Results of a Long-Term Aquifer Test at the Ron McVay Irrigation Well, Klamath County, Oregon

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EXECUTIVE SUMMARY

The U. S. Bureau of Reclamation (USBR) and the Oregon Water Resources Department (OWRD) entered into a joint study in 1998 to identify opportunities to enhance water supplies in the Klamath Basin. The purpose of this study is to investigate options for increasing water supplies in the basin through development of the ground water resource in a selected area as a demonstration project.

Gates (2001) summarized the results of previous investigations of the geology and hydrogeology of the Klamath Basin and described the results of this joint study to that point. That report discussed the potential for ground water development at four areas of the basin which were originally considered for a demonstration project. The Shasta View Irrigation District (SVID) was subsequently selected as the site for the demonstration project.

The demonstration project included selection of a suitable existing well, owned by Ron McVay, for a long-term aquifer test and subsequent design and construction work necessary to inject ground water into the SVID main line. The test was conducted beginning in May 2001 with the pumping period ending in October 2001. Recovery data were collected through late October 2002.

Low precipitation in the winter of 2000 - 2001 resulted in the USBR not delivering surface water to the SVID for much of the 2001 irrigation season. A drought declaration for Klamath County in April 2001 allowed the Department to issue Drought Emergency permits. These actions required modification of original plans to inject the ground water into the SVID main line. Instead, the McVay well was used to directly irrigate lands under both an existing permit for supplemental irrigation of 120.7 acres and an adjacent 438.0 acres covered by a Drought Emergency permit.

The McVay well was pumped for 169 days at an average rate of 1290 gpm. Due to the ongoing drought, intermittent pumping by nearby wells, primarily existing and newly constructed irrigation wells, occurred during both the drawdown and early recovery periods of the test. This pumping caused water levels to respond at the wells being monitored for the long-term test. Analysis of the test data was therefore not straightforward and the aquifer characteristics determined likely have greater variation than would have been the case in the absence of nearby pumping.

The transmissivity calculated from drawdown data collected at the pumping well and the four observation wells ranges from about 71,000 to 569,500 gpd/ft. Transmissivity calculated from recovery data ranges from about 135,000 to 358,000 gpd/ft. The coefficient of storage calculated ranges from 0.0013 to 0.0643, which is expected of semiconfined to unconfined aquifers. Using the results from this aquifer test and those from an earlier test of a nearby well, the average transmissivity is about 200,000 gpd/ft. and the average coefficient of storage is about 0.01.

The average transmissivity and coefficient of storage values were used to predict drawdown after various times of pumping and at various distances from a typical production well. The SVID has filed a permit application that, if approved, would allow irrigation of district lands from up to 14 wells. The potential pumping interference at the center of such a well field could exceed 50 feet after 180 days of pumping at the maximum rate. The impacts of pumping will extend to areas outside the district lands. However, those areas will experience smaller amounts of pumping interference than will areas within the district.

If and when the SVID pumps ground water in the quantity proposed, some existing wells in the area will need work. This may include lowering of pumps, well deepening or replacement. This is likely to be a contentious issue, resulting in complaints by local well owners to the OWRD, the USBR and the district.

Due to the interference of multiple wells pumping during the long-term test, it was not possible to document the presence of any ground water barriers in the area by the usual methods of analysis.

Total ground water pumpage in the vicinity of the SVID and Malin Irrigation District, including existing permitted wells and Emergency Drought permitted wells, is estimated to be over 9100 acre-feet for the year 2001. This was about 3.5 times that in the year 2000 for the same local area. Similarly, data from the California portion of the Tule Lake basin indicate pumpage there in 2001 was about 4.4 times that pumped in 2000.

Water level recovery at most wells increased in rate during middle to late April of 2002, which suggests that there is a local source of recharge to the basalt aquifer. The timing closely corresponded to the release of Klamath project water into local canals and to the beginning of the irrigation season. The basalt ground water system in the area is, in part, dependent on canal leakage, possibly in combination with local application of water for irrigation, as a source of recharge.

The Theresa Perry well did not clearly exhibit this recharge response. It also did not respond to pumping of the TID well #6 as strongly as did the other monitored wells. The Perry well is the only monitored well located north of a recently mapped normal fault near the test site. The fault coincides with a local permeability change in the basalt aquifer that serves to dampen pumping impacts on opposite sides.

None of the wells monitored during the test had water levels recover up to the pre-test levels by the beginning of the 2002 irrigation season. The hydrographs for the monitored wells suggest that recovery to pre-test levels or higher would likely have occurred by late 2002 to early 2003. The rate of recovery may be influenced by local precipitation, which was below normal for the 2001-2002 water year. Therefore, under climatic conditions equivalent to those during the test period, the basalt aquifer requires more time to completely recover from pumping than is available between irrigation seasons. It is unknown whether additional recovery would have occurred in 2002 under “normal” precipitation conditions.

Annual pumpage to satisfy the SVID water rights application for irrigation from the basalt aquifer would likely result in annual water level declines. It is unknown whether such declines would continue or if water levels would stabilize after some period of continued development of the resource. In either case, annual water level recovery would be dependent upon precipitation and the availability of canal leakage.

Pumpage from wells within the SVID for 2001 is estimated to be 3560 acre-feet. During a normal year, the SVID diverts about 12,000 acre-feet of surface water. Therefore, the ground water pumped in 2001 represents approximately 30 percent of the quantity that would need to be pumped to satisfy normal district requirements. If the SVID were to completely replace its usual surface water diversion with ground water, an additional 8,440 acre-feet of ground water would need to be pumped in the area.

INTRODUCTION

Purpose

The Klamath Basin Water Supply Initiative is a joint study by the U. S. Bureau of Reclamation (USBR) and the Oregon Water Resources Department (OWRD) to identify opportunities to enhance water supplies in the Klamath Basin. The purpose of the study is to investigate options for increasing water supplies in the Klamath and Lost River Basins through development of the ground water resource in a selected area as a demonstration project.

Gates (2001) summarized the results of previous investigations of the geology and hydrogeology of the Klamath Basin and described the results of this joint study to October 2000. The report focused on the potential for ground water development at four areas of the basin which were considered for the demonstration project: The Ady District Improvement Company, the Shasta View Irrigation District, the Fort Klamath area and the Langell Valley area. The Shasta View Irrigation District was the site selected for the demonstration project.

Project work included water-level and geologic data collection at 41 field located wells in the Shasta View Irrigation District and surrounding area. In addition, a short-term aquifer test was conducted at the Silbernagel irrigation well within the district in the early spring of 1999. These work elements are summarized in the report by Gates (2001). A long-term aquifer test at the McVay irrigation well within the district was being planned at the time that report was completed. The long-term test was conducted beginning in May 2001 and data were collected through late October 2002. This report summarizes the results of the long-term test, draws conclusions about the ground water resource and makes recommendations regarding further development of the resource.

Background

The Shasta View Irrigation District (SVID) was selected as the preferred site for the ground water demonstration project for the following reasons:

1) The district has a pressurized pipe distribution system in place to deliver water to most of its customers. Injection of ground water into this distribution system could be possible without significant additional costs and at the same time losses due to canal leakage that would have been a factor at other demonstration projects would be avoided.
2) High production irrigation wells already existed within the district. These would allow for data collection during the subsequent investigations and could also be used to select potential areas where confidence would be relatively high that additional high production wells could be constructed.
3) The SVID water demand is large enough to allow a substantial test of the local ground water resource to be conducted, provided that sufficient well production could be obtained.

Following analysis of the data collected during the early part of the project, especially including the results of the short-term aquifer test conducted in the spring of 1999, a long-term test of one or more wells was planned as the next phase of work for the demonstration project. A long-term test would be able to stress a larger volume of the aquifer. This could document the presence of barriers to ground water movement, if any exist in the vicinity. Such a test would also assess the ability of the aquifer to recover through the non-pumping season.

The initial plans for a long-term test included the construction of one or more high production wells and one or more dedicated observation wells. The production well, or wells, would be equipped with appropriately sized pumps and the discharge would be plumbed to the SVID main line or a lateral as necessary. Therefore, the water produced could be put to beneficial use on any lands served by the distribution system. In addition to determining aquifer responses, the test design would also serve to determine how well the distribution system would respond to stress of the water being introduced at high-pressure. The intent of the observation well, or wells, was to allow installation of continuous recording water-level equipment.

These plans for a long-term test were discussed at public meetings in January and August 1999. The public response to the proposal to construct new production wells was quite negative, such that the original proposal was ultimately dropped. Instead, an alternate plan for pumping an existing well, or wells, for a long-term test was proposed. Following a review of several existing irrigation wells within the district, including the one previously tested, a well owned at that time by Ron McVay was selected for use during a long-term test. The well was selected because it is centrally located within the district and there are other wells located reasonably close that could be used as additional observation wells during the test.

Acknowledgements

The financial support of the U. S. Bureau of Reclamation, which funded the work through grant 1425-97-FG-20-15800, is greatly appreciated. Many local well owners provided access to their wells for data collection. In particular, Ron McVay allowed the use of his irrigation well for the test and also allowed an observation well to be installed on his property. The cooperation of the Shasta View Irrigation District and its president, Claude Hagerty, is appreciated. The district's engineer, Dee Jaspar, coordinated closely with Department staff and Bud Cook of the Bureau throughout the design and construction process. Fred Lissner provided guidance during all phases of the project and his review of the report drafts no doubt improved its readability.

GROUND WATER RESOURCES

Shasta View Irrigation District Setting

The Shasta View Irrigation District is an agricultural area in the northern portion of the Tule Lake Valley. The district is north of the town of Malin, and south of the topographic divide that separates the Poe Valley and the Lost River drainage basin from the Tule Lake Basin. The district supplies irrigation water for more than 4,500 acres of mostly potatoes, sugarbeets, alfalfa, and pasture grass. The district receives water from the USBR's D canal and uses about 12,000 acre-feet of water annually. The district supplies water to its users through a pressurized pipe system that normally operates at about 75 psi. The piped distribution system links the D canal to the district's reservoir located on the upland slopes immediately north of the district. Figure 1 shows the location of these features and the wells used for the long-term test.

The topography of the irrigated areas in the Shasta View district is gently sloped in the north and nearly level in the south part of the district. The elevation ranges from a low of 4070 feet next to the D Canal, up to 4240 feet along the northern border of the district. An exception is Turkey Hill, which reaches 4460 feet elevation. Elevations of the steep slopes surrounding the district show much greater variance, reaching 5391 feet on top of Buck Butte. Higher peaks and ridges occur to the west along Modoc ridge and to the east on Bryant Mountain. Historically, any surface water drainage from the Shasta View area flowed into Tule Lake. Prior to the reclamation project, the Tule Lake Basin was a naturally closed drainage system with the shoreline of Tule Lake occurring at the present elevation and position of the USBR's D Canal.

The climate for Shasta View is semiarid, with warm dry summers and cool wet winters. Generally, precipitation amounts increase in proportion to increased altitude. Therefore, the upland hills south and west of the district probably have proportionately higher precipitation amounts. A precipitation data collection site is located 5 miles southeast of Malin at an elevation of 4627 feet. Precipitation for the period of 1969 through 1999 shows an average of 13.86 inches annually (Gates, 2001).

Geology

Previous work on the geology and ground-water resource potential of the Shasta View district area is somewhat limited. Newcomb and Hart (1958) measured water levels and were also the first investigators to geologically map the area. They identified sedimentary strata of the Tertiary Yonna Formation, present within the trough of a synclinal fold. In the lower valley floor area they mapped sedimentary deposits of Quaternary alluvium.

Peterson and McIntyre (1970) mapped older Tertiary lava flows overlain by the Yonna Formation sediments and by younger, well-fractured Quaternary lavas. They stated that the overall thickness of the mid to late Tertiary and Quaternary volcanic flows and sediments of the Basin and Range province exceeded 10,000 feet. They mapped normal faults bounding both sides of Buck Butte and also along the steep slopes of the unnamed

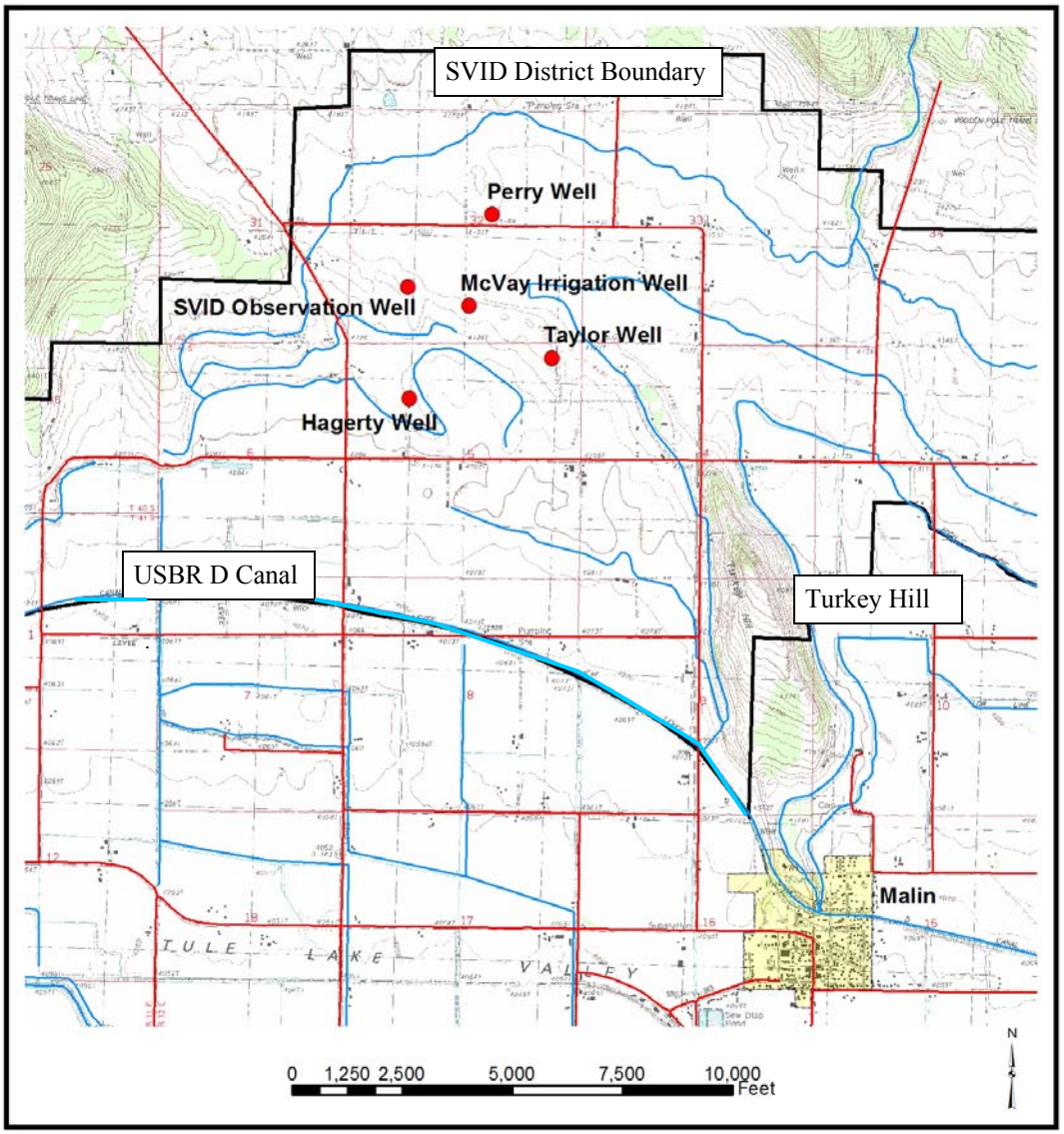

Figure1. Location of Shasta View Irrigation District including the aquifer test site and wells.

upland hills west of Harpold road. These faults appear to structurally control the upland topographic divide between the Poe Valley to the north and the Shasta View area. They mapped the lithology of these buttes as Quaternary-Tertiary basalt.

Veen (1981) studied gravity anomalies and their structural implications. She noted a positive gravity anomaly in the Shasta View area. This anomaly occurred over areas mapped as QTb (basalt flows and pyroclastics) on the geologic map of Peterson and McIntyre (1970). She stated that the QTb unit was not associated with any known volcanic vents, and the source and stratigraphic relationship of this unit is considered by Peterson and McIntyre to be an unknown mapping problem. She also stated that these basalt flows are associated with sections up to hundreds of meters in thickness (Gates, 2001).

The geochemical study by Mallin and Hart (1991) included a basalt sample from near the Shasta View area east of Malin which yielded an age of 4.98 +/- 0.22 million years. This analysis allowed for more accurate age association with the basalts of the bedrock uplands in the Shasta View area. Geologic mapping of the Bryant Mountain, Langell Valley, Malin and Merrill Quadrangles by the Oregon Department of Geology and Mineral Industries (Jenks, in press and Jenks and Madin, in press) will further refine the age, structural relationships and stratigraphy of rock units in the area.

Geology influences the regional ground water system. The geometry of the deep aquifer and its connection with recharge and discharge zones controls ground water flow in the area. Faulting can juxtapose low permeability rock against the aquifer or function as a primary conduit for fluid flow. It can also affect the position and distribution of zones of variable permeability produced by secondary mineralization. Understanding the stratigraphy and structural geology of the area is important for understanding the hydraulic characteristics of the basalt aquifer.

Ground Water Occurrence

The widespread occurrence of Basin and Range faulting in the Klamath Basin has partitioned the basin into many smaller subbasins. Peterson and McIntyre (1970) mapped a system of faults that extend between the southeast Poe Valley and the Shasta View area. Leonard and Harris (1974) and Gorman (1994) indicated that these geologic structures generally impact ground water flow more locally than regionally. They noted that ground water moves freely across fault zones in most areas, but some exceptions do occur.

During the first phase of this study, it was apparent that data were needed in adjacent areas in order to better understand ground water conditions in the Shasta View area. In the southeast corner of Poe Valley, north of the SVID, Leonard and Harris reported water level elevations that had dropped significantly due to pumping within a compartmentalized aquifer. A domestic well in this area was used for quarterly water-level measurements from 1963 through 1978. Seasonal fluctuations at this well were much greater than at other Poe Valley irrigation wells and the annual high water level declined after 1968. They attributed the water level decline in this area to be a localized

effect of the result of faults forming a narrow compartment corresponding to the boundaries for that segment of the southeast corner of Poe Valley. Ground water level elevations of the basalt aquifer in the southeast Poe Valley are generally about 90 feet lower than in basalt wells 1.5 miles to the northeast and northwest toward the central Poe Valley. The water level elevation at these southeast Poe Valley wells is similar to that measured at wells in Shasta View area. Therefore, these wells were included as part of the SVID study (Gates, 2001).

Forty-one wells, including five wells in southeast Poe Valley, were field located and used for data collection in the Shasta View area. Of the 41 field located wells, 33 penetrated Tertiary basalt. Many of these 33 wells penetrated multiple rock types, but if basalt (or lava) was identified in the well log at or below the measured static level, that was interpreted to be the primary aquifer. In May 1999, the water-level elevation ranged from 4021 to 4037 feet for wells that penetrate the basalt aquifer. The average elevation of the potentiometric surface for the basalt aquifer was about 4028 feet. The potentiometric surface appears relatively level over most of the area. It is not possible to determine the gradient locally unless well head elevations are more precisely determined. The relatively flat potentiometric surface suggests that the basalt aquifer has high transmissivity.

Four of the 41 measured wells in the Shasta View area are completed in the Tertiary continental sedimentary deposits. These wells show variable water level elevations. One of these, well KLAM 14829, is an irrigation well on the northern boundary of the district. Water levels in this well coincide with the static water elevations found in the Tertiary basalt aquifer. Here, the continental sedimentary deposit aquifer appears to be in hydraulic connection to the Tertiary basalt aquifer. The hydraulic connection is probably the result of well-fractured strata at depth and/or sufficiently permeable sandstones and cinders as is indicated on the well log. It is reasonable to conclude that there are likely other areas continental sediments are hydraulically connected to the Tertiary basalts (Gates, 2001).

However, this is not true everywhere, as is documented by two other wells (KLAM 15045 and KLAM 15047) in the eastern portion of the district that are completed in continental sedimentary rocks. They have water level elevations almost 100 feet above that of the Tertiary basalt aquifer. This suggests that the continental sedimentary unit can also act as a confining layer. Well KLAM 10462 in the southern part of the district demonstrates this characteristic. As reported by the driller, this well penetrated a water bearing zone in the continental sedimentary rocks with a static water level of 41 feet below land surface. The static level then dropped to 77 feet below land surface when the well penetrated into the underlying basalt aquifer. The final static water level is consistent with other measurements from the regional basalt aquifer, being at an elevation of about 4028 feet (Gates, 2001).

The thickness of the Quaternary alluvial sediments is uncertain in the area. In the study area, well KLAM 15067 penetrated 315 feet of clays without intercepting any basalt or coarse-grained sediments. About six miles south of the Shasta View District, the Tule Lake municipal well in California penetrates 800 feet of alluvium before reaching the

basalt aquifer (California Dept. of Water Resources). Four of the 41 measured wells are completed in alluvial deposits associated with the Quaternary sediments. The water level elevations measured in these wells are extremely variable. However, all of these wells have water levels elevated above that of the Tertiary basalt aquifer. This indicates a poor hydraulic connection with the underlying basalt aquifer, although some interchange likely exists. This issue will be discussed later in the report.

