in the reach was occurring.

Nine measurements were made between October 1992, and December 1993. Figure 13 shows all measurements made of the discharge of Bonanza Springs. This figure illustrates that all 1992 and 1993 measurements indicate spring discharge below the historic measured discharge dating back to 1918. Figure 13 indicates that the lowest flow ever measured on the discharge of Bonanza Springs was made on November 10, 1992. Other surface water draining to the Lost River in that reach was

Lost River Daily Flow

As reported by the Bureau of Redclamaton-Klamath Project Preliminary Report of Daily Operations

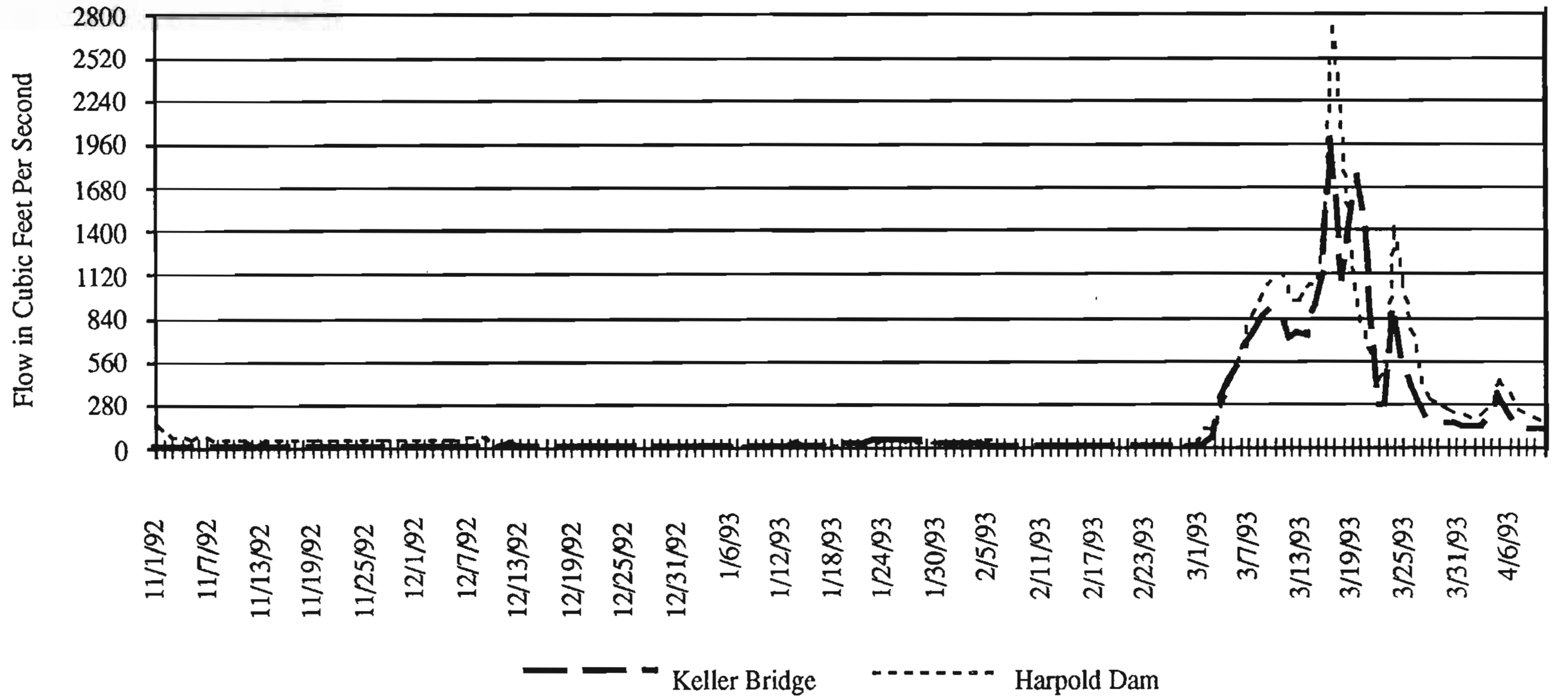
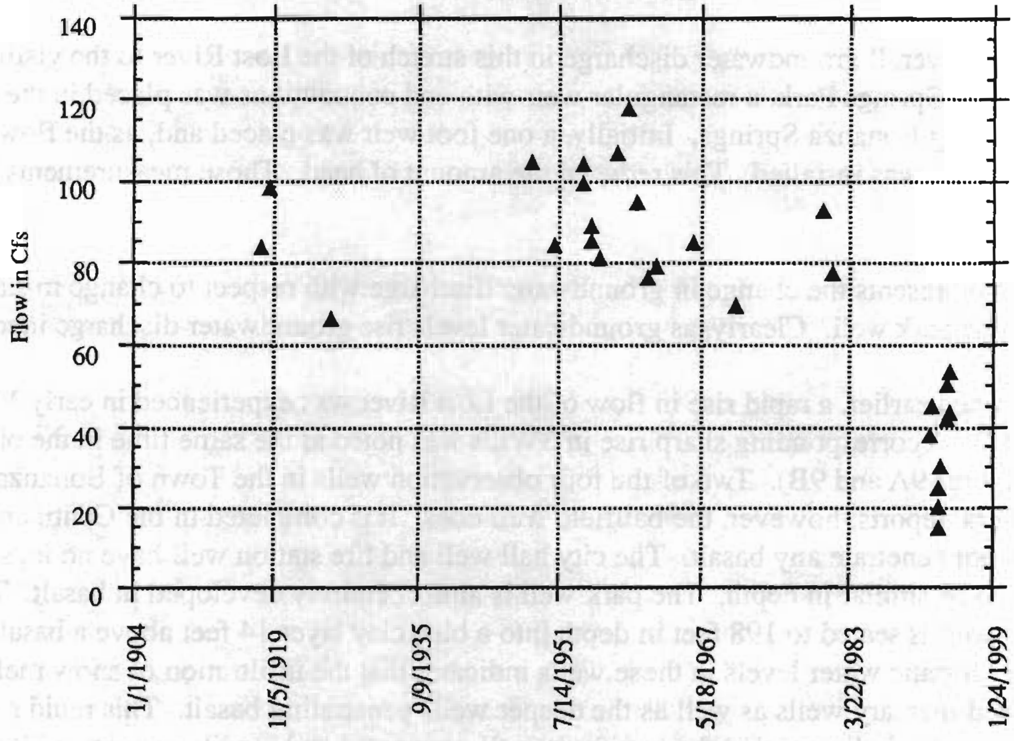


Figure 12

Measured Flow of Big Bonanza Springs
The Difference upstream and Downstream
of the town of Bonanza



Recent Measurements

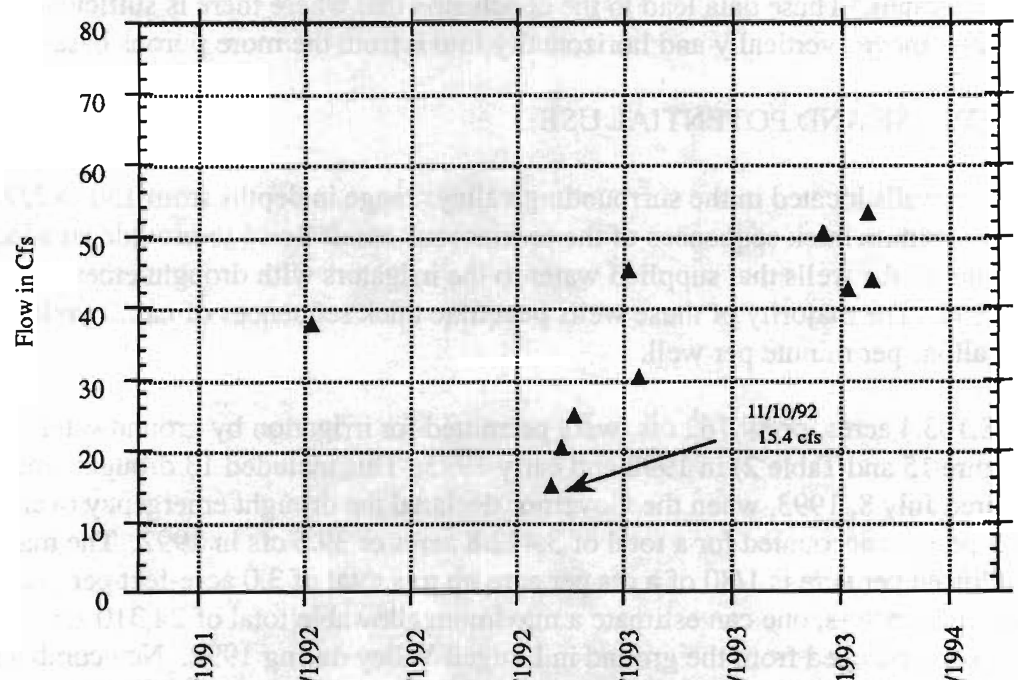


Figure 13

considered insignificant. Some measurements made on and after March 3, 1993, were affected by fluctuations in the Lost River. Appendix 3 gives a detailed listing of all known measurements on the Lost River in the Bonanza vicinity.

To compare overall groundwater discharge in this stretch of the Lost River to the visible springs in Big Bonanza Springs Park, a rectangular weir with end contractions was placed in the northern most channel of Big Bonanza Springs. Initially, a one foot weir was placed and, as the flow increased, a three foot weir was installed. This reduced the amount of head. Those measurements are graphed in Figure 14.