In summary, the primary aquifer in Shasta View area is the Tertiary basalt unit. Nearly all of the irrigation wells in the area penetrate these basalt strata. The continental sedimentary deposits yield water to wells in the Shasta View area but are not a good water producer. Locally, the continental sediments act as a confining layer for the Tertiary basalt aquifer at depth. The near-surface Quaternary sediments consist of sands, silts, and clays. The sediments are generally a poor water producing unit, but yield sufficient quantities of ground water for some domestic wells in the area. The upland areas of Tertiary basalt should readily receive recharge from precipitation provided fracture permeability exists. Hydrographs from wells near the upland areas north of the district distinctly show this seasonal recharge (Gates, 2001).

Figure 2. Hydrograph of McVay pumped well (KLAM 51602).

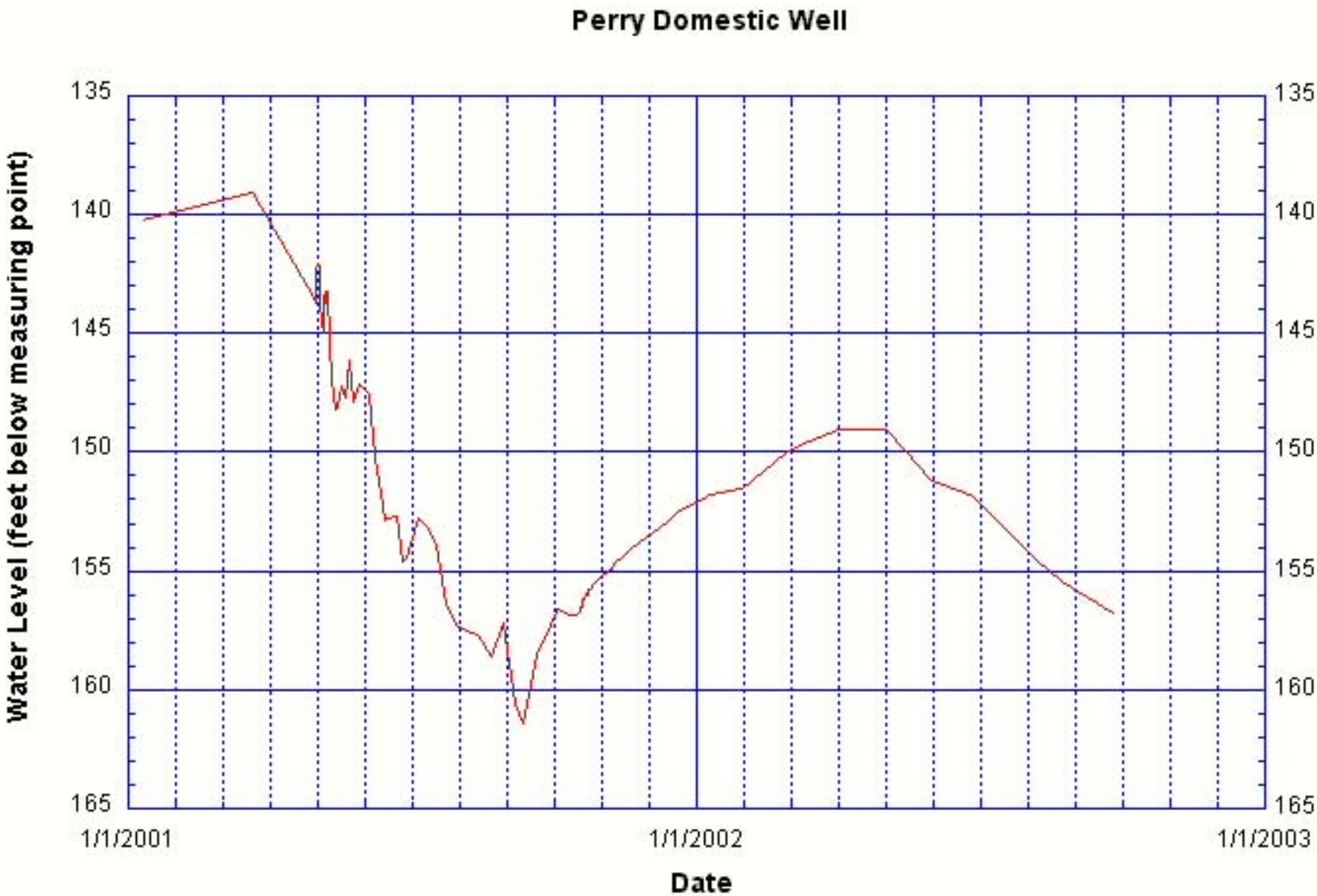

Figure 5. Hydrograph of Theresa Perry domestic well (KLAM 14834).

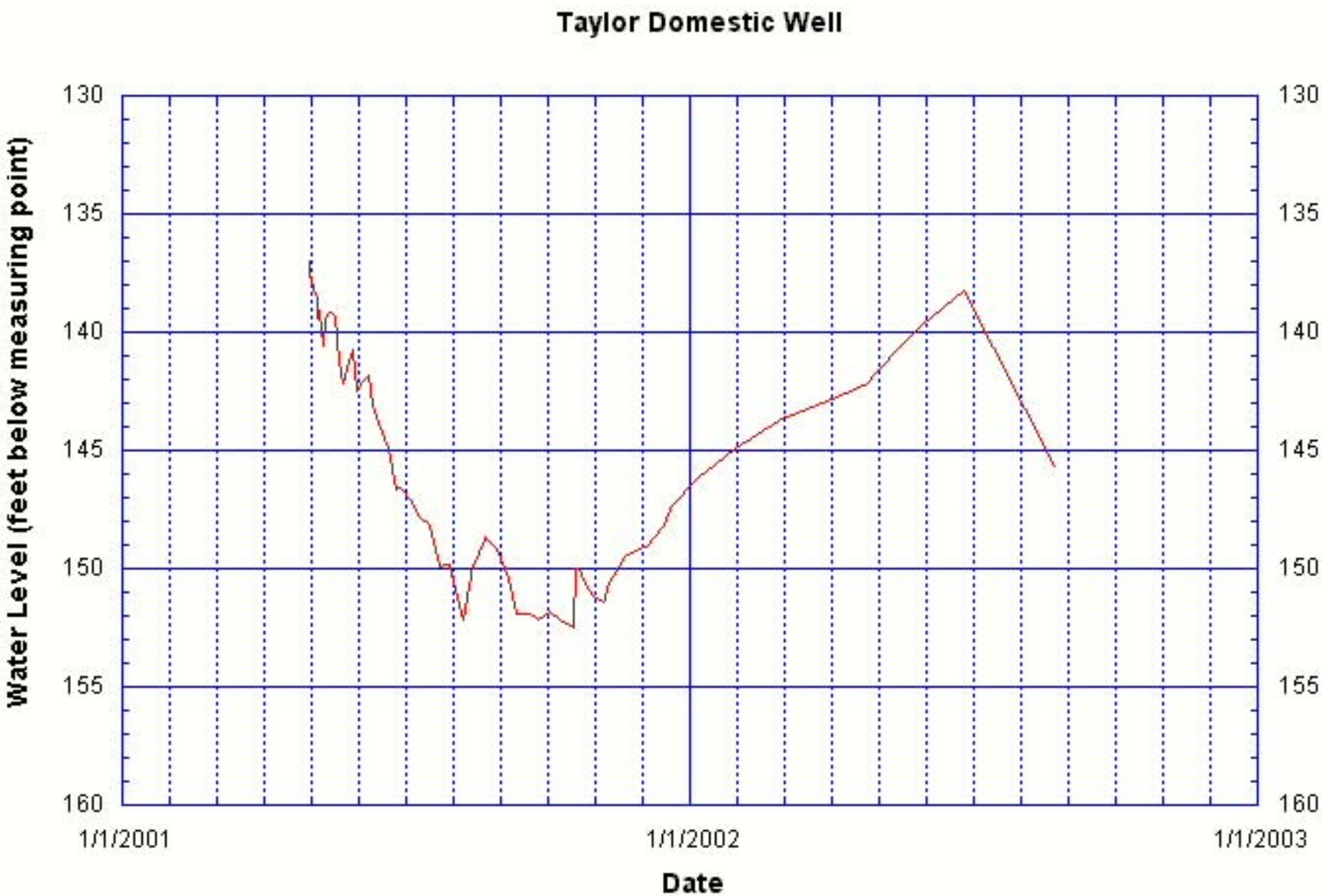

Figure 4. Hydrograph of Sherman Taylor domestic well (KLAM 15061).

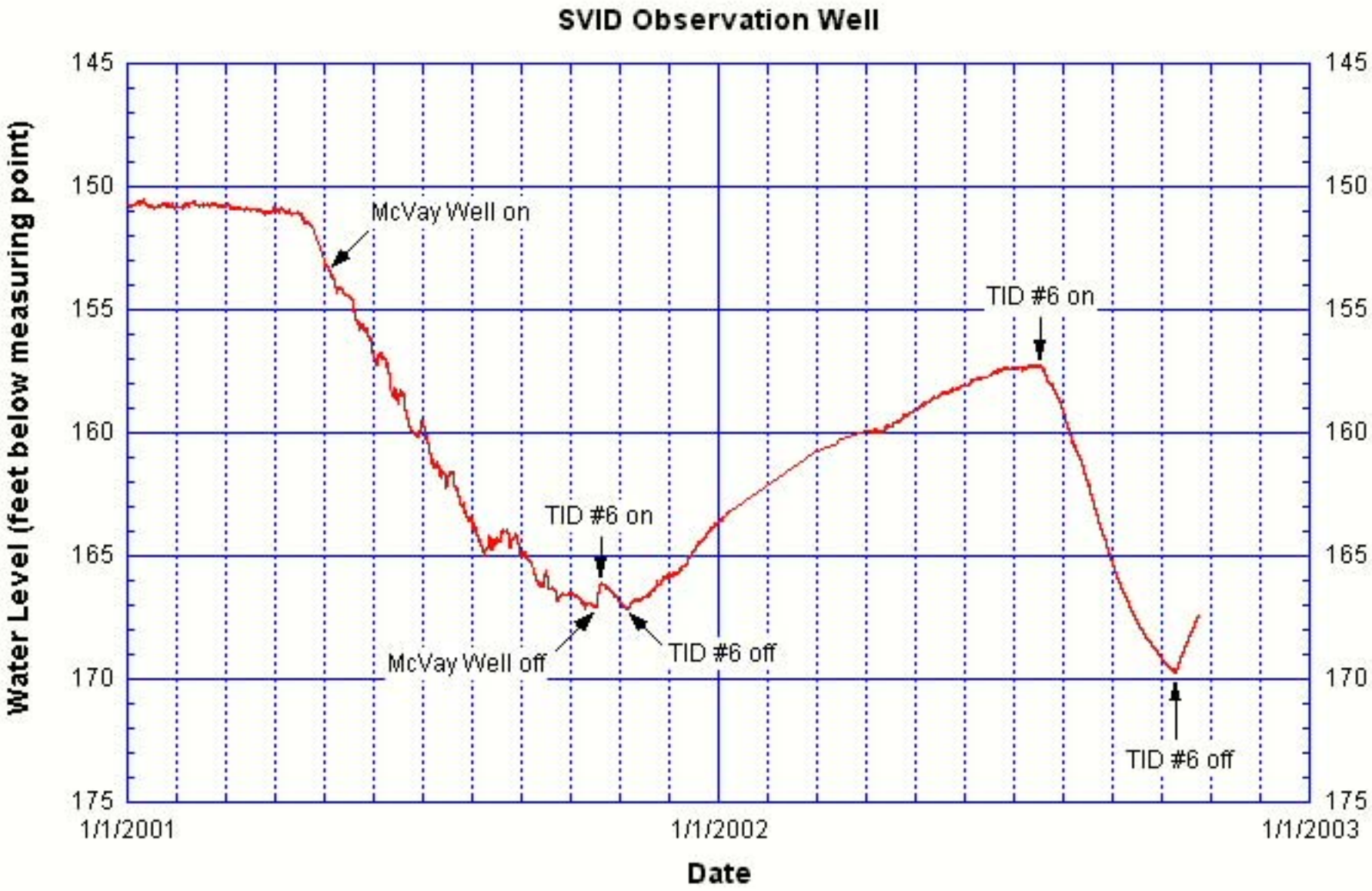

Figure 3. Hydrograph of SVID observation well (KLAM 52194).

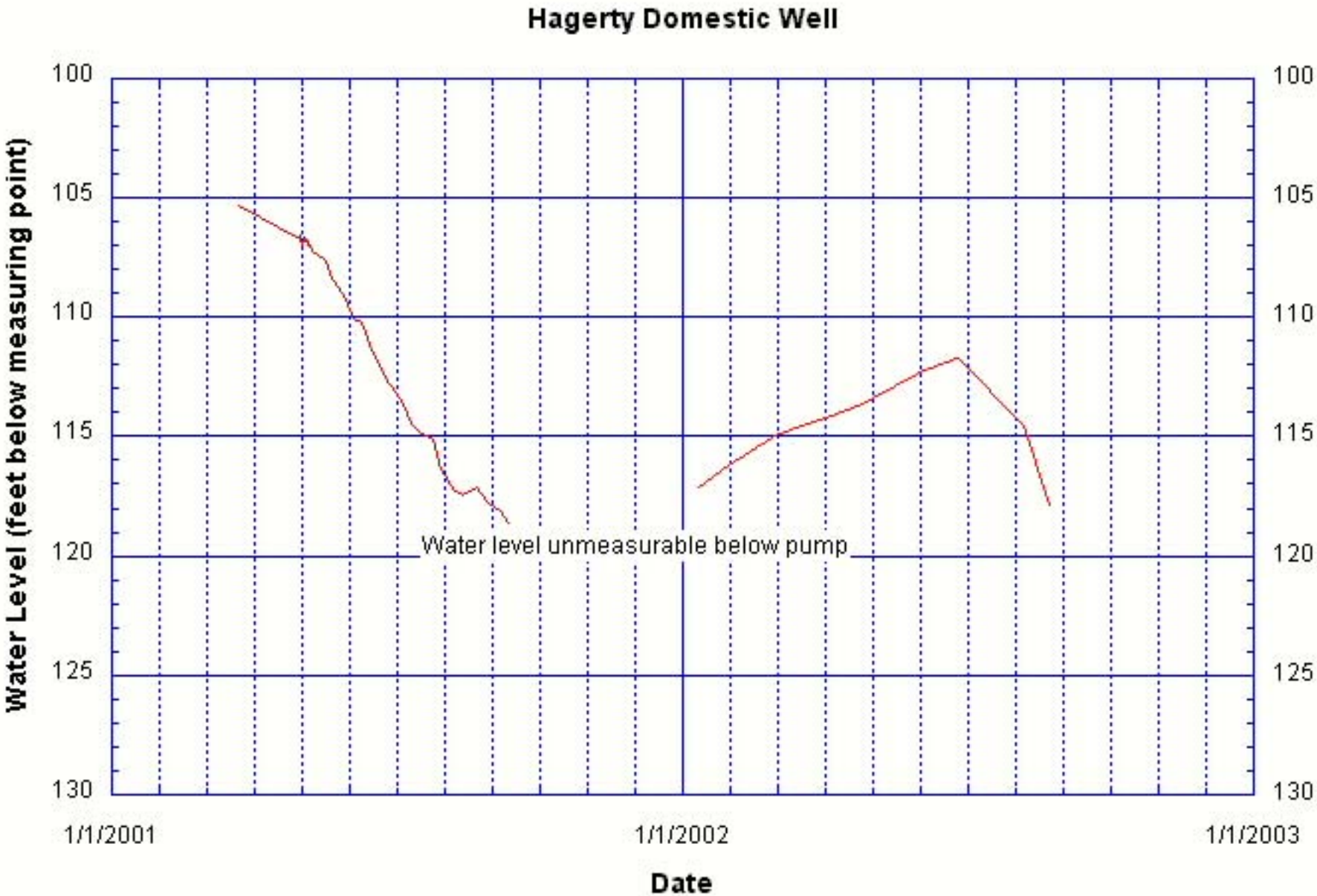

Figure 6. Hydrograph of Claude Hagerty domestic well (KLAM 52514).

Figure 2. Hydrograph of McVay pumped well (KLAM 51602).

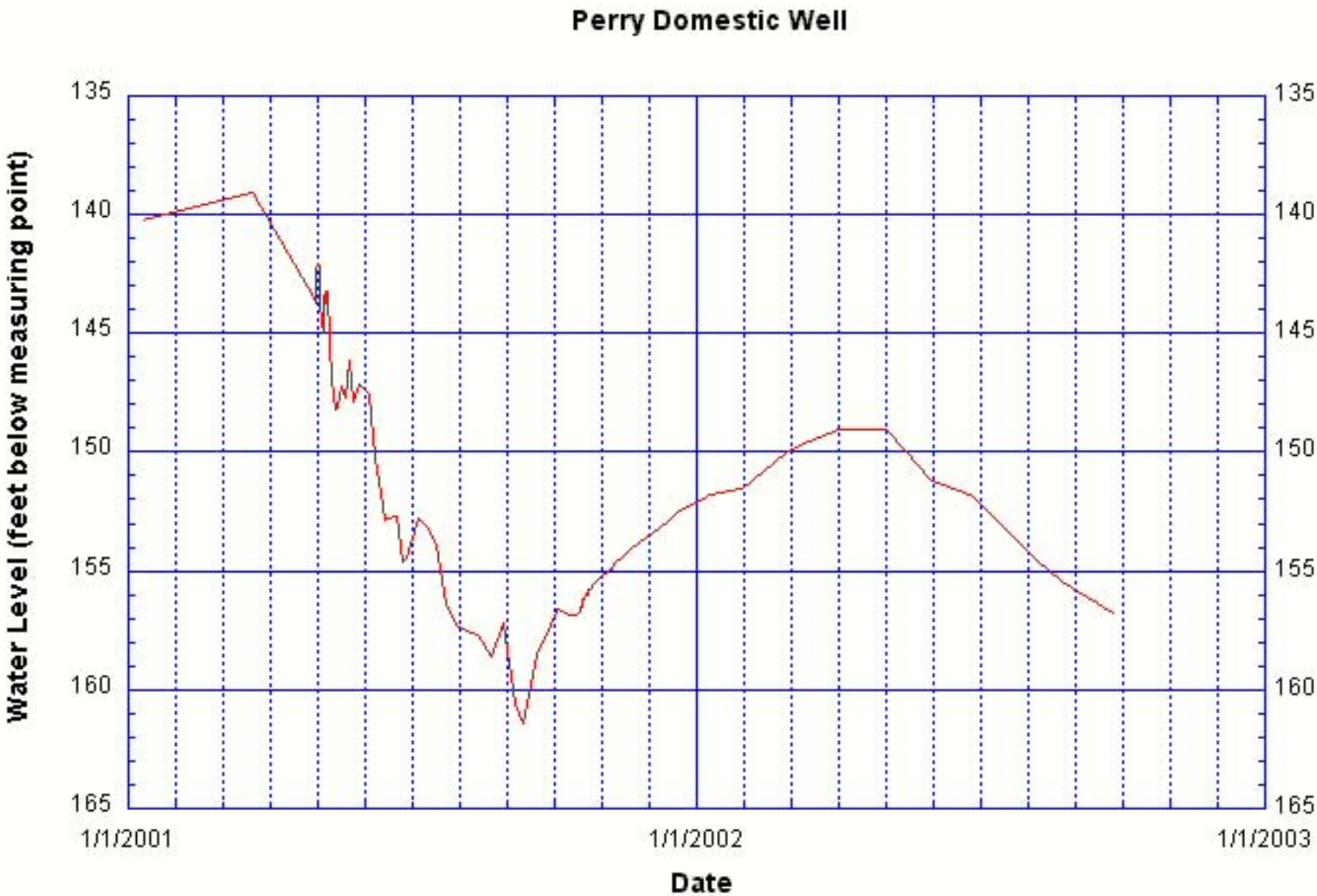

Figure 5. Hydrograph of Theresa Perry domestic well (KLAM 14834).

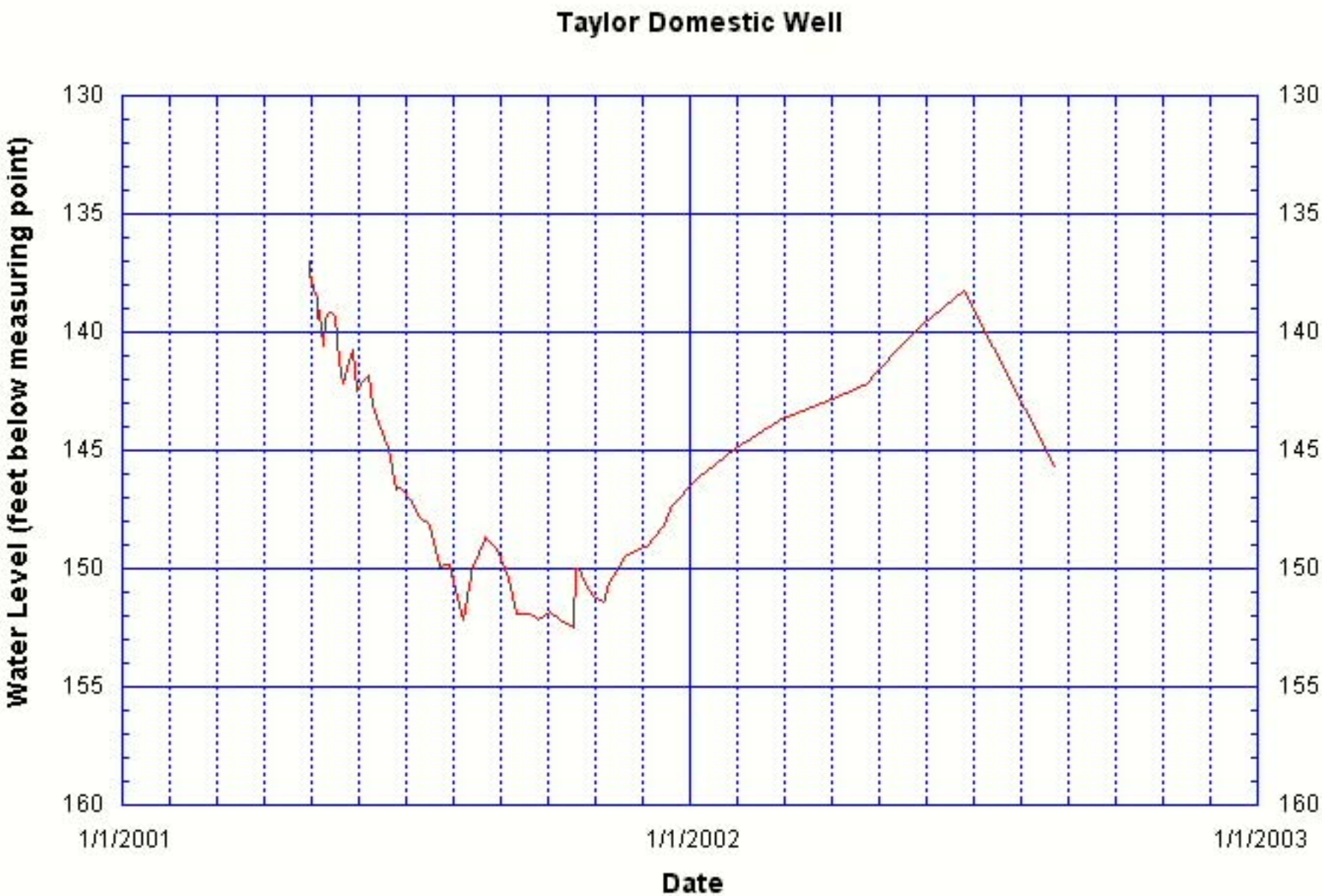

Figure 4. Hydrograph of Sherman Taylor domestic well (KLAM 15061).

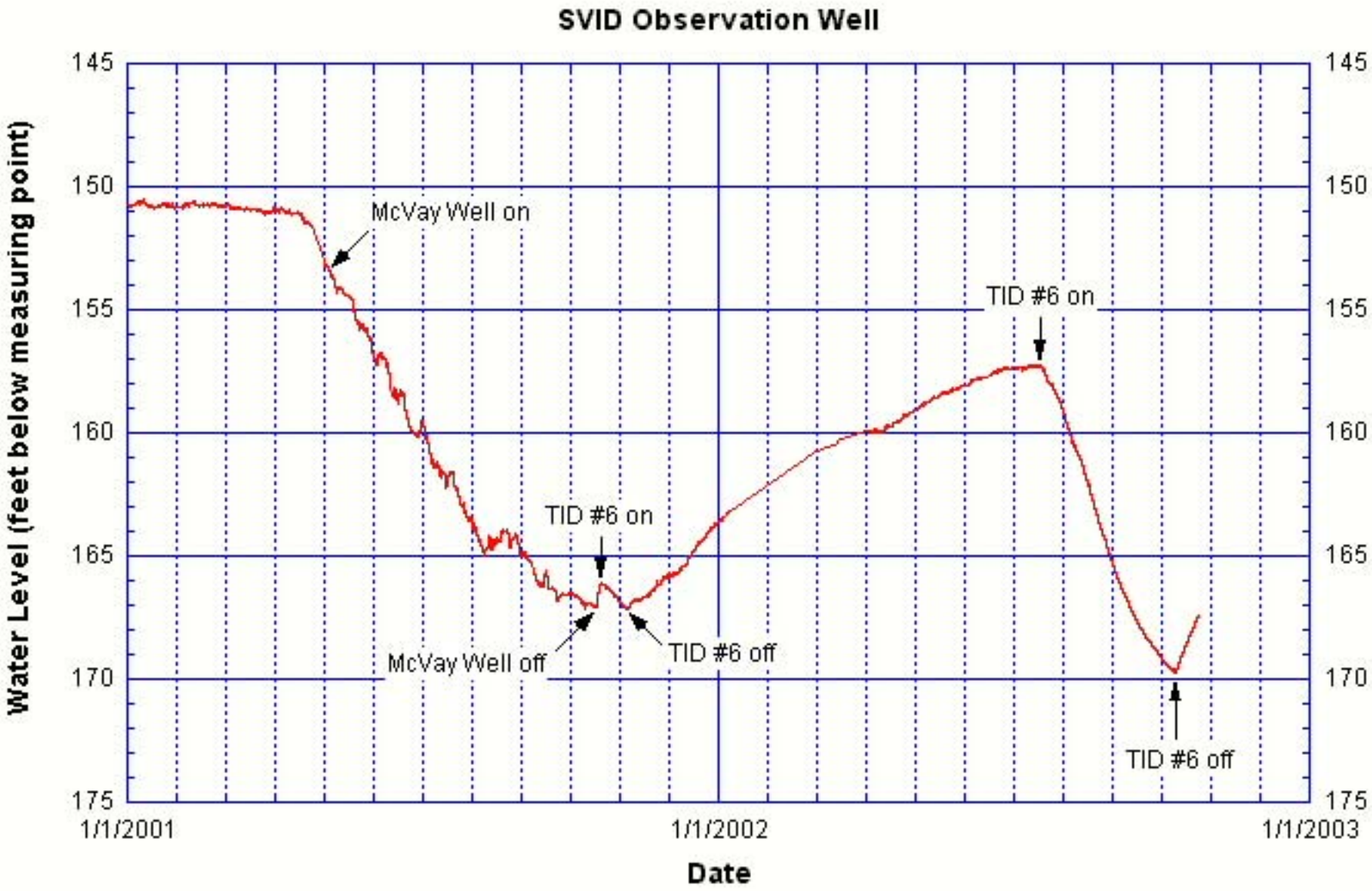

Figure 3. Hydrograph of SVID observation well (KLAM 52194).

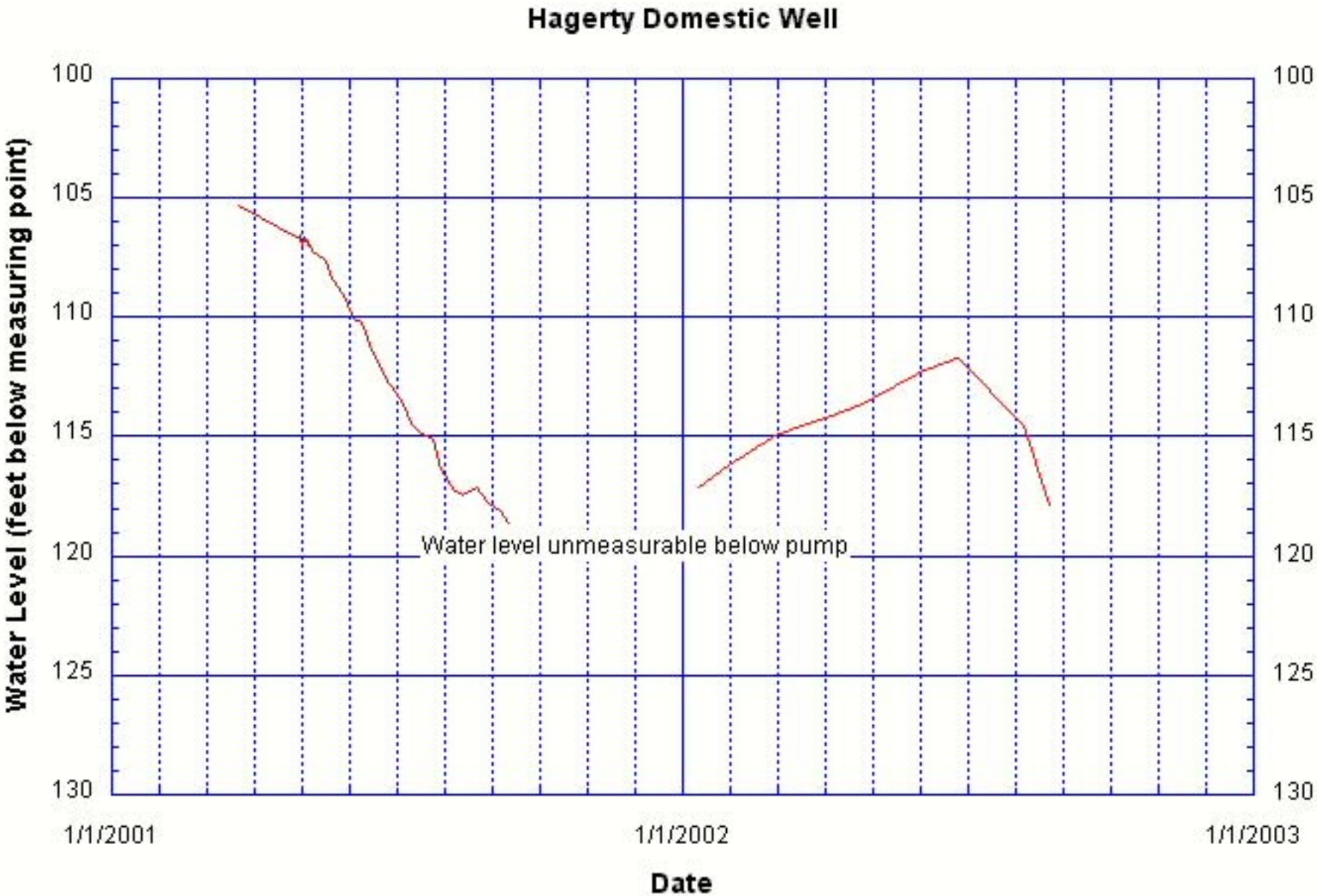

Figure 6. Hydrograph of Claude Hagerty domestic well (KLAM 52514).

AQUIFER TEST

Water Rights Issues

The OWRD does not require any water-use permit to pump water for a well or aquifer test, provided that the water is not put to a beneficial use. The long-term test contemplated injection of the water into the SVID main line, which would allow the water to be used, primarily for irrigation, on any lands served by the distribution system. Therefore, some type of permit was required to perform the test being planned.

A limited license was initially considered since the pumping phase of the test was planned for just one irrigation season. However, limited licenses cannot be issued for irrigation except under special circumstances. The only other option appeared to be to file an application for a permit to use ground water for supplemental irrigation of any lands within the district. Such an application (file G-15043) was filed with the Department in October 1999.

The district was interested in securing a quantity of water that would allow ground water use to meet its peak needs if surface water were not to be available. The SVID board therefore requested that the application seek that quantity of water from as many wells as were estimated to be necessary to produce it. Therefore, the application requests over 59 cubic feet per second (cfs) from up to 14 wells for supplemental irrigation of over 4700 acres. This request was accepted despite the fact that such quantities were well beyond the scope of the demonstration project and the planned long-term test. The advantage of this approach for the district was that if the long-term test produced favorable results, additional wells could be constructed without the need to apply for additional permits. It also secured a relatively early date of priority for the proposed use. A possible disadvantage was that it may have increased the local public mistrust of the SVID and its board, the USBR and the OWRD, because local residents fear interference with their existing wells. The issue of interference will be dealt with later in the report.

Several nearby well owners filed a protest to the proposed permit. This action served to prevent the issuance of a permit until the protest is resolved. A contested case hearing on the matter was held on July 29, 2002. The Administrative Law Judge who presided at the hearing issued a proposed order on December 6, 2002. The proposed order essentially approves the district's application with the conditions stated in the Draft Permit issued on March 20, 2001. If exceptions and arguments to the proposed order are not filed by December 26, 2002, a final order will be issued.

The permitting delay, as well as construction delays, prevented the long-term test from being conducted in the 2000 irrigation season, as originally planned. By spring of 2001 it was apparent that a permit was not likely to be issued to legally allow the planned district-wide irrigation use of the water produced during the test. However, low precipitation in the Klamath Basin in the winter of 2000 - 2001 resulted in the USBR not delivering surface water to most project lands, including those of the Shasta View Irrigation District, for most of the 2001 irrigation season. This action made it possible for the McVay well to be legally

used to pump ground water under an existing permit (G-13181) for supplemental irrigation of 120.7 acres.

In April of 2001, the Governor issued a drought declaration for Klamath County, as well as other parts of Oregon. This allowed the Department to issue Drought Emergency permits, which could be obtained in a relatively short time, allowing timely use of water until the end of October 2001. Mr. Claude Hagerty, president of the SVID, applied for and obtained a Drought Emergency permit (G-13976), which authorized use of the McVay well for irrigation of 438.0 acres of lands adjacent to the lands authorized under permit G-13181, which were also under lease to Mr. Hagerty. These two permits allowed the long-term test to be conducted at the McVay well. The well was pumped nearly continuously to irrigate these lands except for short periods of time when the water was not needed for irrigation. At those times, the water was pumped to waste into the idle SVID main line in order to maintain the relatively constant pump discharge desired during the test.

Well Histories

The pumped well (KLAM 51602) was constructed as an irrigation well for McVay Farms in July 1992 by Walter L. Wilson. It was reportedly cased and sealed to a depth of 19 feet, completed to a depth of 455 feet and penetrates primarily Tertiary basalt rocks from near land surface to the bottom (see Appendix A). The well was reported to produce 1473 gallons per minute with only 10 feet of drawdown. Figure 1 shows the location of this well within the district, as well as the other wells monitored during the long-term test.

Following agreement with the landowner, Mr. McVay, to use this well for the long-term test, a significant amount of engineering and design work was performed by SVID's engineering company, Dee Jaspar and Associates, Inc. The main distribution line of the district has been subject to frequent failures and the potential for water hammer and subsequent failure was a concern of the SVID board and of the engineer. The engineering work was necessary to ensure that the pumping system was properly designed to deliver maximum production while safely injecting the discharge water into the pressurized main line.

The preliminary design called for a minimum 200 horsepower vertical line shaft turbine pump to be installed at the well. Mr. McVay was concerned that this high capacity pump would have too much capacity to be easily used on his permitted acreage following the long-term test. He therefore requested that the pump have a variable speed drive installed. This would allow the user to adjust the speed of the pump motor, and therefore vary the discharge rate of the pump to suit the needs of the irrigation system in use. This request was approved, which ultimately added considerable expense and concomitant time delays to the project work.

Initial work at the well included removal of the existing pump to allow the well bore to be video logged and geophysically logged, including a directional alignment survey. This work revealed some unexpected results. The total well depth was found to be 411 feet, rather than the reported 455 feet, and only 11 feet of casing were installed. The well bore was also crooked, with a pronounced "dog leg" below a depth of about 250 feet. As a result of these

tests, the engineer was concerned that either the initially specified 260 feet of pump column needed to be modified or the well bore reamed and straightened.

The final installation included a 200 horsepower variable speed drive pump and associated electronic control panels. The pump includes 250 feet of column pipe and 16 feet of bowl assembly. Installation included both an airline to a depth of 250 feet and a dedicated PVC tube to a depth of 240 feet to allow access for measurement of water-levels. Approximately 1200 feet of 12-inch diameter discharge line were installed below grade to tie into the SVID main line to the east of the well site. The above grade portion of the discharge line included installation of an impeller type totalizing flowmeter. A 2000 gallon air chamber was also installed at the discharge line. It is designed to dampen both upsurges and downsurges in pressure within the discharge line and especially to prevent any downsurges from falling below atmospheric pressure, which could lead to pipe collapse.

In the spring of 2001, additional modifications to the pump controls and to the discharge system were required to allow the well to be used as a stand-alone system rather than injecting into SVID's pressurized distribution system. Due to the ongoing drought conditions, it was anticipated at that time that no USBR project water would be available to the district. Therefore, there would be no line pressure in the SVID main line, and the original pumping plant was designed to work against that line pressure. With modifications completed in late April, 2001, water could be pumped directly to lands covered by valid permits for supplemental irrigation.

The SVID observation well (KLAM 52194) was constructed in March 2000 by Stephen R. Hughes for the OWRD on property owned by Mr. McVay, approximately 1510 feet west of the pumped well (Figure 1). It is 447 feet deep and is cased and sealed to a depth of 58 feet (Appendix A). It was specifically constructed to allow water-level data to be collected prior to and during the long-term test. A shaft encoder and data logger were installed in the well and a weatherproof recorder shelter placed over the well head. These instruments are programmed to continuously record water-level data at prescribed intervals. Water-level data have been continuously recorded at this well since March 2000, with the exception of occasional periods of time when problems were encountered with the equipment or software. The Department plans to maintain the recording equipment at this well as one of a network of recorder wells established as part of an ongoing investigation of the ground water resources of the Upper Klamath Basin, in cooperation with the U. S. Geological Survey.

The Theresa Perry domestic well (KLAM 14834) was constructed in June 1974 by John A. Van Meter. It is 258 feet deep and is cased and sealed to a depth of 20 feet (Appendix A). It is 2145 feet north of the pumping well (Figure 1). This well was previously used as an observation well during the aquifer test conducted in the spring of 1999. It is an easy well to measure, and it also responded well during that test. These factors, along with its location, made it a high priority for selection as an observation well during this test.

The Sherman Taylor domestic well (KLAM 15061) was constructed in May 1973 by John A. Van Meter. It is about 2230 feet southeast of the pumping well (Figure 1). It is 201 feet deep and is cased and sealed to a depth of 20 feet (Appendix A). Mr. Taylor was interested in

having the well measured as part of the long-term test. However, the well head is about two feet below grade. Mr. Taylor therefore excavated to the well head and provided access to it for the duration of the test, despite its inconvenient location near a driveway. Following the measurement made on August 23, 2002, he indicated that he would soon rebury the well head. At some point during the drawdown portion of the test, he reported that he added five feet of pump column as a result of having pumped air. He reported no further problems with the well following that work.

The Claude Hagerty domestic well (KLAM 15062) was constructed in 1954 by E. E. Storey. It was reconditioned in October 2000 by Larry G. DeSpain. The reconditioning log (KLAM 52514) indicates that the original well, reportedly completed to a depth of 167 feet, had filled in with sand and broken basalt up to a depth of 114 feet. At that time, the well was cleaned out to a depth of 125 feet and a 4-inch diameter perforated liner was installed and the annular space gravel packed (Appendix A). This well is about 2505 feet southwest of the pumping well (Figure 1).

Test Methodology

The final installation, calibration and testing of the new variable speed drive and well pump at the McVay well were completed on April 25, 2001. The successful test allowed Department staff to schedule the personnel needed and coordinate the beginning of the long-term test with Mr. Hagerty, who was at that time interested in irrigating his crops as soon as possible. On May 1, 2001, staff installed electric water level measuring tapes at each well, with the exception of the SVID observation well, and began to collect water level data prior to the test. The electrical contractor provided information on the proper start-up, restart and shut down procedures for the well pump.

On the morning of May 2, 2001, the data logger previously installed at the SVID observation well was downloaded and reprogrammed to record water-level data at 15-minute intervals, rather than at the two-hour intervals used prior to that time. The equipment is currently continuing to record data, but for the purpose of this report, only those data collected up to the most recent download of the recorder, on October 25, 2002, are presented here.

A staff person was assigned to the pumped well and each observation well, again with the exception of the SVID observation well, to manually measure and record water-level data during the early drawdown portion of the test. In addition, the flowmeter at the pumped well was read to record the pumping rate. Mr. Hagerty began the pump start-up sequence at 11:00 a.m., but due to a programmed delay, actual pumping did not begin until 11:02 a.m.

Water-level measurements were made at frequent intervals during the early part of the test, when water levels are expected to change most rapidly. After four hours of pumping, measurements were required at less frequent intervals. At that time, two staff persons were released and the remaining two continued to collect water-level data around the clock until the early afternoon of May 4, 2002. After that time, one staff person collected data at increasingly less frequent intervals for the remainder of the drawdown portion of the test. Pumping and water-level drawdown data are presented in Appendix B.

In addition to the manual water-level measurements being made, the SVID observation well was checked regularly to ensure that the recording equipment was working properly and to occasionally download the data logger. As a result of the drought conditions, other nearby irrigation wells were expected to be pumping during the test period. Therefore, these wells were observed whenever the test site was visited to note whether or not they were pumping. Several nearby well owners were requested to keep records of when they operated their well pumps, but for the most part, owners kept few records.

Mr. Hagerty was able to pump the well more or less continuously during the drawdown phase of the test. The well pump tripped off several times in May and early June due to high temperature in one of the power panels. This problem was traced to a clogged filter at one of the cooling fans. Replacement of the fan and filter assembly rectified the problem. Mr. Hagerty also reported that the pump was shut down for periods of time on September 10 and 16, 2001, due to lightning strikes in the area. He stated that water was occasionally pumped into the SVID main line at times when his irrigation requirements were less than usual.