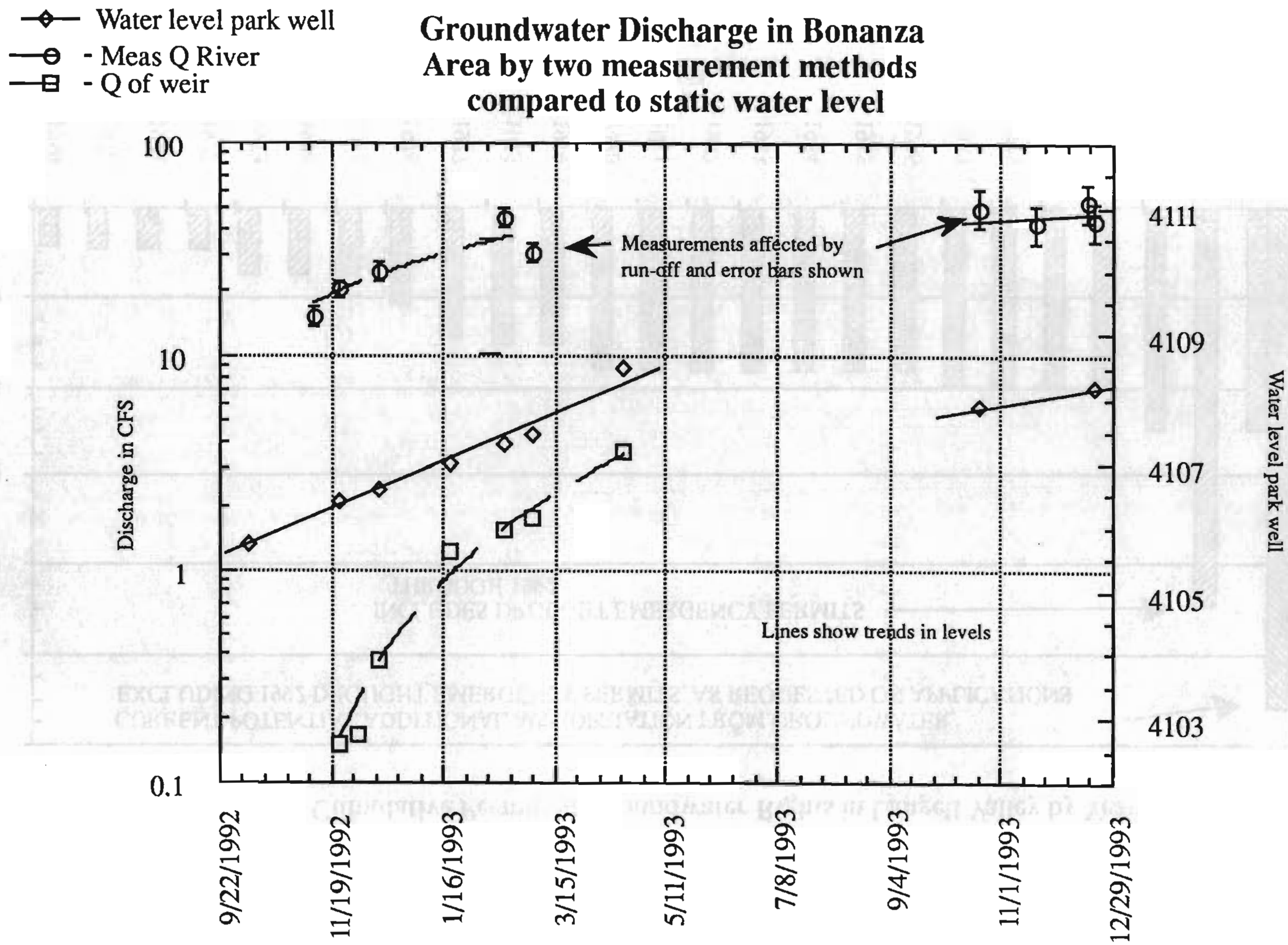
Figure 14 represents the change in groundwater discharge with respect to change in static water levels of the park well. Clearly, as groundwater levels rise groundwater discharge increases.

As mentioned earlier, a rapid rise in flow of the Lost River was experienced in early March 1993 (Figure 12). A corresponding sharp rise in SWL's was noted at the same time in the observation wells (Figures 9A and 9B). Two of the four observation wells in the Town of Bonanza do not have well drillers' reports; however, the ballfield well does. It is completed in the Continental Sediments and does not penetrate any basalt. The city hall well and fire station well have no logs, but they are believed to be similar in depth. The park well is almost entirely developed in basalt. The Don Manning well is sealed to 198 feet in depth into a blue clay layer 14 feet above a basalt layer. The rapid rise in static water levels in these wells indicates that the infiltration of snow melt affects shallow sedimentary wells as well as the deeper wells penetrating basalt. This rapid rise in static water levels also indicates that the aquifer is well-connected and readily accepts infiltration of snow melt. A sharp rise is shown by the recorder hydrograph (Figure 10). The recorder well, the park well and the Manning well all penetrate basalt. The ballfield well does not. However, all show similar hydrographs. These data lead to the conclusion that where there is sufficient porosity in the Tcs unit, water moves vertically and horizontally into it from the more porous basalt.

IRRIGATION USE AND POTENTIAL USE

The irrigation wells located in the surrounding valleys range in depths from 150 to 2,000 feet. The good wells penetrate thick sequences of the scoriaceous basalt flows to provide an adequate water supply. Many of the wells that supplied water to the irrigators with drought emergency permits were drilled in 1992. The majority of these wells penetrate thick sequences of basalt yielding several thousand gallons per minute per well.

A total of 8,103.4 acres, or 89.762 cfs, were permitted for irrigation by groundwater in Langell Valley (Figure 15 and Table 2) in 1992 and early 1993. This included 13 drought emergency permits which expired July 8, 1993, when the Governor declared the drought emergency over. The drought emergency permits accounted for a total of 3,442.8 acres or 39.5 cfs in 1992. The maximum amount of water allowed per acre is 1/80 of a cfs per acre up to a total of 3.0 acre-feet per year per acre. Given these parameters, one can estimate a maximum allowable total of 24,310 acre-feet of water could have been pumped from the ground in Langell Valley during 1992. Newcomb and Hart (1958) estimate that in Yonna Valley, from 1950 to 1952, 3,800 acres received 6,000 acre-feet of groundwater per year. This is 1.58 acre-feet per acre, substantially less than the 3.0 acre-feet allowed under terms of area groundwater permits.



Water level park well
- Meas Q River
- Q of weir
Groundwater Discharge in Bonanza Area by two measurement methods compared to static water level
100
10
1
0.1
Discharge in CFS
4111
4109
4107
4105
4103
Water level park well
Measurements affected by run-off and error bars shown
Lines show trends in levels
9/22/1992
11/19/1992
1/16/1993
3/15/1993
5/11/1993
7/8/1993
9/4/1993
11/1/1993
12/29/1993

Figure 14

Cumulative Permitted Groundwater Rights in Langell Valley by Year

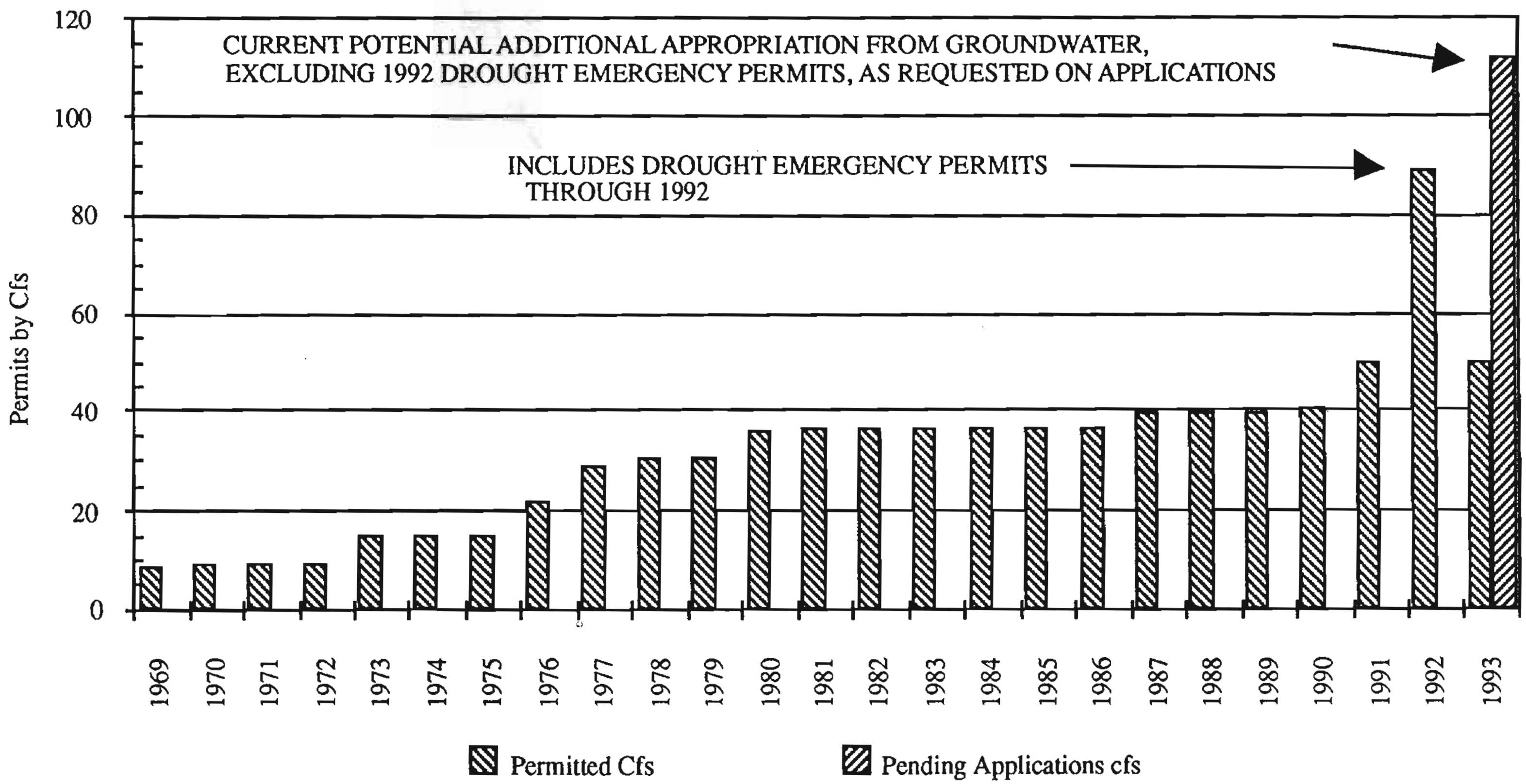


Figure 15

table 2

LANGELL VALLEY GROUNDWATER RIGHTS AS OF 12/13/93
THESE RIGHTS ARE SORTED BY PRIORITY DATE. DROUGHT EMERGENCY PERMITS WERE CANCELLED AS OF JULY 8, 1993, WHEN THE GOVERNOR RESCINDED THE DROUGHT.