As the end of the irrigation season approached, Department staff coordinated with Mr. Hagerty to schedule the recovery portion of the test. The pump was shut off at 11:00 a.m. on October 18, 2001. Four Department staff persons were again assigned to the pumped well and three of the observation wells to manually measure and record water-level data during the early portion of the recovery test. Data were collected at a schedule similar to that of the early drawdown phase of the test. After four hours, two staff persons were released and the remaining two continued to collect data until the afternoon of October 20, 2001. Following that time, one staff person collected the remaining data during the recovery portion of the test.

Recovery data collection continued through the winter of 2001-2002 and nearly all of the 2002 irrigation season. A final round of water-level measurements was made at the wells on October 25, 2002. Water-level data collected during the test are presented in Appendix B, except for data collected at the SVID observation well. The file of downloaded water-level data for that well includes numerous records and is available at the Department or upon request.

ANALYSIS AND RESULTS

Aquifer Characteristics

At the end of the pumping period, the McVay well had pumped a total of 313,915,000 gallons (963.37 acre-feet) of water. The average pumping rate was approximately 1,290 gallons per minute. The pre-pumping water level at this well was 146.4 feet below the measuring point and the deepest water level prior to the pump being shut down was 163.4 feet. Therefore, the water level drew down 17 feet, which results in a specific capacity of nearly 76 gallons per minute per foot of drawdown after 169 days of pumping. All of the other wells monitored during the test also responded to the pumping. Figures 2 through 6 are hydrographs of the pumped well and four observation wells, which show how water levels at these wells varied through time during the long-term test. Key events during the test are also identified on figure 3.

The most important hydraulic characteristics of the aquifer that are determined through analysis of aquifer test data are transmissivity (T) and coefficient of storage (S). Transmissivity is a term that generally describes how easily ground water moves through the aquifer. More specifically, it is the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is usually expressed as either gallons per day per foot (gpd/ft.) or cubic feet per day per foot, which reduces to $ft.^2$/day. The coefficient of storage is the volume of water an aquifer releases from (or takes into) storage per unit surface area per unit change in head (water level). Based on analysis of data collected at a previous aquifer test in the vicinity, it was expected that the T would be moderately high, 140,000 to 200,000 gpd/ft. or higher, and that the S would range from 0.0003 to 0.01, which is indicative of confined to semiconfined aquifers.

The analytical approach began by checking the water-level data collected at the wells for accuracy and entering those values into a spreadsheet. These data are presented in Appendix B. This provided the ability to quickly calculate additional parameters, such as drawdown, residual drawdown and recovery, from the raw water-level and time data. Aquifer characteristics (T and S) were calculated using graphical plots of these parameters. The primary method of analysis used was the Cooper-Jacob modified non-equilibrium method, in which drawdown, residual drawdown or recovery is plotted versus log-time. Under ideal conditions and after sufficient time of pumping or recovery, data plot along relatively straight lines using this method. The slope and intercept of a line, or lines, plotted through the data are then used to calculate T and S.

Unfortunately, ideal conditions were not in evidence during the long-term test. This required that analysis of data collected very early after the pump turned on or off, during which time the Cooper-Jacob method does not apply, be accomplished with the use of other analytical methods. Such early data were analyzed using the Theis non-equilibrium method. For the remaining data, the Cooper-Jacob technique was appropriate.

As a result of drought conditions in 2001, there were additional pumping stresses placed on the aquifer by nearby irrigation wells. The intermittent pumping of these wells caused the water levels to respond at the long-term test well and observation wells. Therefore, the analytical plots of drawdown are overprinted by these pumping impacts, resulting in them being rather "noisy" with few straight segments. As the pumping period progressed, impacts of additional and more distant wells were seen at the test wells. This is especially evident as the State of California constructed and test pumped new wells for the Tulelake Irrigation District (TID) just across the state line. This issue will be discussed in greater detail later in the report.

In general, the influence of the nearby pumping wells resulted in analytical plots having increasingly steep drawdown slopes as time progressed during the pumping period. The total drawdown at all of the test wells was several feet greater than it would have been at the end of the pumping period with only the McVay well being pumped. Therefore, the values calculated for transmissivity are likely to be more accurate using the early portions of the data plots, in which the influence of other pumping wells is minimized. The following table summarizes the range in values for transmissivity and coefficient of storage calculated using early drawdown data at the test wells. Use of later drawdown data results in smaller values for transmissivity which are not believed to be representative because they are calculated using data more heavily impacted by pumping of other wells.

Table 1. Hydraulic Characteristics Derived from Early Drawdown Data.

Well Name	Transmissivity (T, in gpd/ft.)	Coefficient of Storage (S)
McVay Well	92,000 to 330,000	Not Applicable
SVID Observation Well	168,000 to 448,000	0.0314 to 0.0643
Taylor Domestic Well	94,600 to 425,700	0.0021 to 0.0079
Perry Domestic Well	71,000 to 340,500	0.0033 to 0.0177
Hagerty Domestic Well	221,000 to 569,500	0.0396 to 0.0531

Analysis of water-level recovery data following pump shut off is often more straightforward than is analysis of drawdown data. This is because the water levels are not influenced by variations in the discharge rate of the pumped well and by intermittent nearby pumping, which typically influence the drawdown data. In an effort to collect a cleaner set of data following shut-down of the pump, Department staff worked with Mr. Hagerty to continue pumping until most other nearby irrigation wells had already been shut off for the season. Therefore, the McVay well was pumped until October 18, 2001, approximately two weeks or more after the nearest irrigation wells were shut off. Unfortunately, the recently completed Tulelake Irrigation District (TID) Well #6 was pumped at a rate of about 5,300 gallons per minute beginning on October 19, 2001 and continued pumping until November 5, 2001. Interference at the test wells caused by this pumping makes analysis of the recovery data less straightforward and less accurate.

The pumping of the TID well #6 had a profound effect on water levels at the wells monitored for the long-term test during and following the period of the TID pumping. Water levels at the test wells began to be influenced shortly after this well was turned on. Except for the Perry domestic well, which is most distant from the TID well, water levels ceased to recover

and subsequently declined until the TID well shut down. At the Perry well, recovery continued, but at a reduced rate. The water level at the Hagerty domestic well was not measurable after September 21, 2001, because the level was at or below the top of the pump. However, the well was still capable of producing water adequate for domestic needs until October 25, 2001, when it was no longer able to produce water as a result of additional drawdown caused by the TID well. The Hagertys were required to use an alternate source of water until December 1, 2001, 25 days after the TID well was shut off, by which time sufficient recovery had occurred that their domestic well was again able to produce water.

The data plots of the recovery portion of the long-term test include significant portions that are unsuitable for analysis by graphical methods. The values calculated for transmissivity and coefficient of storage are more accurate using the very early portions of the data plots, prior to the time that the TID well was pumped. The late recovery data are impacted by other factors that result in values for T and S which may not be representative of actual aquifer characteristics. The following table summarizes the values for T and S calculated using early recovery data at the test wells. Since no early recovery data are available for the Hagerty domestic well, no analysis was performed using data collected at that well.

Table 2. Hydraulic Characteristics Derived from Early Recovery Data.

Well Name	Transmissivity (T, in gpd/ft.)	Coefficient of Storage (S)
McVay Well	144,300 to 150,700	Not Applicable
SVID Observation Well	217,400 to 248,800	0.0112 to 0.0142
Taylor Domestic Well	135,000 to 302,000	0.0010 to 0.0015
Perry Domestic Well	164,000 to 358,000	0.0119 to 0.0159

In summary, the results of the test analysis indicate that the transmissivity calculated from drawdown data collected at the pumping well and the four observation wells ranges from about 71,000 to 569,500 gpd/ft. Transmissivity calculated from recovery data display a range that is narrower, being about 135,000 to 358,000 gpd/ft. This may be due in part to the fact that only very early recovery data, prior to the time the pumping influence of TID well #6 was detected at the wells, were used for analysis. The coefficient of storage calculated ranges from 0.0013 to 0.0643, which is expected of semiconfined to unconfined aquifers. The range of values for both T and S is not unusual and reflects the variability of aquifer conditions from place to place.

These results compare reasonably well with those obtained by analysis of data collected during a short duration (70.5 hours) test conducted at a nearby well in 1999. Excluding the results from the most distant observation wells, in which anomalously high values of transmissivity were calculated, the transmissivity ranges from about 120,000 to 205,000 gpd/ft. and the coefficient of storage ranges from 0.0003 to 0.01. Using the results from both aquifer tests, the average transmissivity is about 200,000 gpd/ft. and the average coefficient of storage is about 0.01.

Using these values for T and S, the following table predicts drawdown at various durations of pumping and distances from a well pumping 2,000 gpm continuously. It should be noted that the predicted values are smaller than were measured during the long-term test. As stated

earlier, the measured drawdown was greater than it would have been with only the McVay well pumping. It is not known with certainty, but it is estimated that 30 to 50 percent of the measured drawdown is the result of other nearby wells pumping during the long-term test. Alternately, the discrepancy may be explained by variations in the coefficient of storage or transmissivity from the average values used.

Table 3. Projected Drawdowns at Constant 2,000 gpm Pumping Rate.

Days of pumping	Distance = 1,000 feet	Distance = 1 mile	Distance = 3 miles
30	5.96 feet	2.24 feet	0.37 foot
90	7.21 feet	3.43 feet	1.16 feet
180	8.01 feet	4.21 feet	1.82 feet

SVID Ground Water Right

The proposed final order for the SVID water right application, G-15043, authorizes pumping of 59.2 cfs from up to 14 wells. There is some justifiable concern as to what impact the pumping of these proposed wells would have on existing wells within the district. The above table can be used to approximate the drawdown resulting from multiple wells pumping, since drawdown impacts are additive. However, it does not easily convey what the potential maximum drawdown, or mutual interference, is likely to be at an unpumped well located within the center of a well field of 14 pumping wells. This was calculated by simulating a well field closely based on the proposed locations for the 14 wells listed in the SVID water right application, each pumping 1,900 gpm continuously, which approximates 59.2 cfs. The same average values for T and S as above were used, and the aquifer is assumed to be homogeneous and isotropic. The estimated drawdown after 30, 90 and 180 days of pumping is about 28.4, 40.8, and 50.9 feet, respectively.

The above estimates are likely to be conservatively large and only apply to the central part of the district. Based on past average annual use of about 12,000 acre-feet of project water, the average pumping rate is likely to be less than 59.2 cfs. Nonetheless, the implications of these estimates are that existing domestic and irrigation wells, which penetrate the Tertiary basalt aquifer, would experience greater seasonal water-level fluctuations if the district were to completely develop the ground water resource as proposed in the water right application. An unknown number of area wells, including at least two domestic wells monitored during the long-term test, would need to be deepened, replaced or have well pumps lowered, whichever is appropriate, in order to maintain the customary supply of water.

The water-use permit, if issued, will include a comprehensive water-level measurement condition that may result in regulation of water use if any of several water-level decline or interference triggers are exceeded. The condition language pertaining to pumping impacts states that regulation of water use is possible if that use causes hydraulic interference leading to a decline of 25 or more feet in any neighboring well with senior priority. If that same interference limit is applied to the SVID permit, it appears likely that this particular trigger could be exceeded, especially in the central part of the district. Therefore, it is appropriate that the applicant consider this information, so that the final configuration and operation of

the proposed well field can either minimize hydraulic interference or accommodate reduced pumping rates as may be necessary to comply with the permit condition.

Additional Findings

Two additional goals of the long-term test were stated at the beginning of this report. One of them was to determine whether barriers to ground water movement could be documented in the area. Analysis of data collected at the 1999 aquifer test at a nearby well (KLAM 10454) suggested that a ground water barrier or low permeability zone may exist between the pumped well in that test and two observation wells to the north. The long-term test would stress a larger volume of the aquifer, which, under ideal conditions, would have resulted in data that should more clearly document the presence of any such barriers. Due to the mutual interference of multiple wells pumping during the drawdown phase of the long-term test, boundary effects, if present, cannot be detected in the data.

The recovery phase of the test also did not disclose any obvious local ground-water flow barriers. However, the rate of water level recovery at most wells increased in middle to late April of 2002 (see figures 2 – 6). This response suggests that there is a local source of recharge to the basalt aquifer. The timing closely corresponded to the release of Klamath project water into local canals and to the beginning of the 2002 irrigation season. Therefore, canal leakage, possibly in combination with local application of water for irrigation, is one important source of recharge to the basalt ground water system in the area.

The Theresa Perry well did not exhibit the same response to the beginning of the irrigation season, as did the other wells. As was noted earlier, this well also did not respond nearly as much to the pumping of the TID well, as did the other wells monitored during the test. This was noted again late in the recovery phase of the test when, on July 19, 2002, the TID well #6 began pumping and the water level trend at the Perry well changed very little (figure 5) in comparison with the other monitored wells. Jenks and Madin (in press) locate a normal fault trending northwest-southeast along the north side of the low ridge at the site of the long-term test. The Perry well is north of this fault and all other wells monitored during the test are on the south side of the fault. It is therefore speculated that this particular fault may cause a permeability change in the basalt. The impacts of ground water pumping on one side of the fault are dampened at wells on the opposite side.

Another goal of the long-term test was to assess the ability of the basalt aquifer to recover through the non-pumping season. None of the wells monitored during the test showed water level recovery up to the pre-test levels by the beginning of the 2002 irrigation season (see figures 2 – 6). Most irrigation wells in the area, except for those outside the district, did not pump during the 2002 season. This allowed water level recovery to continue at most wells up to the time that TID well #6 began pumping on July 19, 2002. The Perry well recovered until April 2002, after which time the water level declined, likely in response to pumping by out-of-district irrigation wells to the northwest.

The water level at the Perry well recovered to a level about 6.7 feet lower than it was at the time the McVay well began pumping. The recovery of the other monitored wells was greater,

ranging from about 1.2 feet below the pre-test level at the Taylor well to about 5.0 feet below the pre-test level at the Hagerty well. The shape of the hydrographs for the monitored wells (figures 2 – 6) suggests that recovery to pre-test levels or higher would likely have occurred by late 2002 to early 2003 in the absence of significant pumpage in the area during the 2002 irrigation season.

The recovery response of an aquifer following a prolonged period of pumping is dependent upon several factors. These include the local hydraulic properties of the aquifer, proximity to recharge and discharge areas and availability of recharge. Ultimately, precipitation is the source of all recharge to aquifers. For the 2001 – 2002 water year, precipitation in the Klamath Basin was at or above normal levels until about February 2002, but fell and remained below normal for the balance of the year. It is unknown how much of an effect this one year of below normal precipitation had on the rate and magnitude of water-level recovery at the wells being monitored.

The basalt aquifer appears to require greater than one non-irrigation season to completely recover from continuous pumping of the cumulative magnitude experienced during the 2001 irrigation season. This implies that annual pumpage for irrigation would likely result in annual water level declines. The continued development of the basalt ground water resource for irrigation in the Shasta View area should therefore proceed with caution. Water level monitoring should continue in the area and any new water-use permits should likely include conditions to monitor water levels and limit excessive water level declines. In the long term, ground water may be better reserved for a supplemental supply to be used in years when surface water is not available and allowed to recover in year of normal or above normal precipitation.

Impacts of Drought and Local Pumping

Water level measurements were used to construct hydrographs of five additional Shasta View area wells. Figure 7 shows the location of these wells, each with its respective well log ID number. The hydrographs for these wells, figures 8-12, display the water level trends that were observed through the period of record. These hydrographs display water level fluctuations through time. Water level changes are the result of recharge to and discharge from the aquifer. The primary components of recharge are infiltration of precipitation, irrigation return flows, and surface water leakage through canals. The major source of discharge is ground water pumping. Discharge also doubtless occurs to surface water, but the location and rate of that discharge is not currently known. During the drought of 2001, the combined effect of well below average precipitation and curtailment of normal surface water irrigation deliveries resulted in a much lower than normal amount of recharge to the basalt aquifer. Emergency irrigation permits issued for ground water pumping increased the amount of ground water discharged from the aquifer well above the quantity that would be withdrawn during a normal year.

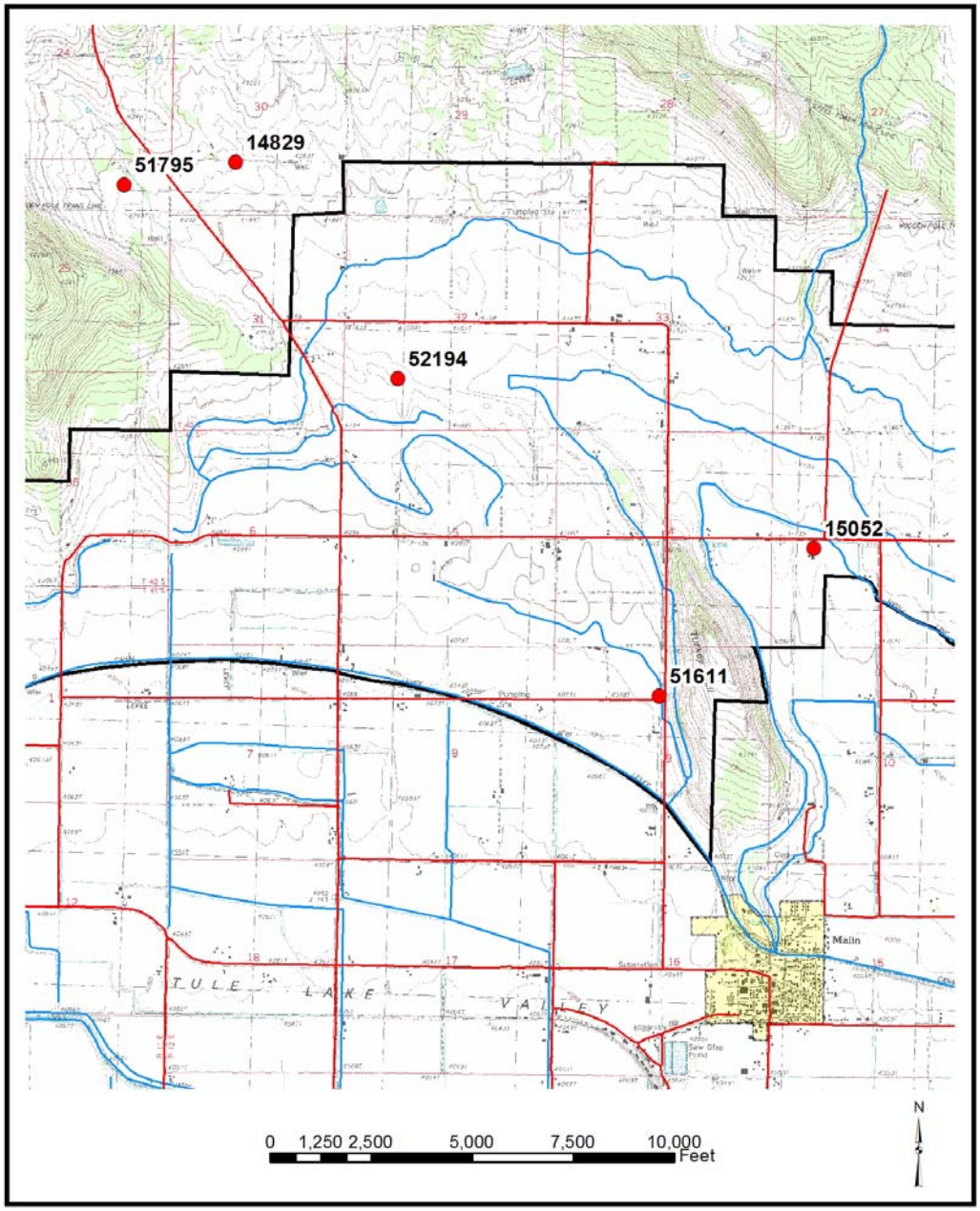

Figure 7. Location of selected other wells.

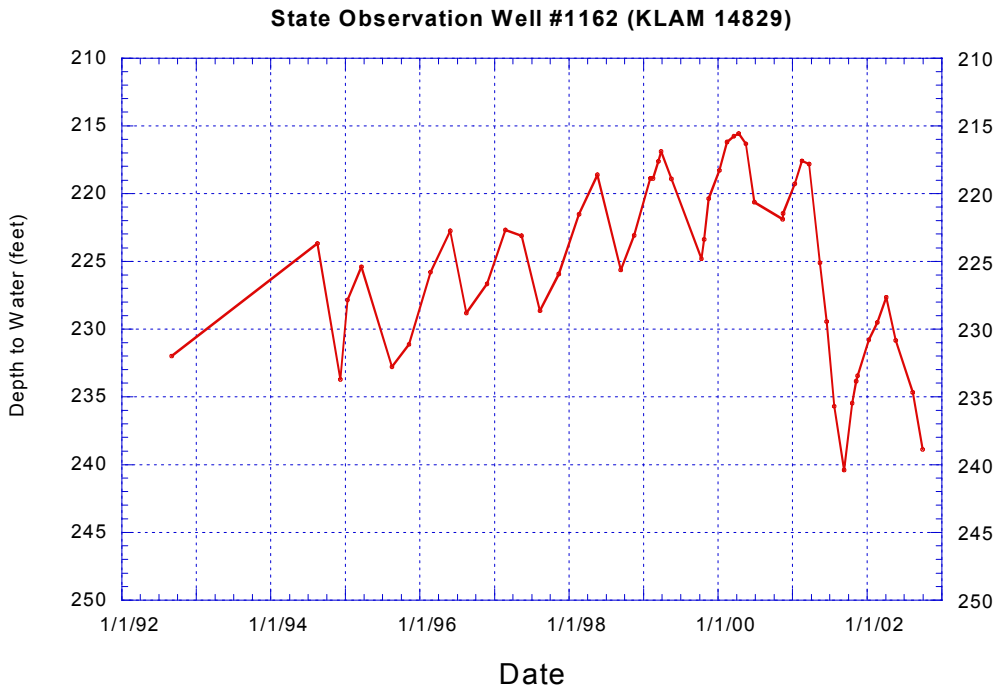

Figure 8. Hydrograph of State Observation Well #1162 (KLAM 14829).