		DROUGHT					NUMBER OF ACRES			Q IN
CODE	PERMIT #	EMERGENCY	WELL LOCATION	Q/Q	ADDNL. LOC.	Q/Q(A)	PRIMARY	SUPPL.	PRIORITY	CFS
U	228		39S/13E/30	DD			12.8		01/07/48	0.16
U	368		39S/11E/21	AD			124.8		02/26/51	1.57
U	440		39S/11E/10	DD			7.8		06/30/53	0.13
G	1834		39S/12E/16	CA			316.8		04/25/61	1.20
G	2371		39S/11E/14	BB			24.6		03/07/63	0.31
G	3602		39S/11E/02	DD			92.2	48.3	02/24/67	1.75
G	4539		39S/13E/29	BA			136.4		03/19/69	1.20
G	4549		39S/12E/21	BD			200		06/12/69	2.50
G	4873		39S/11E/10	DC	39S/11E/22	BB	56.5		03/24/70	0.15
G	5082		39S/13E/29	CD			33		06/18/70	0.41
G	5119		39S/11E/03	AA			15		08/06/70	0.19
G	5329		39S/12E/21	BD			37.6		06/12/73	0.47
G	5680		40S/14E/16	AA			404.6		06/29/73	5.10
G	6557		41S/14E/08	AB			21.2		08/25/75	0.26
G	6580		39S/11E/03	AA			5.3		10/06/75	0.07
G	6643		41S/14E/08	CC			131.2		01/15/76	1.64
G	6362		39S/13E/29	BA			71.9		01/21/76	0.90
G	6754		41S/14E/05	AC			57.4	0.1	03/24/76	0.72
G	6814		39S/11E/12	BB			117.2		05/10/76	1.47
G	6873		39S/11E/24	BB			172.8		06/01/76	2.16
G	7469		39S/11E/03	AA			34		04/26/77	0.17
G	7494		41S/14E/05	AB			96		05/10/77	1.20
G	7654		39S/12E/31	AD			349		06/09/77	4.36
G	11023		39S/13E/29	CC			30	103.5	11/15/77	1.11
G	7998		39S/11E/14	BB			114		03/08/78	1.42
G	8252		39S/11E/03	AB			13.2		03/08/78	0.17
G	8203		39S/11E/13	BC			5		05/05/78	0.07
G	9129		39S/12E/16	DB			397.6		10/31/80	4.97
G	9361		39S/12E/32	CD			51		04/23/81	0.64
G	11535		40S/14E/19	DA			33	394	11/06/87	3.34
G	11050		39S/13E/29	BA			72.6		04/02/90	0.91
G	11114		39S/12E/35	CC			15.7		07/11/90	0.20
G	11460		39S/12E/32	CD			52.6		05/21/91	0.66
G	11430		41S/14E/06	BB				219.7	06/07/91	2.75
G	11327		39S/12E/35	AA				367.2	06/12/91	3.12
G	11431		39S/11E/11	DB			225		12/13/91	2.81
						TOTALS	3527.8	1132.8		50.26
G	11480	Y	39S/11E/16	DB	39S/11E/17	CA	93.7	543.2	02/03/92	7.96
G	11485	Y	39S/11E/04	AD			91.5	316.2	03/11/92	4.90
G	11479	Y	39S/11E/15	BA				350.4	04/17/92	4.37
G	11490	Y	39S/11E/10	AD				118.9	04/28/92	1.49
G	11497	Y	40S/13E/02	AA				476.9	05/04/92	4.00
G	11499	Y	39S/11E/11	BD				191.5	05/04/92	2.39
G	11510	Y	39S/11E/13	CB				229.5	05/08/92	2.87
G	11508	Y	39S/12E/34	CB				160.0	05/20/92	2.00
G	11517	Y	39S/11E/03	BA	39S/11E/03	BD		120.8	06/01/92	1.51
G	11519	Y	39S/11E/03	DA				265.1	06/02/92	3.31
G	11548	Y	39S/11E/10	AB				40.1	06/02/92	0.50
G	11523	Y	39S/12E/27	CD				280.0	06/04/92	3.50
G	11540	Y	40S/13E/26	AB				165.0	06/05/92	0.71
						TOTALS	185.2	3257.6		39.50
			TOTAL INCLUDING DROUGHT EMERGENCY				3713	4390.4		89.762

DESCRIPTION OF TERMS

"Code" = letter code given to permits on file with OWRD; "Permit #" = number given to permit once issued. "Drought Emergency" = If permit was drought emergency; "Well Location" = Location of well head given on application map.; "Q/Q" = Quarter Quarter of section well head is located.; "Addnl. Loc." = Additional well head location given on application if more than one well.; "Q/Q(A)" = Additional well head location quarter quarter if given on application. "Primary" = Number of acres that permit allows to be irrigated from well as the primary source of water. "Supplemental" = Number of acres that permit allows to be irrigated from well as the additional source of water when the primary is not available.; "Priority" = Priority date given to permit, equals the day the application was submitted to the WRD with all necessary items included.; "Q in CFS" = Number of cubic feet per second requested on application to irrigate land from groundwater.

If we estimate 1992 groundwater use at 2.0 acre-feet per acre, the groundwater pumped was 16,207 acre-feet. This is 8.1 times the amount pumped in 1970 when data were collected by Leonard and Harris (1974). They estimated that groundwater pumpage in Langell Valley in 1970 was a little more than 2,000 acre-feet annually. This increased pumping contributed to the depressed water levels observed in the area at the end of the 1992 irrigation season.

Potential Use

There are 36 pending ground water applications for Langell, Poe and Yonna Valleys (Figure 15, Table 3, and Map 1), totaling 37.05 cfs for primary irrigated lands, and 106.28 cfs for supplemental irrigation and other uses.

Figure 15 shows the total permitted diversions for groundwater rights in Langell Valley by year. There is a marked increase in rights granted in 1992, due to issuance of drought emergency permits. As of November 1993, there were 3,527.8 acres primary and 1,132.8 acres supplemental permitted groundwater rights in Langell Valley for a cumulative pumping rate of 50.26 cfs. There are also 28 pending applications in Langell Valley which total 29.25 cfs primary and 83.26 cfs supplemental and other uses. If all these permits are issued, the cumulative permitted pumping rate from groundwater will be 162.77 cfs in Langell Valley.

As concluded from Figures 8, 9A-9C, 10, and 15, as groundwater is pumped, groundwater levels decline. It follows, then, that to the extent that issuing additional groundwater rights increases pumping, it will also decrease static water levels. There is the potential during dry years when supplemental irrigation water is needed to nearly double the rate pumped in the spring and summer of 1992. This effect would cause increased drawdown in the water level surface resulting in a further reduction in spring flow.

DOMESTIC USE

Most of the domestic wells supplying water to homes in the Town of Bonanza are 100 feet deep or less. Many of these domestic wells provide sufficient water for domestic purposes but would be unsuitable for irrigation needs. Very few domestic wells tap the basalt lying below the continental sediments and, consequently, yield only enough water for domestic purposes.

Six new homes have been built in the Town of Bonanza in the past two years (Betty Tyree personal communication). Assuming that there are 100 homes in Bonanza, and they each use 1,000 gallons per day, the total rate of pumpage for all domestic use in Bonanza is 0.15 cfs. Thus, the total domestic usage in Bonanza is about 1/10th of the usage of one irrigation well pumping at a rate of 1.5 cfs or 675 gallons per minute. It is therefore, assumed that domestic use does not contribute to severe declines in the Bonanza area.

STATE HEALTH DIVISION WORK

In August 1991, the State Health Division was notified by Bob Baggett, Environmental Health Director of the Klamath County Health Department, that several small public water systems in the Town of Bonanza, had bacterial contamination. From late August through the first part of October, Dr. Dennis Nelson, Oregon Health Division's Groundwater Coordinator, and Bob Baggett conducted

PENDING GROUNDWATER RIGHT APPLICATIONS FILED WITH THE WATER RESOURCES DEPARTMENT AS OF 12/13/93.

DATE OF FILING	APPLICATION NUMBER	WELL LOCATION	Q/Q	ADDNL. LOC.	Q/Q(A)	Q IN CFS PRIMARY	Q IN CFS SUPPL.
4/22/91	G-12493	39S/12E/26	AA			3.13	
4/22/91	G-12494	41S/14E/05	CA			2.84	
4/26/91	G-12507	39S/11E/13	CB			2.87	
5/6/91	G-12518	39S/11E/10	AB				0.50
8/23/91	G-12642	40S/13E/02	AA				4.00
12/16/91	G-12732	39S/11E/15	BD				4.38
12/23/91	G-12735	39S/11E/03	BA	39S/11E/03	BD	0.69	1.26
1/6/92	G-12746	39S/11E/02	DD	39S/11E/02	CD	1.75	2.41
2/5/92	G-12766	39S/11E/11	CC			1.20	
2/12/92	G-12772	40S/13E/05	CC			1.18	1.92
3/18/92	G-12814	39S/11E/10	AD				1.49
4/22/92	G-12869	39S/12E/19	AC			1.45	4.05
4/22/92	G-12876	39S/11E/03	DA				4.90
4/22/92	G-12877	39S/11E/09	BA	39S/11E/09	AB		7.03
4/29/92	G-12885	40S/13E/26	AB			0.78	2.06
5/13/92	G-12901	40S/14E/16	BC			2.00	
5/27/92	G-12922	39S/12E/32	CD			5.34	
6/17/92	G-12955	39S/11E/04	AD			1.14	3.95
6/17/92	G-12972	41S/14E/18	BD			3.50	
7/1/92	G-12994	39S/12E/35	AA				1.25
7/8/92	G-13011	40S/13E/35	AA	41S/13E/01	AA	1.35	12.75
8/31/92	G-13101	39S/12E/34	AB	39S/12E/34	CA	1.33	3.56
9/16/92	G-13106	41S/13E/13	DD				4.45
11/25/92	G-13184	41S/13E/12	CA				4.45
12/2/92	G-13198	40S/13E/09	AD			1.11	
5/12/93	G-13387	39S/12E/27	BD			0.72	3.44
9/15/93	G-13508	41S/14E/11	CA			0.67	
9/29/93	G-13514	40S/14E/32	CA			4.45	"Other use*"
	NUMBER OF APPLICATIONS FOR LANGELL VALLEY (28)				TOTAL CFS	37.50	67.85
8/23/91	G-12644	39S/11.5E/26	DB	39S/11.5E/25	CA		8.48
7/15/92	G-13019	40S/11E/03		40S/11E/04			3.40
	NUMBER OF APPLICATIONS FOR POE VALLEY (2)				TOTAL CFS	0.00	11.88
8/2/91	G-12617	39S/11.5E/02	DC	39S/11.5E/10	DB	3.66	
8/2/91	G-12618	38S/11.5E/24	CD	38S/11E/19	CB	0.19	6.25
2/12/92	G-12769	38S/11E/08	CD	38S/11E/08	AC	1.15	0.33
4/22/92	G-12874	39S/11E/18	CD			0.85	2.25
4/22/92	G-12877	39S/11E/08	BA			2.67	
5/13/92	G-12897	39S/11.5E/01	BB	38S/11.5E/35	DB	1.33	2.31
4/7/93	G-13349	38S/11E/19	AB			0.62	
	NUMBER OF APPLICATIONS FOR YONNA VALLEY (7)				TOTAL CFS	10.47	11.14
	TOTAL NUMBER FOR THREE VALLEYS (37)						
			TOTAL CFS FOR ALL VALLEYS			47.96	90.87

DESCRIPTION OF TERMS

"Application Number" = Application number OWRD filed application

"Well Location" = Well head location given in the application: Township range and section

"Q/Q" = Quarter Quarter given in application of well head

"Addnl. Loc." = Additional wellhead location given on application if more than one well.

"Q/Q(A)" = Additional well head location quarter quarter if given on application.

"Q in Cfs Primary" = Amount of water requested on application to be withdrawn from groundwater for the irrigation of land with no other water right.

"Q in Cfs Suppl." = Amount of water requested on application to be withdrawn from groundwater to irrigate lands with primary irrigation source already established.

* Application G-13514 is for wetland maintenance.

The 3 principal Valleys excluding Drought Emergency

# of applications	Time period
11	Apr - Dec 1991
16	Jan - Jun 1992
7	Jul - Dec 1992
4	Jan - Dec 1993
Drought Emergency	
13	Feb - Jun 1992 Langell Valley

table 3

a three-phase investigation in the area. The first phase of the investigation included conductivity testing on water samples taken from wells located along a line running west from Big Bonanza Springs Park along Highway 70 to Casebeer Road and ending at the Casebeer's residence. Another line of samples were taken along a line running from the Post office along Bly Mountain Cutoff road to the northeast for a distance of one mile. The second phase conducted on September 10, 1991, included sampling for bacteriological testing from private wells and a survey of sanitary construction methods. The final phase included hydrogeological and conductivity testing on selected wells and evaluation of the geologic formations found within the city.

The late August testing revealed that the selected wells on the east side of town had a total dissolved solids (TDS) concentration similar to that of the Lost River when the level of the river was high and there appeared to be no water discharging from the Bonanza Springs. The samples collected from the wells in October had a marked decline in TDS, even though the TDS of the water from the Lost River had increased. The bacteriological testing during September revealed that contaminants were restricted to the area west of Big Springs Park. Fecal Coliform bacteria were detected in samples from sites located in a six block area near the park.

It was concluded that the presence of these contaminants in the wells was a result of lowering of the water table below the river elevation. This created a hydraulic gradient away from the river. Surface water had access to the groundwater through the vesicular basalt outcropping where the Springs normally discharge. It was noted by Dr. Nelson (1991) that water was entering the ground through the Spring orifices.

The gradient had reversed and was sloping toward the river by October when the last set of samples was collected. At that time a decrease in TDS was observed. Four observation wells located in the Town of Bonanza displayed an average swl increase of one foot (i.e. seven to six feet below land surface) from the period August 28, to October 7, 1992.

CH2M HILL REPORT

CH2M Hill conducted an extensive hydrologic evaluation of a deep well 3.5 miles southeast of Bonanza during the spring, summer and fall of 1993 (CH2M Hill, 1994). The information they collected suggests that there are two highly-productive water-bearing zones in the immediate area of this well. The well is located in T39S, R12E, sec 19aca. The well has been reported to have been drilled to a depth of 5,000 feet. CH2M Hill's study showed the well to be blocked or caved-in at 2,056 feet in depth. The two water-bearing zones encountered in this well are described by the report as the shallow aquifer and the deep aquifer.

The shallow aquifer is further described as being above 500 feet in depth and is comprised of Quaternary alluvium, Tertiary olivine basalt and Tertiary basalt (Walker and Mcleod, 1991) of the middle Miocene to Pliocene. These basalt units correlate with Sherrod and Pickthorn's (1992) Tb_2 and Tb_3 based on lithology but do not correlate in age. Dates published by Sherrod and Pickthorn (1992) suggest these units to be younger than previous authors' findings. The shallow aquifer described by CH2M Hill (1994) is driven by infiltration of precipitation and irrigation practices and discharged to local streams and rivers. The report states that the shallow aquifer in some portions of Langell Valley may be hydraulically-connected with surface water, namely the Lost River, ditch water or both.

The deep aquifer that CH2M Hill (1994) describe occurs in a highly-permeable zone below 1,500 feet in depth and is separated by 1,000 feet of tuffaceous rocks. They describe this deep aquifer to be part of the regional flow system and separate from their shallow aquifer. The nearest surface exposure they found is 25 miles to the east.

The evaluation of the well (called the Babson Well) was comprised of a 100-day pretest data collection period, 30-day deep aquifer test, and a 14-day recovery period of data collection. The initial tests were done on three wells. The Babson well was used with the borehole in open condition; that is, both aquifers contributed to the production of the well. The other two wells were open only to the shallow aquifer. After these initial tests were conducted, it was found that the shallow aquifer system would not be utilized for the project because:

> The transmissivity was generally low and may not support long-term groundwater withdrawal rates high enough to meet project needs.
>
> Potential well and groundwater/surface water interference effects may be exacerbated when groundwater withdrawal rates are increased beyond what is cur rently permitted at these locations.

With these issues present, the company searched for a deep well that could be utilized without tapping the shallow aquifer as a source of groundwater. The Babson well was fitted with an inflatable packer at 496 feet below land surface so that the shallow aquifer was thought to be sealed off. CH2M Hill propose that the shallow aquifer and the deep aquifer are separated by a 1,000 foot thick layer of tuffaceous sediments that acts as an impermeable layer. With the packer in place, it was felt that only the deep aquifer was utilized during the 30-day pump test. Results of those pump tests indicated that with monitoring, no impacts on the shallow aquifer system, springs, or a nearby marshy area occurred. The deep aquifer can be pumped at 3,300 gpm for at least 30 days without the aquifer being dewatered. A transmissivity value given was 3×10^6 gpd/ft. This is similar to tests in Yonna Valley by Leonard and Harris (1974). No hydraulic connection between the deep aquifer and the shallow aquifer system was found based on pumping water level changes.

SUMMARY

The Bonanza Springs located in South Central Oregon are a major tributary to the flow of the Lost River during low flow periods. The principal water-bearing zones supplying water to irrigation wells in this area are contained within the thick sequence of flows of the Basin and Range Basalt. These same basalt flows supply the water that discharges at Bonanza Springs. These basalt flows contain scoriaceous zones that readily transmit water among the rock units. The water-bearing zones contained within these units occur at or above 600 feet below land surface. These units act as one aquifer with extreme variability in hydraulic characteristics. Leonard and Harris (1974), Newcomb and Hart (1958), and Meyers and Newcomb (1952) all measured the flow of the Lost River and found that the reach of the River near the Town of Bonanza, Oregon, receives from 85 to 100 cfs of groundwater discharge. Recent measurements indicate about 50 cfs, ranging from 30.5 to 53.6 cfs, contribute to Lost River Flow.

Using data on age relationships (Pickthorn and Sherrod, 1990, and Mallin and Hart, 1991), and new mapping by Sherrod and Pickthorn (1992), it is apparent that the basalt flows and continental sediments were deposited contemporaneously and are intercalated with each other.

As of December 13, 1993, there are 36 pending applications for groundwater in the Bonanza area totaling 143.33 cfs. In the summer of 1992, the groundwater use was nearly doubled from the previous year. As a consequence, many wells had unprecedented low static water levels due to low recharge and increased pumping. The pending applications could potentially demand 1.81 times the 1992 use.

By the time of this investigation, the area had experienced seven years of below-normal precipitation. As a result, state observation well hydrographs show a marked annual decline in static water levels until the end of the 1992 pumping season.

Previous investigations of the area indicate there is a groundwater flow system percolating beneath the major valleys at or near the base level of the major drainages. The groundwater typically flows from the highlands to the valleys where it generally follows the course of the Lost River. Where this flow system is intersected by permeable rocks exposed at land surface, there is a significant amount of groundwater discharge. Big Bonanza Springs is such an area of discharge.

After a series of years of below-normal precipitation, the area received nearly 150 percent of normal snowfall in the winter of 1992-1993. This resulted in an above average amount of run off during March and April 1993. The increased run off resulted in a large amount of infiltration to the groundwater body and a correspondingly rapid rise in water levels in wells. The recovery lasted until pumping began in the late spring of 1993. One observation well shows quite clearly the effects of additional pumping. When pumping ceased, water levels stabilized.

The Bonanza area experienced a dramatic increase in groundwater pumping during the spring and summer 1992. This ceased during the fall and winter, began again in the spring of 1993, and lasted until late July 1993. With reduced infiltration and increased pumping, state observation wells showed unprecedented low levels. The groundwater surface of the Bonanza area is demonstrated to be sensitive to both natural and human-caused events. Groundwater discharge of the major springs in this area is sensitive to the same factors and was measured at historic low levels in the course of this study.

Data collected in this study, combined with the information presented in previous studies, show that spring discharge and groundwater levels have a strong relationship. The present interpretation of the geologic framework explains how the groundwater system can be closely connected to spring discharge. The geologic units are sufficiently inter-connected to allow groundwater to circulate between units and to flow readily when wells penetrate permeable strata. In irrigation wells, the permeable strata are the Basin and Range Basalts. In the domestic wells, the permeable strata are relatively coarse-grained sedimentary units as well as basalt flows.

RECOMMENDATIONS

It is suggested that monitoring continue. Quarterly water level measurements should be taken on selected wells, specifically-constructed in basalts or continental sediments, to show water level trends in those strata. This information will allow a better understanding of recharge and discharge functions in the groundwater system.

Groundwater pumping should be monitored to ascertain the amount of water pumped. This information can be correlated to seasonal fluctuations.

At least two sets of stream flow measurements should be made annually above and below the Big Springs Park. This will indicate the relative amount of groundwater discharge which can then be related to known groundwater pumpage and seasonal weather variations.

Residents of the Town of Bonanza, Oregon, should have their wells tested for bacteriological contamination at least several times each year. Where problems are defined, residents should assure that well construction meets current state well construction standards. Wells may need to be reconstructed or abandoned to remedy water quality concerns. Extending well depths and extending casing and seals to greater depths may be necessary to maintain adequate quality and quantity for domestic use.

The Town of Bonanza, Oregon, should explore the feasibility of a community water system and develop plans for future water needs.