Well KLAM 14829 is State observation well #1162. This well has been on a quarterly measurement schedule since 1994. This well is 1.5 miles northwest of the McVay pumping well and 5 miles north of the state line. It is hydraulically connected to the basalt aquifer at depth. Figure 8 is the hydrograph for this well. It shows seasonal water level fluctuation, with the high levels occurring in the spring from seasonal precipitation, and lower water levels occurring in the late summer or fall as a result of irrigation pumping. Comparing springtime measurements, water levels had been rising steadily until the spring of 2000. This water level rise is due to the increase in aquifer recharge as a result of the generally greater than normal amount of precipitation during the late 1990's following the drought years of the early 1990's. The spring 2001 water level was about two feet lower than the previous year's spring level as a result of the dry winter of 2001. The hydrograph clearly displays a drop of 23 feet during the summer of 2001 from the increased ground water pumping that occurred from the extensive supplemental ground water use in the area. As a result, the 13 feet of recovery observed during the winter of 2002 was not enough to bring water levels in the aquifer up to levels observed during previous springtime highs since measurements began at this well.

Figure 9 is the hydrograph for well KLAM 51795. This well is 1148 feet deep and penetrates into the basalt aquifer beneath the continental sediments. The well is located about one-half mile to the west of State observation well #1162. This well has never been pumped since measurements began in 1998 and it therefore is representative of static aquifer conditions in the northern district area. During 1999 and 2000, seasonal fluctuations varied only about 5 feet between the springtime highs and fall lows. During the 2001 drought, water levels

declined 13 feet below the springtime high. Both the normal seasonal fluctuation and 2001 drought pumping decline show a lesser amplitude of change than that of the State observation well. This is because this well has not been pumped and is more distant from wells that have been regularly pumped. The State observation well has been pumped for irrigation and is located closer to other pumping wells. Therefore, water levels measured at this well likely reflect these pumping impacts to a greater extent.

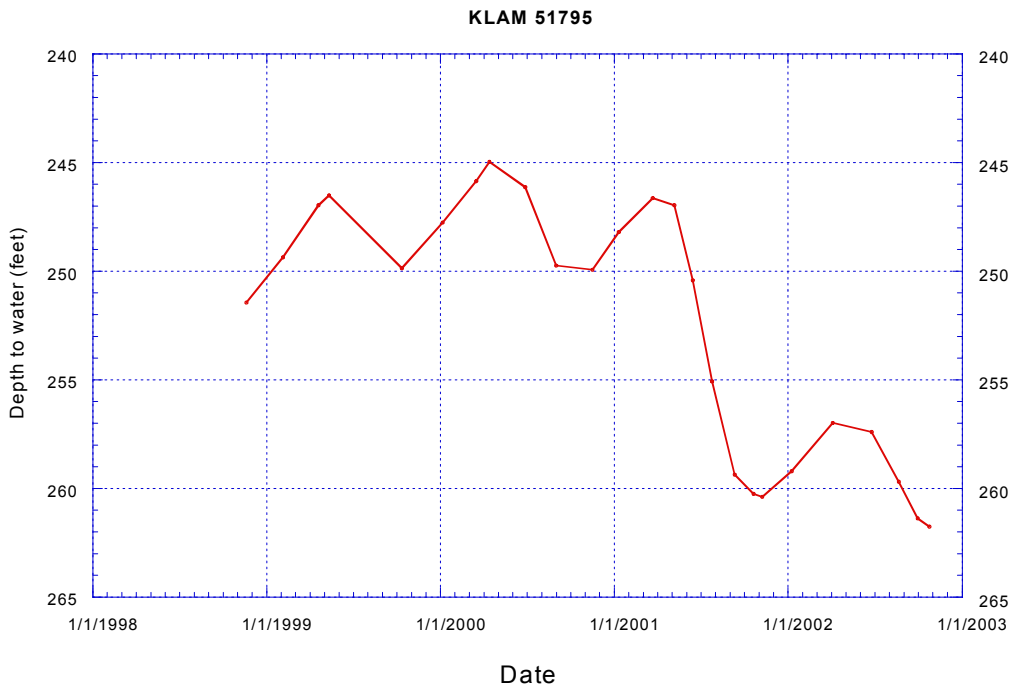

Figure 9. Hydrograph of well KLAM 51795.

Figure 10 is a hydrograph for an irrigation well (KLAM 51611) about 1.5 miles northwest of Malin and 2.2 miles north of the state line. This well is 882 feet deep and penetrates into the basalt aquifer. It is one-half mile north of the D canal and has never been pumped since measurements were initiated in 1998. The hydrograph is typical of basalt aquifer wells in the southern Shasta View district and Malin area. Water levels prior to the 2001 drought showed normally less than five feet of seasonal fluctuation with the highs occurring in the fall. In the summer of 2001 the water level declined about 20 feet as a result of groundwater pumping both to the north and south of this well, and from shut off of the irrigation canals. The hydrograph for this well shows that the recharge effect from canal leakage is greater than recharge from precipitation. During the winter of 2002 water levels were rising but the rate of rise increased in the April through June time period when the canals were in operation. The

steep decline displayed from the August through October measurements was caused by pumping of the Tule Lake irrigation district wells to the south that began in July 2002.

Comparing spring versus fall water levels for the wells that penetrate the basalt aquifer show distinct trends. Generally, water levels in the northern portion of the district, such as well KLAM 51795 (figure 9), show a rising trend in the spring. Many of the wells in the southern portion of the district, such as well KLAM 51611 (figure 10) have their highest water levels in the fall. This demonstrates that local recharge provided through canal leakage and infiltration of surface irrigation application are stronger influences on ground water levels than is recharge from incident precipitation.

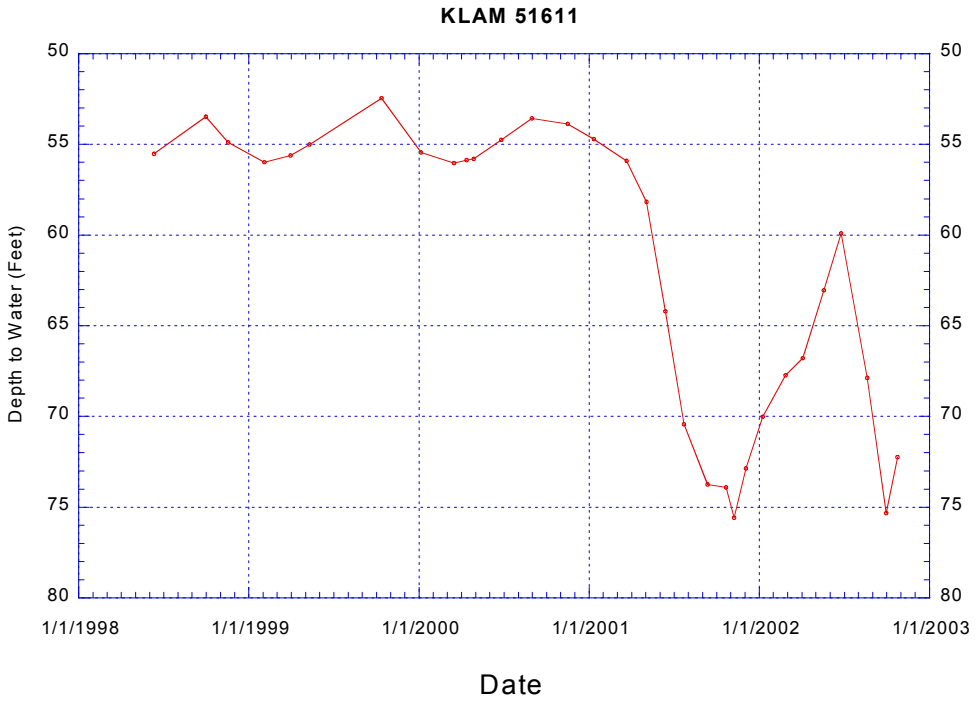

Figure 10. Hydrograph of well KLAM 51611.

Figure 11 is the hydrograph of the SVID observation well (KLAM 52194) discussed previously in the aquifer test section. This hydrograph displays the complete record of water level data collected at the well since March 2000. The hydraulic connection between this well in the aquifer test area and the Tule Lake Irrigation District (TID) wells, nearly four miles to the south, is readily apparent. During the 2002 irrigation season, project water was being delivered to Shasta View and Malin irrigation districts. Therefore, there was no ground water pumping by supplemental use wells as took place in the summer of 2001. The sharp break in slope from gradual rise to abrupt decline beginning in mid July 2002 and the reversal of that trend three months later, in mid October, is obvious. The pumping induced

water level decline is coincident with the operation of the TID wells, and unlike the summer of 2001, the decline can likely only be attributed to the TID pumping.

Ground water level data for this observation well are being recorded at 15-minute intervals. According to the TID operations records, TID well #6 (about one mile south of Malin) began pumping on July 19, 2002, at 2:23 p.m. at a rate of 5,200 gpm. The data file for the observation well shows that the water level trend changed at about 7:15 p.m. This response time of about 5 hours is very rapid for a well about 3.6 miles distant. During the 2002 irrigation season, the TID wells pumped about 20,000 acre-feet of ground water. The SVID observation well declined 12.5 feet during the 12 weeks of TID pumping.

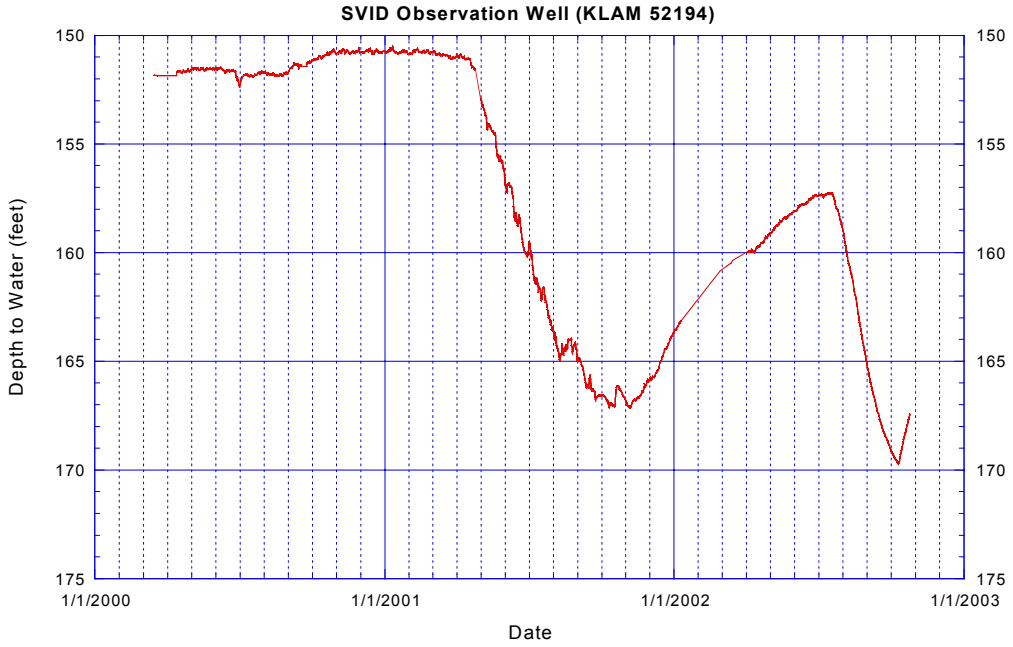

Figure 11. Hydrograph of the Shasta View observation well (KLAM 52194).

The water level response to the shut off of the TID wells is also rapid. TID well #6 was shut off October 10, 2002, at 9:30 a.m. The SVID observation well data shows the water level started recovering within 15 hours. The water level has recovered 2.3 feet during the two weeks since shut off and is presumably still rising following the last download of the data logger on October 25, 2002. The recorder data conclusively demonstrate interference across the state line caused by pumping TID wells.

Not all of the wells in the Shasta View area responded to pumping of the TID wells. Many shallow domestic wells were not affected by pumping of basalt wells. Figure 12 is the

hydrograph for former state observation well #294 (KLAM 15052). This well is 76 feet deep and produces water from the sedimentary aquifer that overlies the basalt aquifer. Water levels have been measured in this well from 1956 to 1993, when the well was dropped as an observation well. Measurements resumed again in 1998 and continue to the present as part of this demonstration project. This well is 3 miles north of the state line and just east of Turkey Hill. The water level in this well only fluctuates a few feet. During the 2001 drought, the water level declined to 6.5 feet below land surface in mid July but partially recovered after the canals were filled for about three weeks during August of 2001. The water level remained at normal levels even after the canals were shut off in September of 2001, despite the TID wells still being in operation. Water levels in 2002 have also remained at normal levels and have not responded to the pumping of the TID wells.

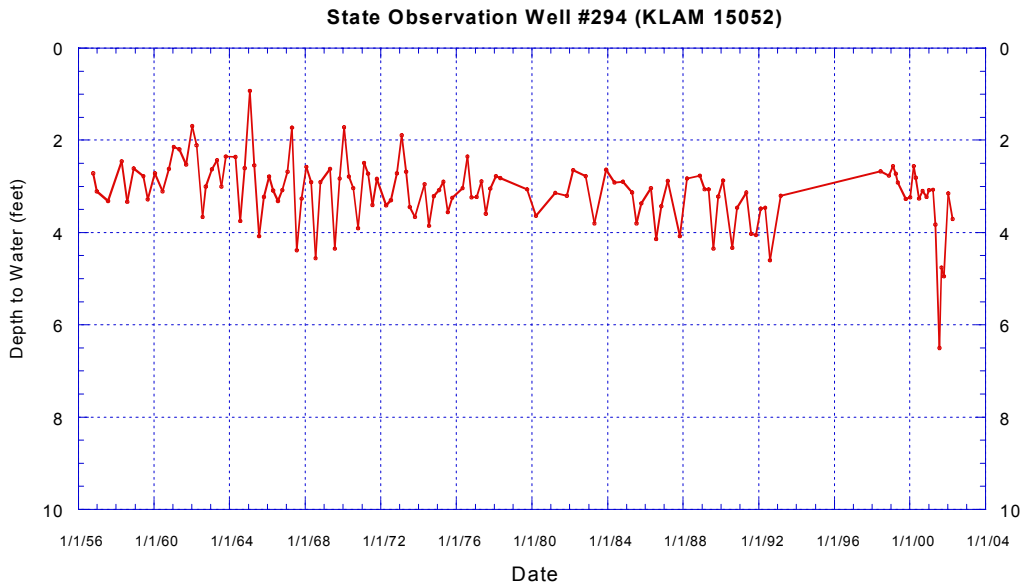

Figure 12. Hydrograph of State observation well #294 (KLAM 15052).

Water Use

During the 2001 drought, the basalt aquifer in the Shasta View area was heavily used for irrigation. Annual ground water pumpage was determined for 36 of the 38 wells authorized under existing primary or supplemental permits or under newly issued emergency drought permits. The quantity of water pumped was estimated by using flow meter readings, power consumption data, or water-use reports filed with the Oregon Water Resources Department.

The Department issued 17 Emergency Drought permits in 2001, covering nearly 1,800 acres within the Shasta View and Malin Irrigation Districts and adjacent areas. These wells pumped just under 4,100 acre-feet of ground water in 2001. Total pumpage, including existing permitted wells both within and outside the two district areas, is estimated to be over 9,100 acre-feet on about 4,146 acres. In contrast, year 2000 had near normal surface water delivery and ground water pumping totaled only about 2,600 acre-feet for this same general area. Therefore, ground water pumpage in 2001 was about 3.5 times that in the year 2000 for the same local area.

Data from the California Water Resources Department show a similar trend for ground water use from the basalt aquifer in the California portion of the Tule Lake basin. In year 2000, wells in the Tule Lake basin pumped a total of 16,100 acre-feet of ground water. During the drought of 2001, 70,300 acre-feet of ground water was pumped from the basalt aquifer, or an increase of about 4.4 times that pumped in 2000.

Pumpage for irrigation from wells only within the SVID for 2001 is estimated to be 3560 acre-feet, including the 963 acre-feet pumped by the McVay well. During a normal year, the SVID diverts about 12,000 acre-feet of surface water. Therefore, the ground water pumped in 2001 represents approximately 30 percent of the quantity that would need to be pumped to satisfy normal district requirements. If the SVID were to completely replace its usual surface water diversion with ground water, an additional 8,440 acre-feet of ground water would need to be pumped in the area.

CONCLUSIONS

- The transmissivity calculated from drawdown data collected at the pumping well and the four observation wells ranges from about 71,000 to 569,500 gpd/ft. Transmissivity calculated from recovery data ranges from about 135,000 to 358,000 gpd/ft. The coefficient of storage calculated ranges from 0.0013 to 0.0643, which is expected of semiconfined to unconfined aquifers. Using the results from this aquifer test and those from an earlier test of a nearby well, the average transmissivity is about 200,000 gpd/ft. and the average coefficient of storage is about 0.01.

- The average transmissivity and coefficient of storage values were used to predict drawdown after various times of pumping and at various distances from a typical production well. The SVID has filed a permit application that, if approved, would allow irrigation of district lands from up to 14 wells. The potential pumping interference at the center of such a well field could exceed 50 feet after 180 days of pumping at the maximum rate. The impacts of pumping will extend to areas outside the district lands. However, those areas will experience smaller amounts of pumping interference than will areas within the district.

- If and when the SVID pumps ground water in the quantity proposed, some existing wells in the area will need work. This may include lowering of pumps, well deepening or replacement. This is likely to be a contentious issue, resulting in complaints regarding pumping interference by local well owners to the OWRD, the USBR and the district.

- Due to the interference of multiple wells pumping during the long-term test, it was not possible to document the presence of any ground water barriers in the area by the usual methods of analysis.

- Pumping by the Tulelake Irrigation District wells just south of the state line in California affects ground water supplies in the Shasta View area. Interference effects spread rapidly throughout the basalt aquifer tapped by most of the test wells.

- Total ground water pumpage in the vicinity of the SVID and Malin Irrigation District, including existing permitted wells and Emergency Drought permitted wells, is estimated to be over 9,100 acre-feet for the year 2001. This was about 3.5 times that in the year 2000 for the same local area. Similarly, data from the California portion of the Tule Lake basin indicate pumpage there in 2001 was about 4.4 times that pumped in 2000.

- Water level recovery at most wells increased in rate during middle to late April of 2002, which suggests that there is a local source of recharge to the basalt aquifer. The timing closely corresponded to the release of Klamath project water into local canals and to the beginning of the irrigation season. The basalt ground water system in the area is, in part, dependent on canal leakage, possibly in combination with local application of water for irrigation, as a source of recharge.

- The Theresa Perry well did not clearly exhibit the same recharge response. It also did not respond to pumping of the TID well #6 as strongly as did the other monitored wells. The Perry well is the only monitored well located north of a recently mapped southeast-northwest trending normal fault near the test site. The fault coincides with a local permeability change in the basalt aquifer that serves to dampen pumping impacts on opposite sides.

- None of the wells monitored during the test had water levels recover up to the pre-test levels by the beginning of the 2002 irrigation season. The hydrographs for the monitored wells suggest that recovery to pre-test levels or higher would likely have occurred by late 2002 to early 2003. The rate of recovery may be influenced by local precipitation, which was below normal for the 2001-2002 water year. Therefore, under climatic conditions equivalent to those during the test period, the basalt aquifer requires more time to completely recover from pumping than is available between irrigation seasons. It is unknown whether additional recovery would have occurred in 2002 under normal precipitation conditions.

- Annual pumpage to satisfy the SVID water rights application for irrigation from the basalt aquifer would likely result in annual water level declines. It is unknown whether such declines would continue or if water levels would stabilize after some period of continued development of the resource. In either case, annual water level recovery would be dependent upon precipitation and the availability of canal leakage.

- Pumpage from wells within the SVID for 2001 is estimated to be 3,560 acre-feet. During a normal year, the SVID diverts about 12,000 acre-feet of surface water. Therefore, the ground water pumped in 2001 represents approximately 30 percent of the quantity that would need to be pumped to satisfy normal district requirements. If the SVID were to completely replace its usual surface water diversion with ground water, an additional 8,440 acre-feet of ground water would need to be pumped in the area.

- Ground water probably cannot be used be used as a full replacement for surface water within the district without generating long-term water level declines and overdraft of the resource. However, ground water can likely be used as a supplemental source to make up deficiencies in years when surface water is in short supply as long as the resource is allowed to recover in years of normal or above normal precipitation.