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APPENDIX 1
WELL DRILLING REPORTS SHOWING DIFFERENT WATER PRODUCTION FIGURES

12

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

Klam 10378

39S/11E/15bc

(START CARD) # 30519

(1) OWNER:
Well Number:
Name Earl Wiersma
Address P.O. Box 177
City Bonanza, State OR Zip 97623

(2) TYPE OF WORK:
x☐ New Well ☐ Deepen ☐ Recondition ☐ Abandon

(3) DRILL METHOD
x☐ Rotary Air ☐ Rotary Mud ☐ Cable
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial x☐ Irrigation
☐ Thermal ☐ Injection ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval Yes ☐ No x☐ Depth of Completed Well 186 ft.
Explosives used Yes ☐ No ☐ Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
20"	0	123	Cemn	0	123	82sack
16"	123	186				

How was seal placed: Method ☐ A ☐ B x☐ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	16"	+1	123	250	x☐	☐	x☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) 123'

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer x☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.
2960		65 ft	
2100		55 ft	1hr

Temperature of water 57 F Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other x surface
Depth of strata: 6-9 ft

(9) LOCATION OF WELL by legal description:
County Klamath Latitude Longitude
Township 39 S N or S. Range 11 E E or W. WM.
Section 15 SE ¼ NW ¼
Tax Lot 300 Lot Block Subdivision
Street Address of Well (or nearest address) 3121 E. Langell Valley Rd. Bonanza, OR 97623

(10) STATIC WATER LEVEL:
7 ft. below land surface. Date
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 6'

From	To	Estimated Flow Rate	SWL
99	122	100 gpm	6'
122	133	1000 gpm	6'
133	186	1900 gpm	6'

(12) WELL LOG:
Ground elevation 4100

Material	From	To	SWL
TOP SOIL	0	2	
SANDY BROWN CLAY	2	6	
BROWN SAND	6	9	6'
YELLOW CLAY	9	13	
BLUE CLAY	13	27	
BLACK SANDSTONE	27	32	
BLUE CLAY	32	66	
HARD BLUE CLAYSTONE	66	70	
GRAY CLAY W/ STREAKS OF - BLACK SANDSTONE	70	94	
HARD GRAY CLAYSTONE	94	99	
BLUE CLAY W/ STREAKS OF - BLACK SAND	99	103	6'
BLACK SANDSTONE	103	116	6'
BLUE CLAY W/ PUMICE & - SAND	116	122	6'
BLACK LAVA ROCK	122	133	6'
BLACK & BROWN LAVA ROCK	133	186	6'

Date started 1-6-92 Completed 1-14-92

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.
WWC Number
Signed Date

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 408
Signed Norm Sevey Date 1-20-92

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X

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

Klam 10382

RECEIVED JAN 3 1 1992 WATER RESOURCES DEPT. SALEM, OREGON

39S/11E/15 bd

(START CARD) # 30518

(1) OWNER: Well Number:
Name Earl Wiersma
Address P.O. Box 177
City Bonanza State OR Zip 97623

(2) TYPE OF WORK:
☒ New Well ☐ Deepen ☐ Recondition ☐ Abandon

(3) DRILL METHOD
☒ Rotary Air ☐ Rotary Mud ☐ Cable
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☒ Irrigation
☐ Thermal ☐ Injection ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval Yes ☐ No ☒ Depth of Completed Well 207 ft.
Explosives used Yes ☐ No ☒ Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
14"	0	18'	cement& bent.	0	18	7sacks 1/2sac
10"	18	207				

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	10"	+1	19'	250	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) NONE

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
20		160	1 hr.

Temperature of water 58 F Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☒ Other surface
Depth of strata: 7 ft.

(9) LOCATION OF WELL by legal description:
County Klamath Latitude Longitude
Township 39 S N or S. Range 11 E E or W. WM.
Section 15 SE ¼ NW ¼
Tax Lot 300 Lot Block Subdivision
Street Address of Well (or nearest address) 3120 E. Langell Valley Rd. Bonanza, OR 97623

(10) STATIC WATER LEVEL:
9' ft. below land surface. Date 1-6-92
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 7 ft.

From	To	Estimated Flow Rate	SWL
7'	10'	2 gpm	7'
125'	129'	10 gpm	7'
180'	185'	20 gpm	7'

(12) WELL LOG: Ground elevation 4100

Material	From	To	SWL
Sandy Top Soil	0	2	
Sandy Brown Clay	2	7	
Brown Sand	7	10	7'
Yellow Clay	10	12	
Blue Clay	12	125	
Soft Black Rock	125	129	7'
Blue Clay	129	180	
Black Sand Rock	180	185	7'
Blue Clay	185	207	

Date started 1-2-92 Completed 1-6-92

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.
WWC Number
Signed Date

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 408
Signed [signature] Date 1-25-92

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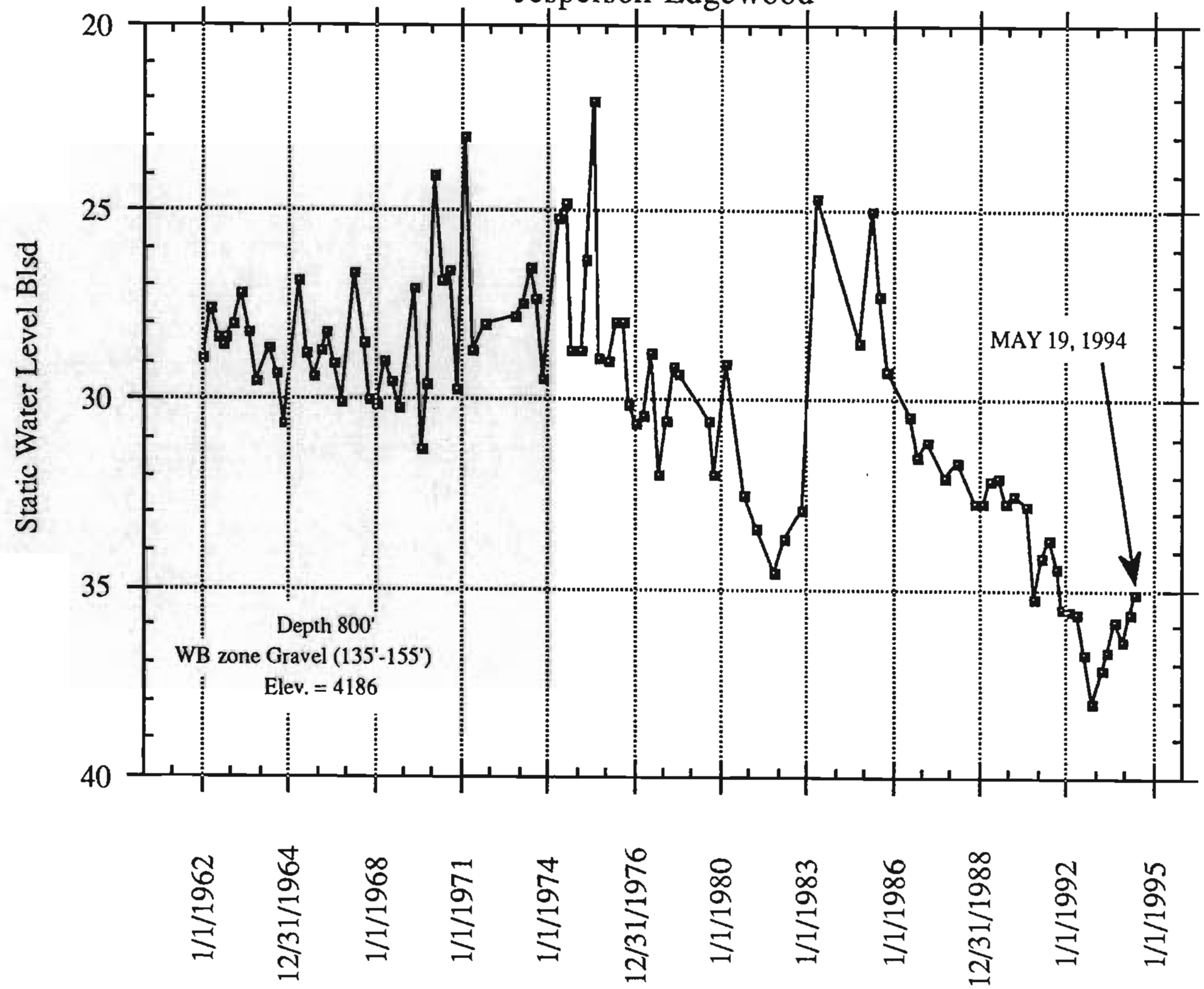
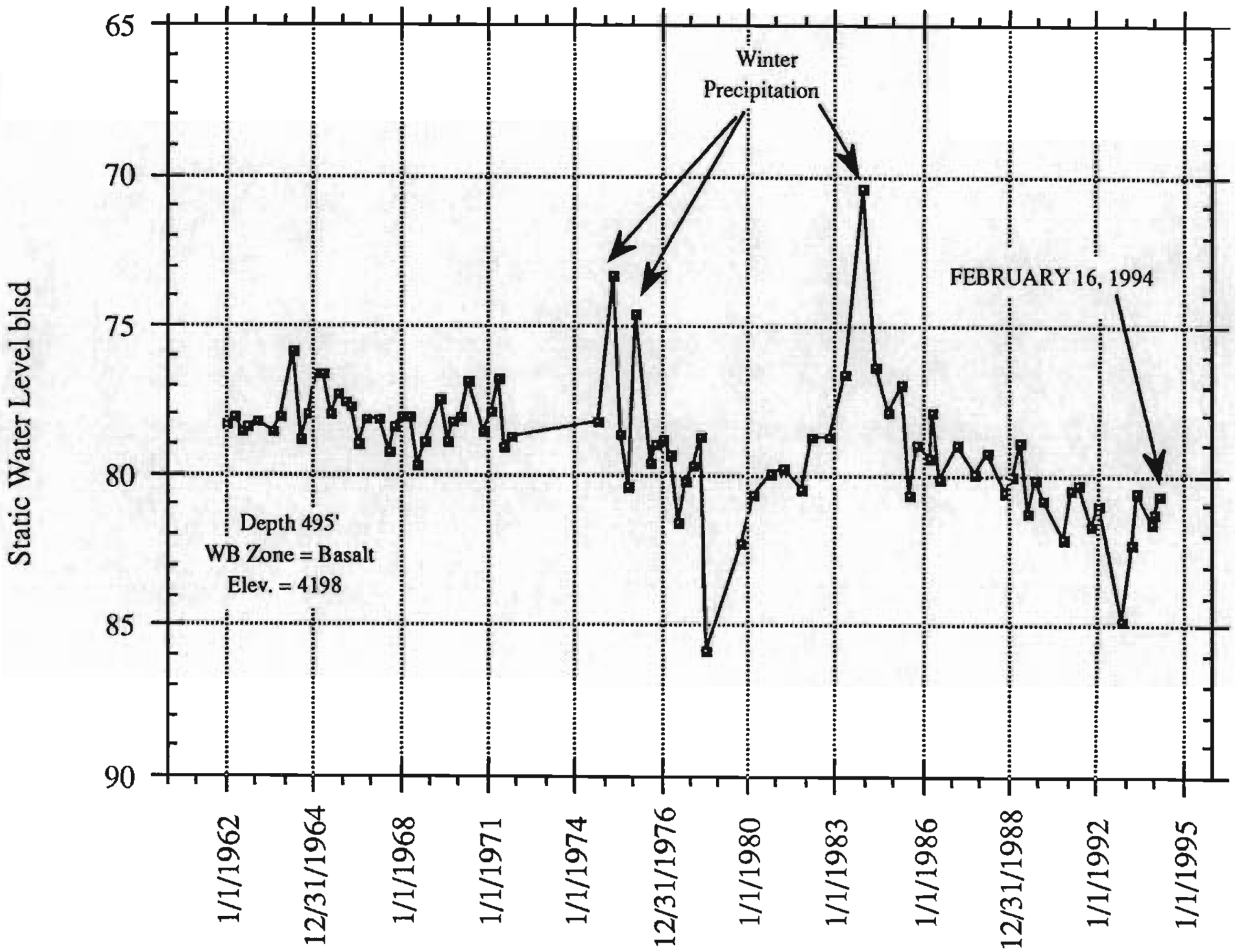
APPENDIX 2
STATE OBSERVATION
WELL HYDROGRAPHS

State Observation Well #281
T37S R10E sec 29ddb(2)
Jesperson-Edgewood



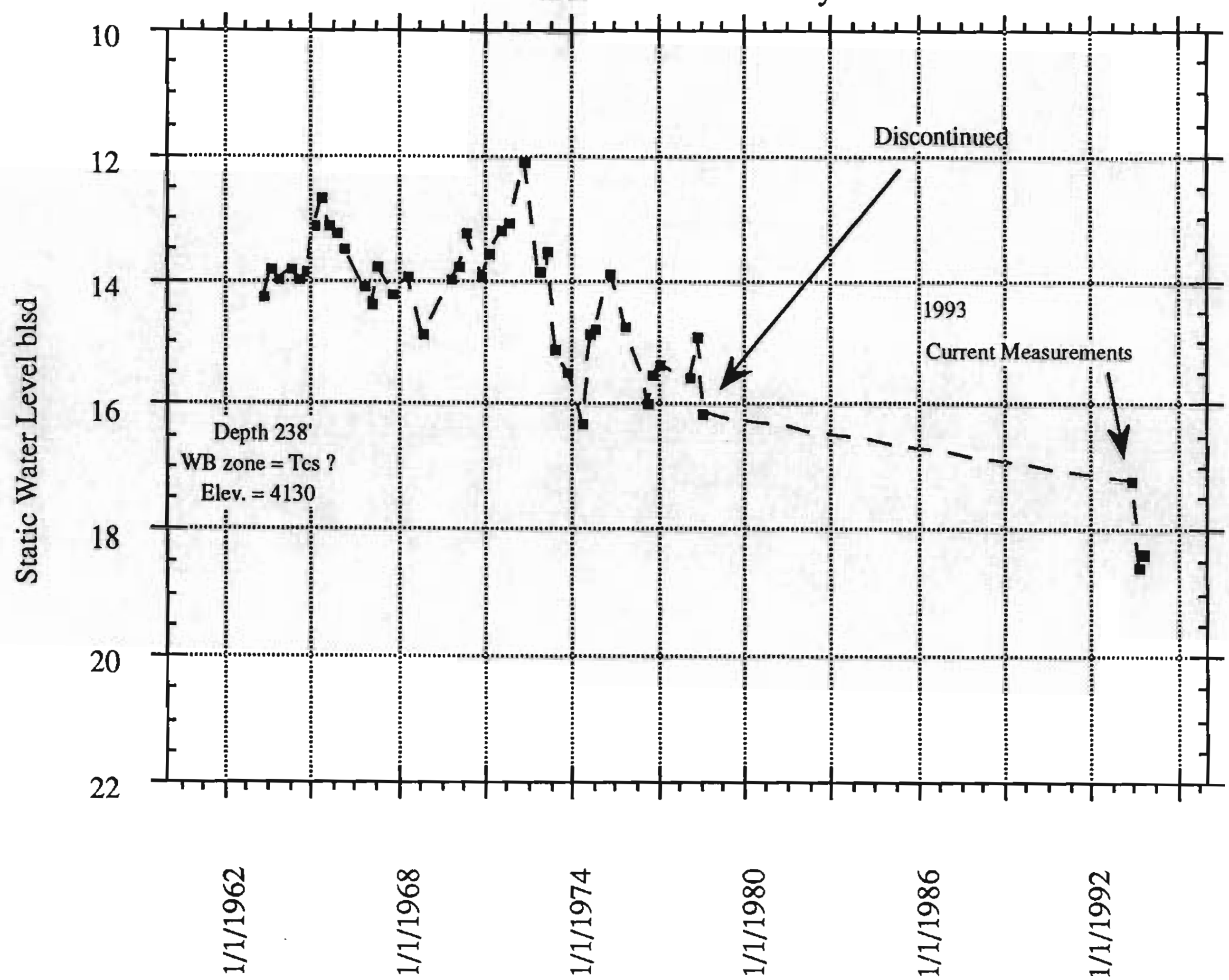
State Observation well #286
T38S R11.5E sec 15 dda
George McCollum



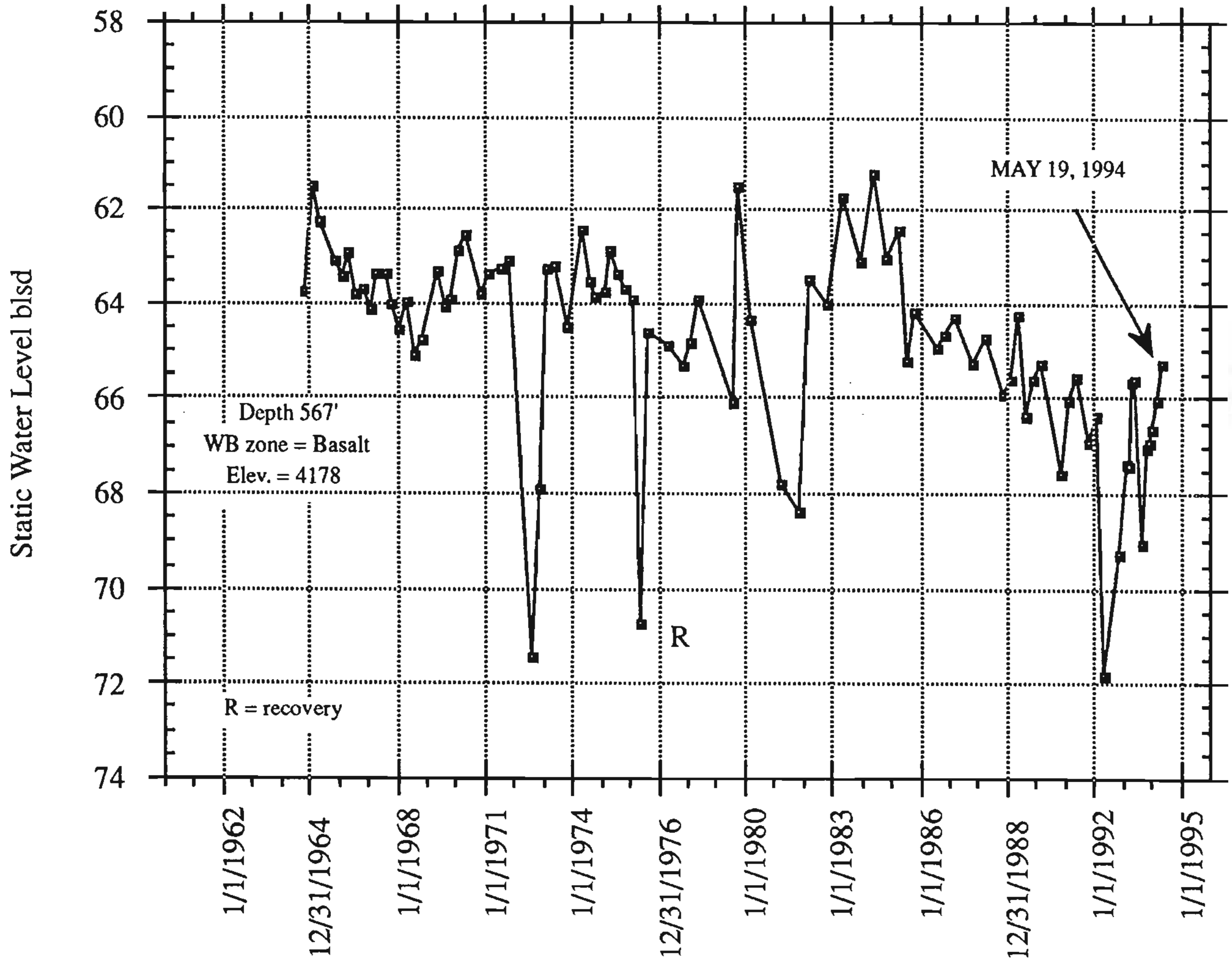
Discontinued State observation well #329