RECOMMENDATIONS

- Proceed with caution with regard to continued development of the basalt ground water resource for irrigation in the Shasta View area. Develop gradually with monitoring of water levels and water use. Be prepared to terminate development based on adverse findings.

- Plan use of ground water within the SVID as a supplemental supply to surface water. In years of adequate surface water availability, allow ground water levels to recover.

- Continue ongoing water-level monitoring in the area, including maintenance of the equipment installed at the SVID observation well.

- Condition any new water-use permits issued in the Shasta View area to include monitoring water levels and limiting water-level declines and pumping interference. Require flowmeters on all wells irrigating more than 10 acres and on all other wells for rights greater than 0.05 cfs.

- Require the SVID to consult with the USBR and the OWRD to develop a plan of action in the event that pumping of proposed district wells causes water-supply problems at existing wells. Such a plan could include sufficient flexibility to address such problems with an array of potential actions, and could address, for example, the sequence of construction of the proposed wells, location of the wells, reconstruction costs, supplemental versus primary use, etc.

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Appendix A

Well Logs

(well logs are available as photocopies, but not included here)

Appendix B

Aquifer Test Water Level Data

Claude Hagerty Well Aquifer Test Data

MINUTES Start	Minutes Stop	HOLD	CUT	Water level	Drawdown	Comments	Clock Time of Measurement
		105	0.31	105.31			3/23/2001 12:00
		105	1.74	106.74		Pre test meas	5/1/2001 16:20
		105	1.77	106.77			5/1/2001 17:45
		105	1.70	106.70			5/2/2001 10:25
		105	1.70	106.70			5/2/2001 10:53
0		105	1.68	106.68	0.00	5/2/2001 11:02	5/2/2001 11:00
3		105	1.68	106.68	0.00		5/2/2001 11:05
8		105	1.68	106.68	0.00		5/2/2001 11:10
13		105	1.68	106.68	0.00		5/2/2001 11:15
18		105	1.67	106.67	-0.01		5/2/2001 11:20
23		105	1.67	106.67	-0.01		5/2/2001 11:25
28		105	1.67	106.67	-0.01		5/2/2001 11:30
33		105	1.67	106.67	-0.01		5/2/2001 11:35
38		105	1.67	106.67	-0.01		5/2/2001 11:40
43		105	1.67	106.67	-0.01		5/2/2001 11:45
48		105	1.67	106.67	-0.01		5/2/2001 11:50
53		105	1.67	106.67	-0.01		5/2/2001 11:55
58		105	1.66	106.66	-0.02		5/2/2001 12:00
68		105	1.66	106.66	-0.02		5/2/2001 12:10
78		105	1.66	106.66	-0.02		5/2/2001 12:20
88		105	1.65	106.65	-0.03		5/2/2001 12:30
98		105	1.64	106.64	-0.04	Turn off valve to water tank	5/2/2001 12:40
108		105	1.64	106.64	-0.04		5/2/2001 12:50
118		105	1.64	106.64	-0.04		5/2/2001 13:00
128		105	1.63	106.63	-0.05		5/2/2001 13:10
138		105	1.63	106.63	-0.05		5/2/2001 13:20
148		105	1.64	106.64	-0.04		5/2/2001 13:30
158		105	1.63	106.63	-0.05		5/2/2001 13:40
168		105	1.64	106.64	-0.04		5/2/2001 13:50
178		105	1.64	106.64	-0.04		5/2/2001 14:00
188		105	1.63	106.63	-0.05		5/2/2001 14:10
198		105	1.64	106.64	-0.04		5/2/2001 14:20
208		105	1.63	106.63	-0.05		5/2/2001 14:30
218		105	1.65	106.65	-0.03		5/2/2001 14:40
228		105	1.65	106.65	-0.03		5/2/2001 14:50
238		105	1.62	106.62	-0.06		5/2/2001 15:00
248		105	1.62	106.62	-0.06		5/2/2001 15:10
316		105	1.59	106.59	-0.09		5/2/2001 16:18
370		105	1.59	106.59	-0.09		5/2/2001 17:12
440		105	1.59	106.59	-0.09		5/2/2001 18:22
499		105	1.70	106.70	0.02	pump off (recovering slowly)	5/2/2001 19:21
558		105	1.75	106.75	0.07	pump on after meas	5/2/2001 20:20
616		105	1.80	106.80	0.12	slowly recovering	5/2/2001 21:18
743		105	1.83	106.83	0.15		5/2/2001 23:25
841		105	1.85	106.85	0.17		5/3/2001 1:03
898		105	1.85	106.85	0.17		5/3/2001 2:00
960		105	1.85	106.85	0.17		5/3/2001 3:02
1020		105	1.87	106.87	0.19		5/3/2001 4:02
1082		105	1.87	106.87	0.19		5/3/2001 5:04
1141		105	1.89	106.89	0.21		5/3/2001 6:03
1278		105	1.92	106.92	0.24		5/3/2001 8:20

1346		105	1.93	106.93	0.25		5/3/2001 9:28
1441		105	1.95	106.95	0.27		5/3/2001 11:03
1520		105	1.96	106.96	0.28		5/3/2001 12:22
1720		105	1.97	106.97	0.29		5/3/2001 15:42
1993		105	1.89	106.89	0.21		5/3/2001 20:15
2216		105	1.80	106.80	0.12	ppg upon arrival?	5/3/2001 23:58
2268		105	1.78	106.78	0.10	RP	5/4/2001 0:50
2590		105	1.71	106.71	0.03		5/4/2001 6:12
2840		105	1.72	106.72	0.04		5/4/2001 10:22
2998		105	1.70	106.70	0.02		5/4/2001 13:00
3238		105	1.68	106.68	0.00	Halousek not ppg	5/4/2001 17:00
3488		105	1.74	106.74	0.06		5/4/2001 21:10
4402		105	1.80	106.80	0.12		5/5/2001 12:24
4628		105	1.77	106.77	0.09		5/5/2001 16:10
4940		105	1.82	106.82	0.14		5/5/2001 21:22
5604		105	1.82	106.82	0.14		5/6/2001 8:26
5909		105	1.85	106.85	0.17		5/6/2001 13:31
6130		105	1.83	106.83	0.15	pump cycling - off for 3 min	5/6/2001 17:12
6420		105	1.93	106.93	0.25		5/6/2001 22:02
7132		105	1.98	106.98	0.30	RP	5/7/2001 9:54
7538		105	1.91	106.91	0.23	pump cycling - lawn watering	5/7/2001 16:40
7858		105	1.94	106.94	0.26		5/7/2001 22:00
8570		105	1.96	106.96	0.28		5/8/2001 9:52
8833		105	1.99	106.99	0.31		5/8/2001 14:15
10245		105	2.14	107.14	0.46	ppg upon arrival - off for 5 min	5/9/2001 13:47
11631		105	2.32	107.32	0.64	ppg after meas	5/10/2001 12:53
13120		105	2.28	107.28	0.60	Halousek not ppg	5/11/2001 13:42
17413		105	2.45	107.45	0.77	Halousek not ppg	5/14/2001 13:15
21685		105	2.58	107.58	0.90	Halousek not ppg - dom ppg after meas	5/17/2001 12:27
23115		105	2.68	107.68	1.00		5/18/2001 12:17
27528		105	3.12	108.12	1.44	Halousek not ppg - dom ppg after meas	5/21/2001 13:50
30358		105	3.47	108.47	1.79	Halousek not ppg - dom ppg after meas	5/23/2001 13:00
33206		105	3.70	108.70	2.02	Halousek not ppg	5/25/2001 12:28
39040		105	4.05	109.05	2.37	Halousek not ppg	5/29/2001 13:42
46198		110	-0.08	109.92	3.24	Halousek ppg - dom use on arrival	6/3/2001 13:00
49096		110	0.04	110.04	3.36	Halousek not ppg - dom ppg after meas	6/5/2001 13:18
53398		110	0.12	110.12	3.44	Halousek not ppg - dom ppg after meas	6/8/2001 13:00
57900		110	0.40	110.40	3.72	Halousek not ppg	6/11/2001 16:02
63504		110	1.14	111.14	4.46	Halousek ppg - dom use on arrival	6/15/2001 13:26
72368		110	1.99	111.99	5.31	Halousek ppg	6/21/2001 17:10
79380		110	2.71	112.71	6.03	Halousek ppg	6/26/2001 14:02
83760		110	2.89	112.89	6.21	Halousek ppg	6/29/2001 15:02
93804		110	3.62	113.62	6.94	Halousek ppg	7/6/2001 14:26
100980		115	-0.52	114.48	7.80	Halousek ppg	7/11/2001 14:02
111062		115	-0.16	114.84	8.16	No ppg at Halousek	7/18/2001 14:04
121143		115	0.12	115.12	8.44	No ppg at Halousek	7/25/2001 14:05
130040		115	1.35	116.35	9.67	ppg at Halousek & dom ppg	7/31/2001 18:22
141470		115	2.25	117.25	10.57		8/8/2001 16:52
150193		115	2.47	117.47	10.79	ppg at Halousek	8/14/2001 18:15
161319		115	2.11	117.11	10.43	No ppg at Halousek	8/22/2001 11:41
172914		115	2.76	117.76	11.08	Halousek ppg	8/30/2001 12:56
183202		115	3.13	118.13	11.45	No ppg at Halousek	9/6/2001 16:24
191858		115	3.62	118.62	11.94	No ppg at Halousek-weights hit pump?	9/12/2001 16:40
204528		115				No Reading	9/21/2001 11:50

210643		115				No Reading	9/25/2001 17:45
222130		115				No Reading	10/3/2001 17:12
243303		115				No Reading	10/18/2001 10:05
243358	0	115				Shut off McVay well at 11:00 10/18/01	10/18/2001 11:00
243449	91	115				No Reading	10/18/2001 12:31
243519	161	115				No Reading	10/18/2001 13:41
						10/25/2001 - Claude lost domestic use	
						About 12/1/2001 - Domestic use regained	
366006	122648	115	2.15	117.15	10.47	1/11/2002	1/11/2002 15:08
393463	150105	115	1.20	116.20	9.52		1/30/2002 16:45
433783	190425	115	0.06	115.06	8.38		2/27/2002 16:45
456612	213252	115	-0.40	114.60	7.92		3/15/2002 13:14
485678	242320	115	-0.80	114.20	7.52		4/4/2002 17:40
514164	270806	115	-1.30	113.70	7.02		4/24/2002 12:26
527184	283826	115	-1.62	113.38	6.70		5/3/2002 13:26
546138	302778					ppg - no meas.	5/16/2002 17:20
567463	324105	110	2.40	112.40	5.72		5/31/2002 12:45
605058	361700	110	1.73	111.73	5.05		6/26/2002 15:20
665718	422360	115	-0.48	114.52	7.84	Recent pumping	8/7/2002 18:20
688340	444982	115	2.91	117.91	11.23		8/23/2002 11:22

Theresa Perry Well Aquifer Test Data

MINUTES Start	Minutes Stop	Ratio t/t'	HOLD	CUT	Water level	Drawdown	Comments	Clock Time of Measurement
-1270			145	-1.36	143.64		Pre test meas	
-1120			145	-1.27	143.73		Pre test meas	
-20			140	2.40	142.40		Pre test meas	
0			140	2.36	142.36	0.00	5/2/2001 11:02	5/2/2001 11:02
3			140	2.39	142.39	0.03	Start test at 11:02	5/2/2001 11:05
8			140	2.37	142.37	0.01		5/2/2001 11:10
13			140	2.37	142.37	0.00		5/2/2001 11:15
18			140	2.36	142.36	0.00		5/2/2001 11:20
23			140	2.35	142.35	-0.01		5/2/2001 11:25
28			140	2.36	142.36	0.00		5/2/2001 11:30
33			140	2.34	142.34	-0.02		5/2/2001 11:35
38			140	2.34	142.34	-0.02		5/2/2001 11:40
43			140	2.34	142.34	-0.03		5/2/2001 11:45
48			140	2.35	142.35	-0.01		5/2/2001 11:50
53			140	2.34	142.34	-0.02		5/2/2001 11:55
58			140	2.32	142.32	-0.04		5/2/2001 12:00
68			140	2.32	142.32	-0.04		5/2/2001 12:10
78			140	2.32	142.32	-0.04		5/2/2001 12:20
88			140	2.31	142.31	-0.06		5/2/2001 12:30
98			140	2.30	142.30	-0.06		5/2/2001 12:40
108			140	2.30	142.30	-0.06		5/2/2001 12:50
118			140	2.30	142.30	-0.06		5/2/2001 13:00
128			140	2.29	142.29	-0.08		5/2/2001 13:10
138			140	2.29	142.29	-0.07		5/2/2001 13:20
148			140	2.29	142.29	-0.07		5/2/2001 13:30
158			140	2.28	142.28	-0.08		5/2/2001 13:40
168			140	2.27	142.27	-0.09		5/2/2001 13:50
178			140	2.27	142.27	-0.09		5/2/2001 14:00
188			140	2.28	142.28	-0.08		5/2/2001 14:10
198			140	2.26	142.26	-0.10		5/2/2001 14:20
208			140	2.26	142.26	-0.10		5/2/2001 14:30
218			140	2.26	142.26	-0.10		5/2/2001 14:40
228			140	2.25	142.25	-0.11		5/2/2001 14:50
238			140	2.25	142.25	-0.11		5/2/2001 15:00
308			140	2.22	142.22	-0.14		5/2/2001 16:10
353			140	2.22	142.22	-0.14		5/2/2001 16:55
425			140	2.21	142.21	-0.15		5/2/2001 18:07
485			140	2.21	142.21	-0.15		5/2/2001 19:07
545			140	2.20	142.20	-0.16		5/2/2001 20:07
605			140	2.21	142.21	-0.15		5/2/2001 21:07
725			140	2.21	142.21	-0.15		5/2/2001 23:07
861			140	2.18	142.18	-0.18		5/3/2001 1:23
915			140	2.17	142.17	-0.19		5/3/2001 2:17
970			140	2.15	142.15	-0.21		5/3/2001 3:12
1030			140	2.15	142.15	-0.21		5/3/2001 4:12
1092			140	2.14	142.14	-0.22		5/3/2001 5:14
1150			140	2.15	142.15	-0.21		5/3/2001 6:12
1288			140	2.16	142.16	-0.20		5/3/2001 8:30
1358			140	2.15	142.15	-0.21		5/3/2001 9:40
1449			140	2.15	142.15	-0.21		5/3/2001 11:11

1511			140	2.13	142.13	-0.23		5/3/2001 12:13
1736			140	2.08	142.08	-0.28		5/3/2001 15:58
1973			140	2.09	142.09	-0.27		5/3/2001 19:55
2234			140	2.13	142.13	-0.23		5/4/2001 0:16
2600			140	2.17	142.17	-0.19		5/4/2001 6:22
2813			140	2.70	142.70	0.34	recovering slowly	5/4/2001 9:55
3008			140	3.22	143.22	0.86	Silbernagel ppg	5/4/2001 13:10
3246			140	3.49	143.49	1.13	Silbernagel ppg	5/4/2001 17:08
3500			140	3.70	143.70	1.34		5/4/2001 21:22
4412			140	4.39	144.39	2.03		5/5/2001 12:34
4638			140	4.35	144.35	1.99	Silbernagel ppg	5/5/2001 16:20
4954			140	4.69	144.69	2.33	Haught & Silbernagel ppg	5/5/2001 21:36
5576			140	4.69	144.69	2.33	Haught & Silbernagel ppg	5/6/2001 7:58
5882			140	4.59	144.59	2.23	Haught & Silbernagel ppg	5/6/2001 13:04
6140			140	4.87	144.87	2.51	Haught & Silbernagel ppg	5/6/2001 17:22
6370			140	4.95	144.95	2.59	Haught & Silbernagel ppg	5/6/2001 21:12
7104			140	3.67	143.67	1.31	Haught ppg, Silbernagel off	5/7/2001 9:26
7478			140	3.43	143.43	1.07	Silbernagel off	5/7/2001 15:40
7813			140	4.21	144.21	1.85	rising - well ppg on arrival	5/7/2001 21:15
8533			140	3.29	143.29	0.93	Silbernagel off	5/8/2001 9:15
8789			140	3.25	143.25	0.89	Silbernagel off	5/8/2001 13:31
10210			140	3.26	143.26	0.90	Silbernagel ppg	5/9/2001 13:12
11670			145	0.29	145.29	2.93	Silbernagel ppg	5/10/2001 13:32
13132			145	2.01	147.01	4.65	Silbernagel ppg	5/11/2001 13:54
17425			145	3.22	148.22	5.86	Silbernagel ppg	5/14/2001 13:27
20294			145	3.03	148.03	5.67	Silbernagel ppg	5/16/2001 13:16
23133			145	2.26	147.26	4.90	Silbernagel off	5/18/2001 12:35
27552			145	2.73	147.73	5.37	Silbernagel ppg	5/21/2001 14:14
30376			145	1.11	146.11	3.75	Silbernagel off	5/23/2001 13:18
33230			145	2.86	147.86	5.50	Silbernagel ppg	5/25/2001 12:52
39065			145	2.12	147.12	4.76	Silbernagel off	5/29/2001 14:07
43336			145	2.29	147.29	4.93	Silbernagel off	6/1/2001 13:18
49108			145	2.57	147.57	5.21	Silbernagel off	6/5/2001 13:30
53411			150	0.20	150.20	7.84	Silbernagel ppg	6/8/2001 13:13
60618			150	2.18	152.18	9.82	Silbernagel ppg	6/13/2001 13:20
63425			150	2.84	152.84	10.48	Silbernagel ppg	6/15/2001 12:07
73568			150	2.74	152.74	10.38	Silbernagel ppg	6/22/2001 13:10
79400			155	-0.37	154.63	12.27	Silbernagel ppg	6/26/2001 14:22
83683			155	-0.57	154.43	12.07	Silbernagel ppg	6/29/2001 13:45
93758			150	2.83	152.83	10.47	No ppg at Silbernagel	7/6/2001 13:40
100935			150	3.12	153.12	10.76	No ppg at Silbernagel	7/11/2001 13:17
111023			150	3.85	153.85	11.49	Silbernagel ppg	7/18/2001 13:25
119801			155	1.40	156.40	14.04	Silbernagel ppg	7/24/2001 15:43
129968			155	2.30	157.30	14.94	Silbernagel ppg	7/31/2001 17:10
141413			155	2.58	157.58	15.22	Silbernagel ppg	8/8/2001 15:55
150139			155	2.69	157.69	15.33	Silbernagel ppg	8/14/2001 17:21
161274			155	3.58	158.58	16.22	Silbernagel ppg	8/22/2001 10:56
172864			155	2.19	157.19	14.83	Silbernagel off 2 days	8/30/2001 12:06
183148			160	0.60	160.60	18.24	Silbernagel ppg	9/6/2001 15:30
191785			160	1.43	161.43	19.07	Silbernagel ppg	9/12/2001 15:27
204426			160	-1.51	158.49	16.13	No ppg at Silbernagel	9/21/2001 10:08
210576			155	2.81	157.81	15.45	No ppg at Silbernagel	9/25/2001 16:38
222110			155	1.62	156.62	14.26	No ppg at Silbernagel	10/3/2001 16:52
233302			155	1.87	156.87	14.51	No ppg at Silbernagel	10/11/2001 11:24