T39S R11E Sec 10ddd

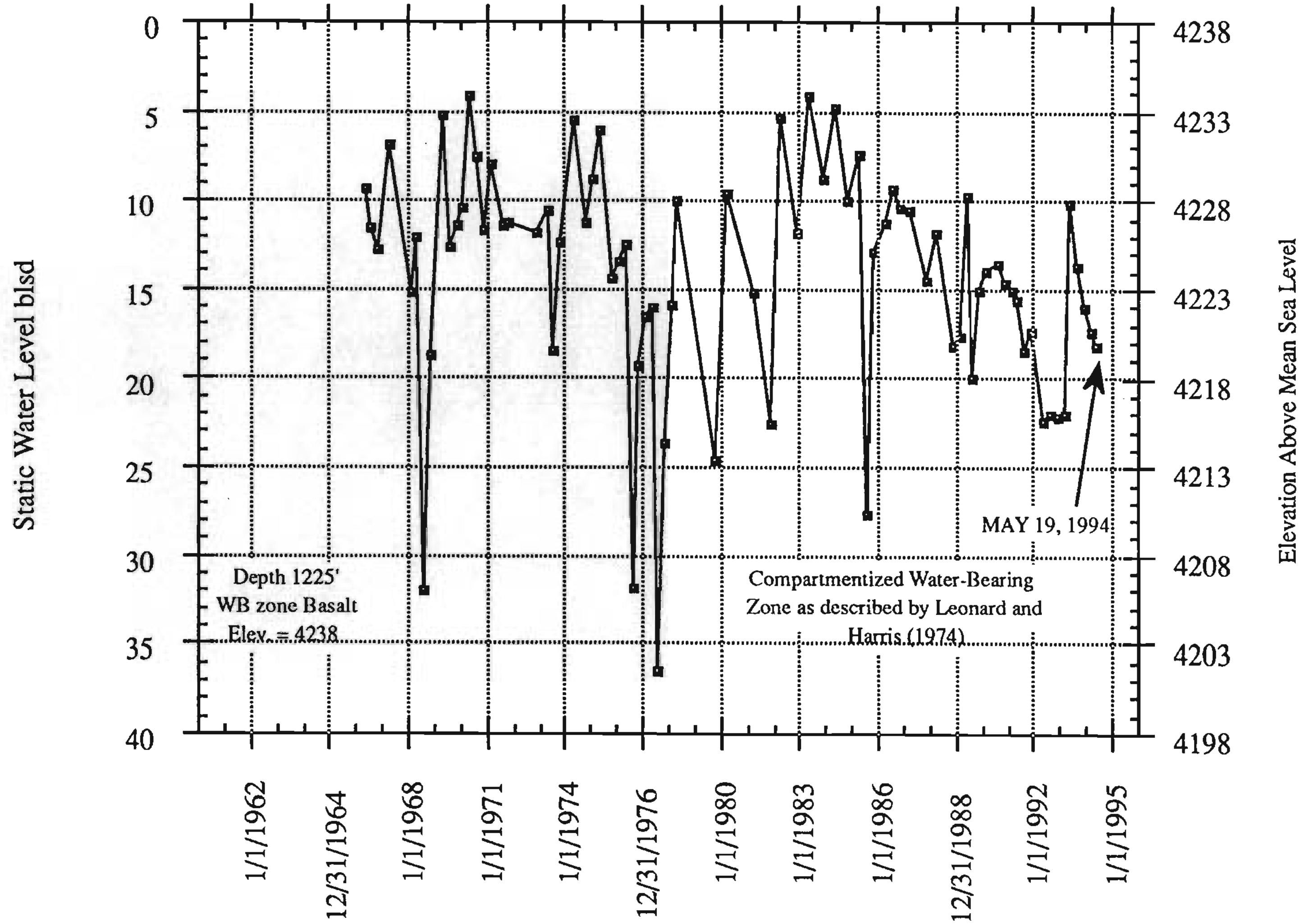
Lost River Cemetary



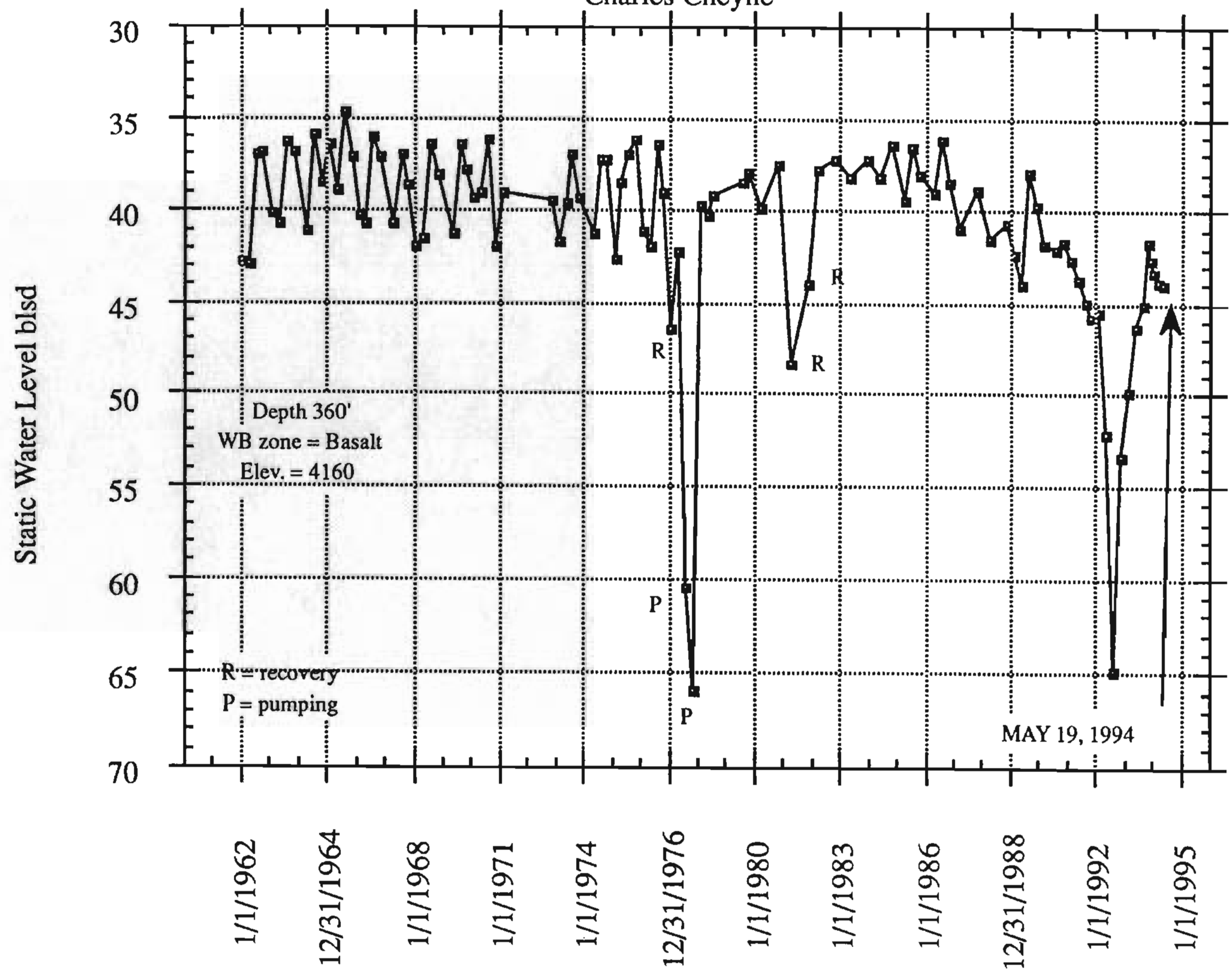
State Observation well #288
T39S R11E sec 20aad
Robert Woods

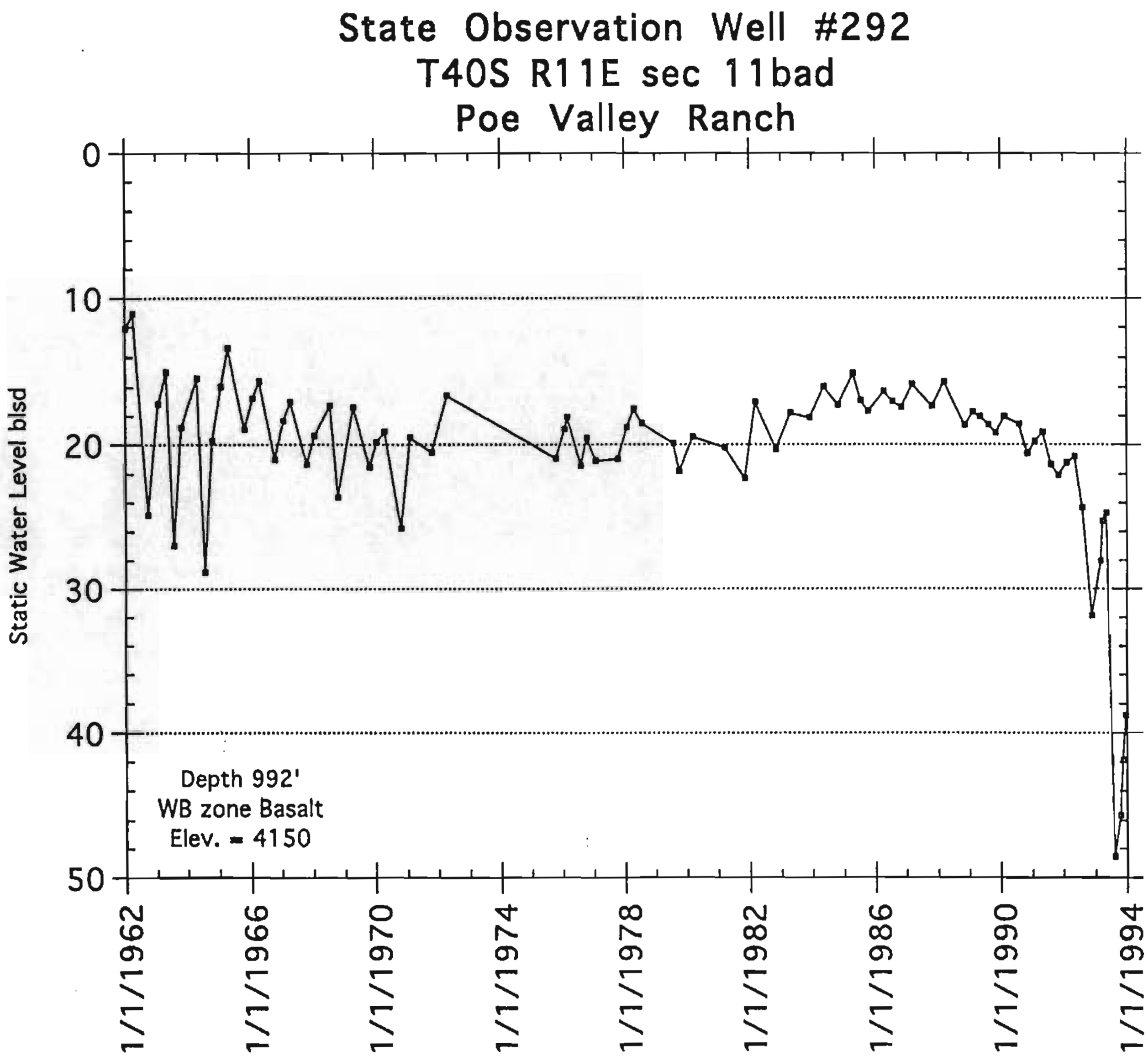


State Observation Well #289
T39S R11E sec 26abd
H. D. Knox

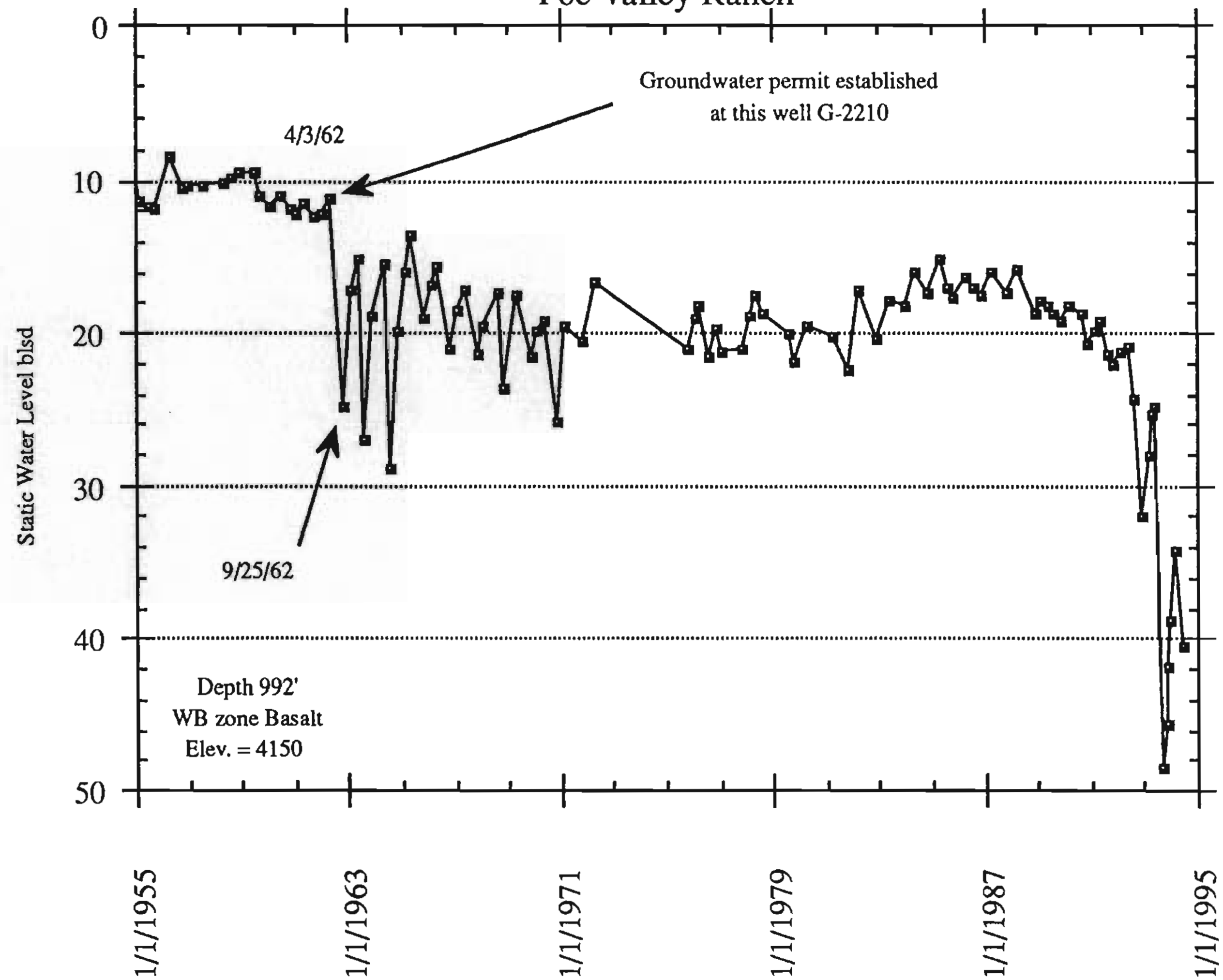


State Observation Well #291
T39S R12E 35 add
Charles Cheyne

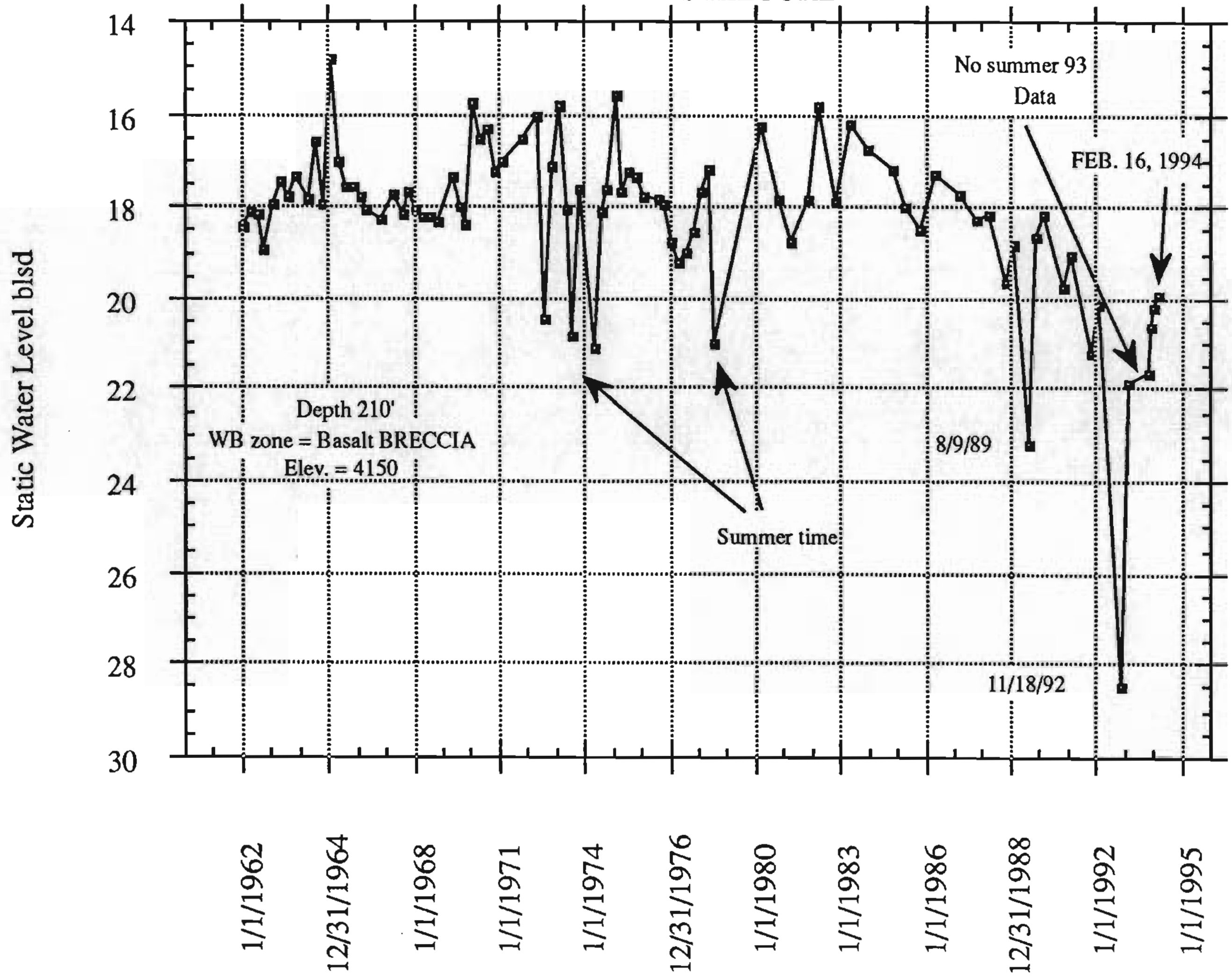



State Observation Well #292
T40S R11E sec 11bad
Poe Valley Ranch
Static Water Level blsd
0
10
20
30
40
50
Depth 992'
WB zone Basalt
Elev. = 4150
1/1/1962
1/1/1966
1/1/1970
1/1/1974
1/1/1978
1/1/1982
1/1/1986
1/1/1990
1/1/1994

State Observation Well #292
T40S R11E sec 11bad
Poe Valley Ranch



STATE OBSERVATION WELL #295
T41S R14E SEC 18 CCA
CHARLES KILGORE



APPENDIX 3
BONANZA SPRINGS MEASUREMENTS

Measured flow of Lost River By Various Agencies (U. S. Geological Survey, U. S. Bureau of Reclamation and Oregon Water Resources Department.)

Upstream and Downstream of the town of Bonanza, Oregon.

All flow figures are in cubic feet per second (Cfs).

DATE	BONANZA SPRINGS FLOW	KELLER BRIDGE	HARPOLD DAM	MISC INFLOW	REMARKS
02/07/18	84.4				
02/03/19	98.6				
11/04/25	67				
04/13/48	105				Doubtful
11/22/50	84.6			1.41	Buck Ck
10/22/53	100				
10/22/53	104.5				
10/27/54	85.7				
11/06/54	89.6				
11/07/55	81.5				
10/23/57	107				
10/30/58	118				
11/12/59	95.3				
01/25/61	77			3.1	Buck Ck
12/07/61	79.3			7.8	Buck Ck
01/01/66	85				estimates
11/01/70	70				estimates
04/07/80	93	32.3	125		
04/03/81	78	208	286		
01/07/92	38	11	49		
11/10/92	15.4	5.39	20.8		
11/24/92	20.63	3.27	23.9		
12/10/92	25.1	11.7	36.8		
02/17/93	45.5	50.3	95.8		
03/03/93	30.5	46.8	77.3		
10/21/93	50.5	27.6	86.1	8	Buck Ck and drain
11/19/93	42.6	16.7	60.3	1	
12/16/93	53.6	26	91.6	12	others
12/20/93	43.94	25	71.3	2.36	Buck Ck
01/25/94	50.81	22.9	80.8	7.09	Buck Ck
03/18/94	43.4	15.1	60.5	2	Buck Ck

APPENDIX 4

WELL NUMBER	STATE #	TOWNSHIP	RANGE	SECTION	QQQ	ELEVATION	DEPTH	OWNER'S LAST NAM	FIRST NAME	NOTES
BON002		39S	11E	10	CDA	4120	108	BIG SPRINGS	BONANZA	PARK WELL
BON003		39S	11E	19	AAB	4120	299	NIKOLA	JOHN	
BON004		39S	11E	19	ADB	4182	425	GOOSSEN	FRED	
BON008		39S	11E	13	BCD	4158	173	FOX	CURTIS	
BON010		39S	11E	9	DAC	4120	125	BALL FIELD	BONANZA	BALL FIELD WELL
BON011		39S	11E	10	CBD	4135	?	CITY HALL	BONANZA	NO WELL REPORT
BON012		39S	11E	10	CAD	4120	?	FIRESTATION	BONANZA	NO WELL REPORT
BON013	KLAM10431	39S	11E	13	DAD	4132	104	DEJONG	ELSO	BONANAZA VIEW DAIRY
BON014		39S	11E	10	CCC	4122	187	TURNER	KEITH	
BON018		39S	11E	4	ADB	4158	190	BENNETT	BRADLEY	
BON019		39S	11E	20	AAD	4180	567	WOODS	ROBERT	SOW
BON020	KLAM10647	39S	12E	29	ACA	4138	290	BOERSMA,D	PAUL	DOMESTIC
BON021		39S	11E	10	DDD	4125	238	CEMETARY	CITY	
BON022		39S	12E	29	ADA	4175	604	BOERSMA,I	PAUL	IRRIGATION
BON023		39S	11E	4	DAC	4168	?	BENNETT,D	BRAD	DOMESTIC
BON024		39S	11E	3	BDC	4155	107	LETCH	ALBERT	IRRIGATION
BON025	KLAM10416	39S	11E	10	ADC	4118	232	MANNING	DON	
BON026	KLAM10440	39S	11E	11	BDD	4135	373	HORSLEY#2	DON	HAS OIL
BON027		39S	12E	19	ACA	4132	2056	BABSON DEEP		NO LOG, HAS OIL
BON028		39S	11E	22	BBA	4170	?	DEJONG	CABIN	NO LOG
BON029		39S	11E	21	ADD	4158	?	DEJONG	W. LNGLVLY	NO LOG
BON030		40S	11E	11	BAD	4160	992	POE VALLEY RNCH		STATE OBS WELL
BON031	KLAM10491	38S	11E	31	DAA	4190	304	ARATA	LOUIS	IRRIGATION
BON032	KLAM10285	39S	11E	10	CCA	4121	93	MILES	HAROLD	
State Observation Wells										
#281		37S	10E	29	DDB(2)	4186	800	JESPERSON	EDGEWOOD	
#286		38S	11.5E	15	DDA	4198	495	MCCOLLUM	GEORGE	
#329		39S	11E	10	DDD	4130	238	CEMETARY		
#288		39S	11E	20	AAD	4178	567	WOODS	ROBERT	
#289		39S	11E	26	ABD	4238	1225	KNOX	HD	
#289		39S	12E	35	ADD	4160	360	CHEYNE	CHARLES	
#292		40S	11E	11	BAD	4150	992	RANCH	POE VALLEY	
#295		41S	14E	18	CCA	4150	210	KILGORE	CHARLES	