240976			155	1.90	156.90	14.54	No ppg at Silbernagel	10/16/2001 19:18
243276			155	1.70	156.70	14.34	Pre shut off meas	10/18/2001 9:38
243350			155	1.69	156.69	14.33	Pre shut off meas	10/18/2001 10:52
SHUT OFF PUMPING WELL								
243358	0		155	1.69	156.69	14.33	Well off @ 11:00	10/18/2001 11:00
243363	5	48673	155	1.69	156.69	14.33		10/18/2001 11:05
243368	10	24337	155	1.69	156.69	14.33		10/18/2001 11:10
243373	15	16225	155	1.69	156.69	14.33		10/18/2001 11:15
243378	20	12169	155	1.68	156.68	14.32		10/18/2001 11:20
243383	25	9735			0.00		Lost signal	10/18/2001 11:25
243388	30	8113			0.00		Lost signal	10/18/2001 11:30
243393	35	6954			0.00		Lost signal	10/18/2001 11:35
243398	40	6085			0.00		Lost signal	10/18/2001 11:40
243403	45	5409	155	1.69	156.69	14.33	Fixed weights	10/18/2001 11:45
243408	50	4868	155	1.69	156.69	14.33		10/18/2001 11:50
243413	55	4426	155	1.69	156.69	14.33		10/18/2001 11:55
243418	60	4057	155	1.69	156.69	14.33		10/18/2001 12:00
243428	70	3478	155	1.69	156.69	14.33		10/18/2001 12:10
243438	80	3043	155	1.69	156.69	14.33		10/18/2001 12:20
243448	90	2705	155	1.68	156.68	14.32		10/18/2001 12:30
243458	100	2435	155	1.67	156.67	14.31		10/18/2001 12:40
243468	110	2213	155	1.67	156.67	14.31		10/18/2001 12:50
243478	120	2029	155	1.67	156.67	14.31		10/18/2001 13:00
243488	130	1873	155	1.66	156.66	14.30		10/18/2001 13:10
243498	140	1739	155	1.66	156.66	14.30		10/18/2001 13:20
243508	150	1623	155	1.66	156.66	14.30		10/18/2001 13:30
243518	160	1522	155	1.66	156.66	14.30		10/18/2001 13:40
243528	170	1433	155	1.66	156.66	14.30		10/18/2001 13:50
243538	180	1353	155	1.65	156.65	14.29		10/18/2001 14:00
243548	190	1282	155	1.64	156.64	14.28		10/18/2001 14:10
243558	200	1218	155	1.64	156.64	14.28		10/18/2001 14:20
243568	210	1160	155	1.63	156.63	14.27		10/18/2001 14:30
243578	220	1107	155	1.63	156.63	14.27		10/18/2001 14:40
243588	230	1059	155	1.63	156.63	14.27		10/18/2001 14:50
243598	240	1015	155	1.63	156.63	14.27		10/18/2001 15:00
243663	305	799	155	1.62	156.62	14.26		10/18/2001 16:05
243723	365	668	155	1.60	156.60	14.24		10/18/2001 17:05
243783	425	574	155	1.58	156.58	14.22		10/18/2001 18:05
243843	485	503	155	1.57	156.57	14.21		10/18/2001 19:05
243903	545	448	155	1.57	156.57	14.21		10/18/2001 20:05
243963	605	403	155	1.57	156.57	14.21		10/18/2001 21:05
244023	665	367	155	1.58	156.58	14.22		10/18/2001 22:05
244159	801	305	155	1.57	156.57	14.21		10/19/2001 0:21
244250	892	274	155	1.57	156.57	14.21		10/19/2001 1:52
244350	992	246	155	1.54	156.54	14.18		10/19/2001 3:32
244438	1080	226	155	1.50	156.50	14.14		10/19/2001 5:00
244518	1160	211	155	1.49	156.49	14.13		10/19/2001 6:20
244683	1325	185	155	1.45	156.45	14.09		10/19/2001 9:05
244864	1506	163	155	1.41	156.41	14.05		10/19/2001 12:06
245043	1685	145	155	1.34	156.34	13.98		10/19/2001 15:05
245223	1865	131	155	1.31	156.31	13.95		10/19/2001 18:05
245670	2312	106	155	1.32	156.32	13.96		10/20/2001 1:32
246043	2685	92	155	1.26	156.26	13.90		10/20/2001 7:45
246183	2825	87	155	1.26	156.26	13.90		10/20/2001 10:05

246423	3065	80	155	1.21	156.21	13.85		10/20/2001 14:05
246698	3340	74	155	1.17	156.17	13.81		10/20/2001 18:40
247642	4284	58	155	1.16	156.16	13.80		10/21/2001 10:24
248121	4763	52	155	1.11	156.11	13.75		10/21/2001 18:23
249070	5712	44	155	1.05	156.05	13.69		10/22/2001 10:12
249598	6240	40	155	0.97	155.97	13.61		10/22/2001 19:00
250539	7181	35	155	1.01	156.01	13.65		10/23/2001 10:41
250956	7598	33	155	0.95	155.95	13.59		10/23/2001 17:38
251996	8638	29	155	0.88	155.88	13.52		10/24/2001 10:58
252433	9075	28	155	0.81	155.81	13.45		10/24/2001 18:15
253473	10115	25	155	0.77	155.77	13.41		10/25/2001 11:35
259420	16062	16	155	0.44	155.44	13.08		10/29/2001 14:42
262408	19050	14	155	0.29	155.29	12.93		10/31/2001 16:30
263954	20596	13	155	0.19	155.19	12.83		11/1/2001 18:16
271198	27840	10	155	-0.04	154.96	12.60	recent dom ppg	11/6/2001 19:00
272600	29242	9	155	-0.07	154.93	12.57		11/7/2001 18:22
275493	32135	9	155	-0.32	154.68	12.32		11/9/2001 18:35
285210	41852	7	155	-0.68	154.32	11.96	recent dom ppg	11/16/2001 12:32
291092	47734	6	155	-0.96	154.04	11.68		11/20/2001 14:34
311133	67775	5	150	3.38	153.38	11.02		12/4/2001 12:35
325390	82032	4	150	2.91	152.91	10.55	57 days	12/14/2001 10:12
334204	90846	4	150	2.58	152.58	10.22	12/20/2001	12/20/2001 13:06
361864	118506	3	150	1.91	151.91	9.55		1/8/2002 18:06
365977	122619	3	150	1.81	151.81	9.45	85 days of recovery	1/11/2002 14:39
393426	150068	3	150	1.51	151.51	9.15		1/30/2002 16:08
433750	190392	2	150	0.06	150.06	7.70	132 days since shut off	2/27/2002 16:12
456575	213215	2	150	-0.43	149.57	7.21		3/15/2002 12:37
485648	242290	2	150	-0.96	149.04	6.68		4/4/2002 17:10
514102	270734	2	150	-0.93	149.07	6.71		4/24/2002 11:24
527158	283800	2	150	-0.91	149.09	6.73	366 days total	5/3/2002 13:00
546169	302811	2	150	0.00	150.00	7.64	no one home - no ppg	5/16/2002 17:51
567363	324005	2	150	1.10	151.10	8.74		5/31/2002 11:05
605008	361650	2	150	1.79	151.79	9.43	no one home - no ppg	6/26/2002 14:30
665660	422302	2	155	-0.49	154.51	12.15		8/7/2002 17:22
688376	445018	2	155	0.44	155.44	13.08		8/23/2002 11:58
737463	494105	1	155	1.79	156.79	14.43		9/26/2002 14:05

McVay Well Aquifer Test Data

MINUTES - start	Minutes - stop	Ratio t/t'	HOLD	CUT	Water level (BMP)	Drawdown	Comments	Clock time of measurement
			145	1.49	146.49			5/1/2001 13:15
			145	1.59	146.59			5/1/2001 16:15
			145	1.64	146.64			5/2/2001 8:30
			145	1.59	146.59			5/2/2001 8:55
			145	1.52	146.52		Silbernagel & Halousek off	5/2/2001 9:30
			145	1.46	146.46			5/2/2001 10:00
			145	1.38	146.38			5/2/2001 10:32
			145	1.40	146.4			5/2/2001 10:45
			145	1.39	146.39		Pre test measurement	5/2/2001 10:55
0			145	1.41	146.41		5/2/2001 11:02	5/2/2001 11:01
0			145	1.39	146.39	-0.01	Pump on at 11:02 (2 min delay)	5/2/2001 11:02
1			145	2.35	147.35	0.95	Silbernagel & Halousek off	5/2/2001 11:03
2			145	2.88	147.88	1.48		5/2/2001 11:04
3			145	2.95	147.95	1.55		5/2/2001 11:05
4			145	3.00	148.00	1.60		5/2/2001 11:06
5			145	3.02	148.02	1.62		5/2/2001 11:07
6			145	3.05	148.05	1.65		5/2/2001 11:08
7			145	3.08	148.08	1.68		5/2/2001 11:09
8			145	3.10	148.10	1.70		5/2/2001 11:10
10			145	3.13	148.13	1.73		5/2/2001 11:12
12			145	3.14	148.14	1.74		5/2/2001 11:14
14			145	3.16	148.16	1.76		5/2/2001 11:16
16			145	3.18	148.18	1.78		5/2/2001 11:18
18			145	3.20	148.20	1.80		5/2/2001 11:20
20			145	3.18	148.18	1.78		5/2/2001 11:22
22			145	2.99	147.99	1.59		5/2/2001 11:24
24			145	3.01	148.01	1.61		5/2/2001 11:26
26			145	2.99	147.99	1.59		5/2/2001 11:28
28			145	3.00	148.00	1.60		5/2/2001 11:30
33			145	3.02	148.02	1.62		5/2/2001 11:35
38			145	3.02	148.02	1.62		5/2/2001 11:40
43			145	3.04	148.04	1.64		5/2/2001 11:45
48			145	3.04	148.04	1.64		5/2/2001 11:50
53			145	3.08	148.08	1.68		5/2/2001 11:55
58			145	3.08	148.08	1.68		5/2/2001 12:00
68			145	3.04	148.04	1.64		5/2/2001 12:10
78			145	3.10	148.10	1.70		5/2/2001 12:20
88			145	3.14	148.14	1.74		5/2/2001 12:30
98			145	3.09	148.09	1.69		5/2/2001 12:40
108			145	3.10	148.10	1.70		5/2/2001 12:50
118			145	3.11	148.11	1.71		5/2/2001 13:00
130			145	3.12	148.12	1.72		5/2/2001 13:12
140			145	3.14	148.14	1.74		5/2/2001 13:22
160			145	3.15	148.15	1.75		5/2/2001 13:42
180			145	3.39	148.39	1.99		5/2/2001 14:02
200			145	3.45	148.45	2.05		5/2/2001 14:22
220			145	3.43	148.43	2.03		5/2/2001 14:42
240			145	3.29	148.29	1.89		5/2/2001 15:02
290			145	3.28	148.28	1.88		5/2/2001 15:52
350			145	3.37	148.37	1.97		5/2/2001 16:52

420			145	3.38	148.38	1.98		5/2/2001 18:02
480			145	3.40	148.40	2.00		5/2/2001 19:02
540			145	3.44	148.44	2.04		5/2/2001 20:02
600			145	3.44	148.44	2.04		5/2/2001 21:02
660			145	3.41	148.41	2.01		5/2/2001 22:02
720			145	3.69	148.69	2.29		5/2/2001 23:02
851			145	3.51	148.51	2.11		5/3/2001 1:13
924			145	3.52	148.52	2.12		5/3/2001 2:26
980			145	3.54	148.54	2.14		5/3/2001 3:22
1040			145	3.54	148.54	2.14		5/3/2001 4:22
1100			145	3.56	148.56	2.16		5/3/2001 5:22
1159			145	3.60	148.60	2.20		5/3/2001 6:21
1294			145	3.54	148.54	2.14		5/3/2001 8:36
1364			145	3.57	148.57	2.17		5/3/2001 9:46
1454			145	3.59	148.59	2.19		5/3/2001 11:16
1500			145	3.62	148.62	2.22		5/3/2001 12:02
1740			145	3.79	148.79	2.39		5/3/2001 16:02
1980			145	3.80	148.80	2.40		5/3/2001 20:02
2242			145	3.86	148.86	2.46		5/4/2001 0:24
2605			145	3.81	148.81	2.41		5/4/2001 6:27
2820			145	4.04	149.04	2.64		5/4/2001 10:02
3014			145	3.88	148.88	2.48	Silbernagel PPG	5/4/2001 13:16
3254			145	4.03	149.03	2.63	Silbernagel PPG	5/4/2001 17:16
3506			145	4.08	149.08	2.68		5/4/2001 21:28
4433			145	4.19	149.19	2.79		5/5/2001 12:55
4645			145	4.22	149.22	2.82	Silbernagel PPG	5/5/2001 16:27
4962			145	4.30	149.30	2.90	Haught & Silbernagel PPG	5/5/2001 21:44
5585			145	4.41	149.41	3.01	Haught & Silbernagel PPG	5/6/2001 8:07
5891			145	4.20	149.20	2.80	Haught & Silbernagel PPG	5/6/2001 13:13
6160			150	-0.13	149.87	3.47	Haught & Silbernagel PPG	5/6/2001 17:42
6380			150	-0.05	149.95	3.55	Haught & Silbernagel PPG	5/6/2001 21:22
7112			150	-0.30	149.70	3.30	No ppg at Silbernagel	5/7/2001 9:34
7488			150	-0.39	149.61	3.21	No ppg at Silbernagel	5/7/2001 15:50
7822			150	0.22	150.22	3.82	No ppg at Silbernagel	5/7/2001 21:24
8542			150	-0.15	149.85	3.45	No ppg at Silbernagel	5/8/2001 9:24
8802			150	0.04	150.04	3.64	No ppg at Silbernagel	5/8/2001 13:44
10221			150	0.55	150.55	4.15	Silbernagel PPG	5/9/2001 13:23
11658			150	1.20	151.20	4.80	Silbernagel PPG	5/10/2001 13:20
13140			150	0.08	150.08	3.68	Silbernagel PPG	5/11/2001 14:02
17436			150	-0.14	149.86	3.46	Silbernagel PPG	5/14/2001 13:38
20268			150	-0.05	149.95	3.55	Silbernagel PPG	5/16/2001 12:50
23148			150	0.17	150.17	3.77	No ppg at Silbernagel	5/18/2001 12:50
27562			150	2.16	152.16	5.76	Silbernagel PPG	5/21/2001 14:24
30388			150	3.02	153.02	6.62	No ppg at Silbernagel	5/23/2001 13:30
33240			150	2.11	152.11	5.71	Silbernagel PPG	5/25/2001 13:02
39078			150	0.73	150.73	4.33	No ppg at Silbernagel	5/29/2001 14:20
43348			150	3.41	153.41	7.01	No ppg at Silbernagel	6/1/2001 13:30
49120			150	2.73	152.71	6.31	ET NG#1	6/5/2001 13:42
53420			150	2.61	152.59	6.19	Silbernagel PPG	6/8/2001 13:22
57928			150	4.10	154.08	7.68	Silbernagel PPG	6/11/2001 16:30
63438			155	-0.37	154.61	8.21	Silbernagel PPG	6/15/2001 12:20
72400			155	0.91	155.89	9.49	Silbernagel PPG	6/21/2001 17:42
79414			155	2.48	157.46	11.06	Silbernagel PPG	6/26/2001 14:36
83695			155	2.45	157.43	11.03	Silbernagel PPG	6/29/2001 13:57

93771			155	3.12	158.10	11.70	No ppg at Silbernagel	7/6/2001 13:53
100945			155	3.87	158.85	12.45	No ppg at Silbernagel	7/11/2001 13:27
111033			160	-0.91	159.07	12.67	Silbernagel PPG	7/18/2001 13:35
119810			160	1.06	161.04	14.64	Silbernagel PPG	7/24/2001 15:52
129976			160	0.85	160.83	14.43	Silbernagel PPG	7/31/2001 17:18
141420			160	3.10	163.08	16.68	Silbernagel PPG	8/8/2001 16:02
150170			160	1.27	161.25	14.85	Silbernagel PPG	8/14/2001 17:52
161286			160	-0.41	159.57	13.17	Silbernagel PPG	8/22/2001 11:08
172878			160	0.19	160.17	13.77	No ppg at Silbernagel for 2 days	8/30/2001 12:20
183158			160	1.35	161.33	14.93	Silbernagel PPG	9/6/2001 15:40
191798			160	2.86	162.84	16.44	Silbernagel PPG	9/12/2001 15:40
204436			160	2.88	162.86	16.46	No ppg at Silbernagel	9/21/2001 10:18
210592			160	3.07	163.05	16.65	No ppg at Silbernagel	9/25/2001 16:54
222097			160	2.76	162.74	16.34	No ppg at Silbernagel	10/3/2001 16:39
233315			160	3.21	163.19	16.79	No ppg at Silbernagel	#############
240961			160	3.37	163.35	16.95	No ppg at Silbernagel	#############
243243			160	3.40	163.40	17.00	ET MZ	10/18/2001 9:05
243353			160	3.38	163.38	16.98	169 days	#############
243359	1	243359	160	2.16	162.16	15.76	Well Shut off @ 11:00	#############
243360	2	121680	160	2.20	162.20	15.80		#############
243361	3	81120	160	2.18	162.18	15.78		#############
243362	4	60841	160	2.15	162.15	15.75		#############
243363	5	48673	160	2.12	162.12	15.72		#############
243364	6	40561	160	2.11	162.11	15.71		#############
243365	7	34766	160	2.10	162.10	15.70		#############
243366	8	30421	160	2.10	162.10	15.70		#############
243367	9	27041	160	2.08	162.08	15.68		#############
243368	10	24337	160	2.07	162.07	15.67		#############
243370	12	20281	160	2.03	162.03	15.63		#############
243372	14	17384	160	1.99	161.99	15.59		#############
243374	16	15211	160	1.99	161.99	15.59		#############
243376	18	13521	160	2.01	162.01	15.61		#############
243378	20	12169	160	1.96	161.96	15.56		#############
243380	22	11063	160	1.94	161.94	15.54		#############
243382	24	10141	160	1.96	161.96	15.56		#############
243384	26	9361	160	1.91	161.91	15.51		#############
243386	28	8692	160	1.91	161.91	15.51		#############
243388	30	8113	160	1.90	161.90	15.50		#############
243393	35	6954	160	1.88	161.88	15.48		#############
243398	40	6085	160	1.87	161.87	15.47		#############
243403	45	5409	160	1.84	161.84	15.44		#############
243408	50	4868	160	1.81	161.81	15.41		#############
243413	55	4426	160	1.79	161.79	15.39		#############
243418	60	4057	160	1.78	161.78	15.38		#############
243428	70	3478	160	1.77	161.77	15.37		#############
243438	80	3043	160	1.75	161.75	15.35		#############
243448	90	2705	160	1.73	161.73	15.33		#############
243458	100	2435	160	1.69	161.69	15.29		#############
243468	110	2213	160	1.68	161.68	15.28		#############
243478	120	2029	160	1.63	161.63	15.23		#############
243488	130	1873	160	1.61	161.61	15.21		#############
243498	140	1739	160	1.60	161.60	15.20		#############
243508	150	1623	160	1.56	161.56	15.16		#############
243518	160	1522	160	1.54	161.54	15.14		#############

243538	180	1353	160	1.52	161.52	15.12		#############
243558	200	1218	160	1.48	161.48	15.08		#############
243578	220	1107	160	1.44	161.44	15.04		#############
243598	240	1015	160	1.43	161.43	15.03		#############
243658	300	812	160	1.33	161.33	14.93		#############
243718	360	677	160	1.24	161.24	14.84		#############
243778	420	580	160	1.14	161.14	14.74		#############
243838	480	508	160	1.08	161.08	14.68		#############
243898	540	452	160	1.00	161.00	14.60		#############
243958	600	407	160	0.93	160.93	14.53		#############
244018	660	370	160	0.88	160.88	14.48		#############
244154	796	307	160	0.73	160.73	14.33		10/19/2001 0:16
244245	887	275	160	0.63	160.63	14.23		10/19/2001 1:47
244319	961	254	160	0.56	160.56	14.16		10/19/2001 3:01
244410	1052	232	160	0.46	160.46	14.06		10/19/2001 4:32
244499	1141	214	160	0.40	160.40	14.00		10/19/2001 6:01
244678	1320	185	160	0.25	160.25	13.85		10/19/2001 9:00
244858	1500	163	160	0.11	160.11	13.71		#############
245038	1680	146	160	0.01	160.01	13.61		#############
245218	1860	132	160	-0.05	159.95	13.55		#############
245664	2306	107	160	-0.08	159.92	13.52		10/20/2001 1:26
246033	2675	92	160	-0.19	159.81	13.41		10/20/2001 7:35
246178	2820	87	160	-0.23	159.77	13.37		#############
246418	3060	81	160	-0.28	159.72	13.32		#############
246693	3335	74	160	-0.28	159.72	13.32		#############
247662	4304	58	160	-0.27	159.73	13.33		#############
248128	4770	52	160	-0.26	159.74	13.34		#############
249079	5721	44	160	-0.21	159.79	13.39		#############
249604	6246	40	160	-0.22	159.78	13.38		#############
250548	7190	35	160	-0.10	159.90	13.50		#############
250964	7606	33	160	-0.08	159.92	13.52		#############
252005	8647	29	160	0.00	160.00	13.60		#############
252426	9068	28	160	0.01	160.01	13.61		#############
253466	10108	25	160	0.13	160.13	13.73		#############
259430	16072	16	160	0.58	160.58	14.18	no adjustment for PST	#############
262434	19076	14	160	0.82	160.82	14.42		#############
263963	20605	13	160	0.96	160.96	14.56		11/1/2001 18:25
271188	27830	10	160	1.13	161.13	14.73	ET NG#1	11/6/2001 18:50
272591	29233	9	160	0.90	160.90	14.50		11/7/2001 18:13
274022	30664	9	160	0.66	160.66	14.26		11/8/2001 18:04
274925	31567	9	160	0.55	160.55	14.15		11/9/2001 9:07
275471	32113	9	160	0.44	160.44	14.04		11/9/2001 18:13
285223	41865	7	160	-0.38	159.62	13.22		#############
291108	47750	6	160	-0.74	159.26	12.86		#############
311158	67800	5	160	-1.15	158.85	12.45		12/4/2001 13:00
325374	82016	4	155	2.92	157.92	11.52		12/14/2001 9:56
334226	90868	4	155	2.11	157.11	10.71		#############
361875	118517	3	155	0.64	155.64	9.24		1/8/2002 18:17
365959	122601	3	155	0.48	155.48	9.08		1/11/2002 14:21
393413	150055	3	155	-0.51	154.49	8.09	1/30/2002	1/30/2002 15:55
433738	190380	2	155	-1.71	153.29	6.89	132 days since shut off	2/27/2002 16:00
456565	213205	2	150	2.78	152.78	6.38		3/15/2002 12:27
485638	242280	2	150	2.30	152.30	5.90		4/4/2002 17:00
514080	270722	2	150	1.72	151.72	5.32		4/24/2002 11:02

527148	283790	2	150	1.05	151.05	4.65	366 days total	5/3/2002 12:50
546152	302792	2	150	0.08	150.08	3.68		5/16/2002 17:34
567353	323995	2	150	-0.68	149.32	2.92	394 days	5/31/2002 10:55
604993	361635	2	150	-2.04	147.96	1.56	420 days	6/26/2002 14:15
665648	422170	2	150	2.25	152.25	5.85		8/7/2002 17:10
688360	445002	2	155	0.42	155.42	9.02		8/23/2002 11:42
737453	494095	1	160	1.26	161.26	14.86		9/26/2002 13:55
779153	535795	1	160	-0.76	159.24	12.84	TID wells off	#############

Sherman Taylor Well Aquifer Test Data

MINUTES-start	Minutes-stop	Ratio t/t'	HOLD	CUT	Water level	Drawdown	Comments	Clock time of measurement
			135	2.02	137.02	-0.01	Pre test meas - 5/1/01 @ 14:40	5/1/2001 14:40
			135	2.12	137.12	0.09	Pre test meas - 5/1/01 @ 18:00	5/1/2001 18:00
			135	2.03	137.03	0.00	Pre test meas @ 10:58	5/2/2001 10:58
0			135	2.03	137.03	0.00	5/2/2001 11:02	5/2/2001 11:00
3			135	2.04	137.04	0.01	ppg start at 11:02	5/2/2001 11:05
8			135	2.06	137.06	0.03	adjust time steps	5/2/2001 11:10
12			135	2.08	137.08	0.05		5/2/2001 11:14
14			135	2.09	137.09	0.06		5/2/2001 11:16
16			135	2.10	137.10	0.07		5/2/2001 11:18
18			135	2.10	137.10	0.07		5/2/2001 11:20
20			135	2.11	137.11	0.08		5/2/2001 11:22
22			135	2.11	137.11	0.08		5/2/2001 11:24
24			135	2.11	137.11	0.08		5/2/2001 11:26
26			135	2.12	137.12	0.09		5/2/2001 11:28
28			135				Bad signal-replace Battery	5/2/2001 11:30
40			135	2.15	137.15	0.12	Good reading	5/2/2001 11:42
43			135	2.16	137.16	0.13		5/2/2001 11:45
48			135	2.17	137.17	0.14		5/2/2001 11:50
53			135	2.17	137.17	0.14		5/2/2001 11:55
58			135	2.18	137.18	0.15		5/2/2001 12:00
63			135	2.19	137.19	0.16		5/2/2001 12:05
68			135	2.20	137.20	0.17	Domestic ppg 2 minutes after meas	5/2/2001 12:10
73			135	2.20	137.20	0.17	Recent ppg	5/2/2001 12:15
74			135	2.20	137.20	0.17		5/2/2001 12:16
76			135	2.21	137.21	0.18		5/2/2001 12:18
78			135	2.21	137.21	0.18		5/2/2001 12:20
83			135	2.22	137.22	0.19		5/2/2001 12:25
88			135	2.22	137.22	0.19		5/2/2001 12:30
93			135	2.22	137.22	0.19		5/2/2001 12:35
98			135	2.23	137.23	0.20		5/2/2001 12:40
103			135	2.23	137.23	0.20		5/2/2001 12:45
108			135	2.24	137.24	0.21	Domestic ppg 1 minute after meas	5/2/2001 12:50
114			135	2.24	137.24	0.21		5/2/2001 12:56
118			135	2.25	137.25	0.22		5/2/2001 13:00
128			135	2.26	137.26	0.23		5/2/2001 13:10
138			135	2.27	137.27	0.24		5/2/2001 13:20
148			135	2.27	137.27	0.24		5/2/2001 13:30
158			135	2.28	137.28	0.25		5/2/2001 13:40
168			135	2.29	137.29	0.26		5/2/2001 13:50
178			135	2.29	137.29	0.26		5/2/2001 14:00
188			135	2.30	137.30	0.27		5/2/2001 14:10
198			135	2.32	137.32	0.29		5/2/2001 14:20
208			135	2.34	137.34	0.31		5/2/2001 14:30
218			135	2.34	137.34	0.31		5/2/2001 14:40
228			135	2.35	137.35	0.32		5/2/2001 14:50
238			135	2.35	137.35	0.32		5/2/2001 15:00
296			135	2.39	137.39	0.36		5/2/2001 15:58
360			135	2.43	137.43	0.40		5/2/2001 17:02
430			135	2.47	137.47	0.44		5/2/2001 18:12
490			135	2.50	137.50	0.47		5/2/2001 19:12
550			135	2.53	137.53	0.50		5/2/2001 20:12

610			135	2.56	137.56	0.53		5/2/2001 21:12
664			135	2.59	137.59	0.56		5/2/2001 22:06
733			135	2.64	137.64	0.61		5/2/2001 23:15
874			135	2.68	137.68	0.65		5/3/2001 1:36
934			135	2.69	137.69	0.66		5/3/2001 2:36
989			135	2.71	137.71	0.68		5/3/2001 3:31
1049			135	2.73	137.73	0.70		5/3/2001 4:31
1108			135	2.74	137.74	0.71		5/3/2001 5:30
1166			135	2.76	137.76	0.73		5/3/2001 6:28
1301			135	2.81	137.81	0.78	Domestic ppg after meas	5/3/2001 8:43
1372			135	2.83	137.83	0.80		5/3/2001 9:54
1492			135	2.86	137.86	0.83		5/3/2001 11:54
1770			135	2.92	137.92	0.89		5/3/2001 16:32
1987			135	2.97	137.97	0.94		5/3/2001 20:09
2252			135	3.03	138.03	1.00		5/4/2001 0:34
2618			135	3.09	138.09	1.06		5/4/2001 6:40
2828			135	3.14	138.14	1.11		5/4/2001 10:10
3020			135	3.17	138.17	1.14		5/4/2001 13:22
3266			135	3.20	138.20	1.17		5/4/2001 17:28
3513			135	3.25	138.25	1.22		5/4/2001 21:35
4443			135	3.38	138.38	1.35	Recent domestic use	5/5/2001 13:05
4663			135	3.40	138.40	1.37	RP-pump off for 4 min Dom.watering	5/5/2001 16:45
4971			135	3.45	138.45	1.42		5/5/2001 21:53
5596			135	3.52	138.52	1.49		5/6/2001 8:18
5899			135	3.53	138.53	1.50		5/6/2001 13:21
6173			135	3.89	138.89	1.86		5/6/2001 17:55
6391			135	4.18	139.18	2.15		5/6/2001 21:33
7123			135	3.97	138.97	1.94		5/7/2001 9:45
7498			135	3.90	138.90	1.87	Domestic well in use	5/7/2001 16:00
7848			135	4.43	139.43	2.40		5/7/2001 21:50
8558			135	4.12	139.12	2.09		5/8/2001 9:40
8812			135	4.20	139.20	2.17		5/8/2001 13:54
10229			140	-0.20	139.80	2.77		5/9/2001 13:31
11651			140	0.61	140.61	3.58	RP-pump off for 6 min, Dom.watering	5/10/2001 13:13
13150			140	-0.56	139.44	2.41		5/11/2001 14:12
17449			135	4.15	139.15	2.12		5/14/2001 13:51
20282			140	-0.81	139.19	2.16		5/16/2001 13:04
23166			140	-0.66	139.34	2.31		5/18/2001 13:08
27576			140	1.25	141.25	4.22		5/21/2001 14:38
30404			140	2.16	142.16	5.13	Domestic use-wait a few minutes	5/23/2001 13:46
33260			140	1.47	141.47	4.44	Domestic use-wait a few minutes	5/25/2001 13:22
39093			140	0.78	140.78	3.75	Domestic use-wait a few minutes	5/29/2001 14:35
43373			140	2.49	142.49	5.46		6/1/2001 13:55
49138			140	2.07	142.07	5.04		6/5/2001 14:00
53446			140	1.81	141.81	4.78		6/8/2001 13:48
57910			140	3.11	143.11	6.08		6/11/2001 16:12
63466			140	3.86	143.86	6.83	Domestic use-wait a few minutes	6/15/2001 12:48
72380			145	-0.04	144.96	7.93	Domestic use-wait a few minutes	6/21/2001 17:22
79430			145	1.66	146.66	9.63		6/26/2001 14:52
83710			145	1.60	146.60	9.57	Domestic use-wait a few minutes	6/29/2001 14:12
93780			145	2.18	147.18	10.15	Halousek south well ppg	7/6/2001 14:02
100958			145	2.82	147.82	10.79		7/11/2001 13:40
111045			145	3.16	148.16	11.13	Halousek south well ppg	7/18/2001 13:47
119828			150	-0.04	149.96	12.93	Halousek south well ppg	7/24/2001 16:10

130008			150	-0.18	149.82	12.79	No ppg at Halousek south well	7/31/2001 17:50
141440			150	2.20	152.20	15.17		8/8/2001 16:22
151230			150	-0.15	149.85	12.82	No ppg at Halousek south well	8/15/2001 11:32
161303			150	-1.35	148.65	11.62	No ppg at Halousek south well	8/22/2001 11:25
172890			150	-0.80	149.20	12.17	No ppg at Halousek south well	8/30/2001 12:32
183174			150	0.45	150.45	13.42		9/6/2001 15:56
191814			150	1.93	151.93	14.90	Jones well ppg	9/12/2001 15:56
204450			150	1.96	151.96	14.93	Jones well ppg	9/21/2001 10:32
210610			150	2.16	152.16	15.13	No ppg at Jones well	9/25/2001 17:12
222086			150	1.86	151.86	14.83	No ppg at Jones well	10/3/2001 16:28
233343			150	2.26	152.26	15.23	RP - off for 5 min before meas	10/11/2001 12:05
240949			150	2.44	152.44	15.41		10/16/2001 18:51
243292			150	2.47	152.47	15.44		10/18/2001 9:54
243333			150	2.46	152.46	15.43		10/18/2001 10:35
243358	0		150	2.46	152.46	15.43	SHUT Pump Off @ 11:00 10/18/01	10/18/2001 11:00
243363	5	48672.6	150	2.45	152.45	15.42		10/18/2001 11:05
243368	10	24336.8	150	2.42	152.42	15.39		10/18/2001 11:10
243373	15	16224.9	150	2.40	152.40	15.37		10/18/2001 11:15
243378	20	12168.9	150	2.39	152.39	15.36		10/18/2001 11:20
243383	25	9735.3	150	2.37	152.37	15.34		10/18/2001 11:25
243388	30	8112.9	150	2.35	152.35	15.32		10/18/2001 11:30
243393	35	6954.1	150	2.33	152.33	15.30		10/18/2001 11:35
243398	40	6085.0	150	2.32	152.32	15.29		10/18/2001 11:40
243403	45	5409.0	150	2.30	152.30	15.27		10/18/2001 11:45
243408	50	4868.2	150	2.29	152.29	15.26		10/18/2001 11:50
243413	55	4425.7	150	2.28	152.28	15.25		10/18/2001 11:55
243418	60	4057.0	150	2.28	152.28	15.25		10/18/2001 12:00
243428	70	3477.5	150	2.24	152.24	15.21		10/18/2001 12:10
243438	80	3043.0	150	2.20	152.20	15.17		10/18/2001 12:20
243448	90	2705.0	150	2.20	152.20	15.17		10/18/2001 12:30
243458	100	2434.6	150	2.16	152.16	15.13		10/18/2001 12:40
243468	110	2213.3	150	2.14	152.14	15.11		10/18/2001 12:50
243478	120	2029.0	150	2.12	152.12	15.09		10/18/2001 13:00
243488	130	1873.0	150	2.10	152.10	15.07		10/18/2001 13:10
243498	140	1739.3	150	2.09	152.09	15.06		10/18/2001 13:20
243508	150	1623.4	150	2.07	152.07	15.04		10/18/2001 13:30
243518	160	1522.0	150	2.03	152.03	15.00		10/18/2001 13:40
243528	170	1432.5	150	2.02	152.02	14.99		10/18/2001 13:50
243538	180	1353.0	150	2.00	152.00	14.97		10/18/2001 14:00
243548	190	1281.8	150	1.99	151.99	14.96		10/18/2001 14:10
243558	200	1217.8	150	1.97	151.97	14.94		10/18/2001 14:20
243568	210	1159.8	150	1.94	151.94	14.91		10/18/2001 14:30
243578	220	1107.2	150	1.93	151.93	14.90		10/18/2001 14:40
243588	230	1059.1	150	1.92	151.92	14.89		10/18/2001 14:50
243598	240	1015.0	150	1.90	151.90	14.87		10/18/2001 15:00
243671	313	778.5	150	1.77	151.77	14.74		10/18/2001 16:13
243728	370	658.7	150				PPG - No meas	10/18/2001 17:10
243790	432	564.3	150	1.59	151.59	14.56		10/18/2001 18:12
243849	491	496.6	150	1.50	151.50	14.47		10/18/2001 19:11
243911	553	441.1	150	1.42	151.42	14.39		10/18/2001 20:13
243969	611	399.3	150	1.35	151.35	14.32		10/18/2001 21:11
244029	671	363.7	150	1.27	151.27	14.24		10/18/2001 22:11
244146	788	309.8	150	1.15	151.15	14.12		10/19/2001 0:08
244236	878	278.2	150	1.06	151.06	14.03		10/19/2001 1:38

244330	972	251.4	150	0.96	150.96	13.93		10/19/2001 3:12
244421	1063	229.9	150	0.86	150.86	13.83		10/19/2001 4:43
244508	1150	212.6	150	0.79	150.79	13.76		10/19/2001 6:10
244691	1333	183.6	150	0.63	150.63	13.60		10/19/2001 9:13
244872	1514	161.7					PPG - No meas	10/19/2001 12:14
244948	1590	154.1	150	0.43	150.43	13.40		10/19/2001 13:30
245053	1695	144.6	150	0.37	150.37	13.34		10/19/2001 15:15
245233	1875	130.8	150	0.29	150.29	13.26		10/19/2001 18:15
245654	2296	107.0	150	0.19	150.19	13.16		10/20/2001 1:16
246028	2670	92.1	150	0.11	150.11	13.08		10/20/2001 7:30
246193	2835	86.8	150	0.09	150.09	13.06		10/20/2001 10:15
246433	3075	80.1	150	0.05	150.05	13.02		10/20/2001 14:15
246684	3326	74.2	150	0.03	150.03	13.00	recent domestic ppg	10/20/2001 18:26
247670	4312	57.4	150	0.02	150.02	12.99		10/21/2001 10:52
248137	4779	51.9	150	0.04	150.04	13.01		10/21/2001 18:39
249084	5726	43.5	150	0.09	150.09	13.06		10/22/2001 10:26
249612	6254	39.9	150	0.09	150.09	13.06		10/22/2001 19:14
250552	7194	34.8	150	0.20	150.20	13.17		10/23/2001 10:54
250972	7614	33.0	150	0.23	150.23	13.20		10/23/2001 17:54
252010	8652	29.1	150	0.32	150.32	13.29		10/24/2001 11:12
252420	9062	27.9	150	0.34	150.34	13.31		10/24/2001 18:02
253458	10100	25.1	150	0.45	150.45	13.42		10/25/2001 11:20
259440	16082	16.1	150	0.94	150.94	13.91	No clock adjustment for Standard time	10/29/2001 15:02
262443	19085	13.8	150	1.15	151.15	14.12		10/31/2001 17:05
263981	20623	12.8	150	1.28	151.28	14.25		11/1/2001 18:43
271178	27820	9.7	150	1.45	151.45	14.42		11/6/2001 18:40
272581	29223	9.3	150	1.22	151.22	14.19	TID #6 off Nov. 5th at 9:00 am.	11/7/2001 18:03
275460	32102	8.6	150	0.74	150.74	13.71	TID #6 off	11/9/2001 18:02
285256	41898	6.8	150	-0.10	149.90	12.87		11/16/2001 13:18
291075	47717	6.1	150	-0.46	149.54	12.51		11/20/2001 14:17
311098	67740	4.6	150	-0.87	149.13	12.10		12/4/2001 12:00
325420	82062	4.0	145	3.24	148.24	11.21		12/14/2001 10:42
334262	90904	3.7	145	2.45	147.45	10.42		12/20/2001 14:04
361803	118445	3.1	145	1.06	146.06	9.03		1/8/2002 17:05
365992	122634	3.0	145	0.92	145.92	8.89	1/11/2002	1/11/2002 14:54
393450	150092	2.6	145	-0.07	144.93	7.90		1/30/2002 16:32
433766	190408	2.3	145	-1.22	143.78	6.75	132 days since shut off	2/27/2002 16:28
456596	213238	2.1	140	3.35	143.35	6.32		3/15/2002 12:58
485663	242305	2.0	140	2.88	142.88	5.85		4/4/2002 17:25
514148	270790	1.9	140	2.28	142.28	5.25		4/24/2002 12:10
527170	283812	1.9	140	1.61	141.61	4.58		5/3/2002 13:12
546123	302765	1.8	140	0.64	140.64	3.61		5/16/2002 17:05
567380	324022	1.8	140	-0.33	139.67	2.64	used ET#1 - ET#3=bad signal	5/31/2002 11:22
605028	361670	1.7	140	-1.74	138.26	1.23	6/26/02 = 251 days since shut off	6/26/2002 14:50
688398	445040	1.5	145	0.66	145.66	8.63	ET Corr = 450 ft.	8/23/2002 12:20

Appendix C

Selected Shasta View Project Well Data

Selected Shasta View Project Well Data

DATE	Date of water level measuremen
WL BLSD	Water Level Below Land Surface Datum
COMMENTS	Miscellaneous Comments about measuremen
WL ELEV	Water Level Elevation (surveyed to 0.1 foot

KLAM 14829 - State Obs well #1162 - T40S/R12E-30cda

DATE	WL BLSD	COMMENTS	WL ELEV
5/20/1998	218.63	ST OBS MEAS	4024.8
9/10/1998	225.63	Data collected for Bonanza Project	4017.8
11/17/1998	223.07		4020.3
2/3/1999	218.90	SVID	4024.5
2/17/1999	218.87	ST OBS MEAS	4024.5
3/15/1999	217.61	SVID	4025.8
3/29/1999	216.88	SVID-PRE PUMP TEST	4026.5
5/18/1999	218.92	ST OBS MEAS	4024.5
10/12/1999	224.73	SVID	4018.7
10/25/1999	223.29	SVID	4020.1
11/17/1999	220.37	ST OBS MEAS	4023.0
1/7/2000	218.28	SVID	4025.1
2/14/2000	216.20	ST OBS MEAS	4027.2
3/17/2000	215.78	SVID	4027.6
4/12/2000	215.58	SVID	4027.8
5/16/2000	216.33	ST OBS MEAS	4027.1
6/27/2000	220.64	Pump off for 4 hrs before meas	4022.8
11/14/2000	221.89		4021.5
11/16/2000	221.46	ST OBS MEAS	4021.9
1/11/2001	219.29	SVID	4024.1
2/15/2001	217.59	ST OBS MEAS	4025.8
3/23/2001	217.83		4025.6
5/15/2001	225.09	ST OBS MEAS	4018.3
6/15/2001	229.45		4014.0
7/24/2001	235.71	Pump off for 1/2 hour	4007.7
9/11/2001	240.39		4003.0
10/21/2001	235.47		4007.9
11/8/2001	233.86		4009.5
11/14/2001	233.43	ST OBS MEAS	4010.0
1/9/2002	230.81		4012.6
2/20/2002	229.51	ST OBS MEAS	4013.9
4/5/2002	227.66		4015.7
5/22/2002	230.83		4012.6
8/8/2002	235.26	Pump off for 4 hrs before meas	4008.1
8/12/2002	234.68	ST OBS MEAS	4008.7
10/1/2002	238.90		4004.5

KLAM 51795 - Dan Rajnus - T40S/R11E-25aat

DATE	WL BLSD	COMMENTS	WL ELEV
11/20/1998	251.45	NO PUMP IN WELL	4025.5
2/5/1999	249.36		4027.5
4/20/1999	246.97		4029.9
5/13/1999	246.52		4030.4
10/13/1999	249.87		4027.0
1/6/2000	247.76		4029.1
3/17/2000	245.86		4031.0
4/14/2000	244.97		4031.9
6/28/2000	246.13		4030.8
9/1/2000	249.74		4027.2
11/16/2000	249.94		4027.0
1/11/2001	248.20		4028.7
3/23/2001	246.63		4030.3
5/7/2001	246.96		4029.9
6/15/2001	250.42		4026.5
7/25/2001	255.07		4021.8
9/11/2001	259.36		4017.5
10/21/2001	260.25		4016.7
11/8/2001	260.38		4016.5
1/9/2002	259.21		4017.7
4/5/2002	256.99		4019.9
6/26/2002	257.41		4019.5
8/22/2002	259.70		4017.2
10/1/2002	261.37		4015.5

KLAM 15052 - State Obs well #294 - T41S/R12E-03cba

DATE	WL BLSD	COMMENTS	WL ELEV
6/11/1998	2.67	Well head elevation not surveyed	
11/20/1998	2.77	Pump cycles	
2/4/1999	2.56	Pump cycles	
4/1/1999	2.73		
5/12/1999	2.92		
10/11/1999	3.27		
1/5/2000	3.24		
3/16/2000	2.56		
4/27/2000	2.81		
6/28/2000	3.26	Recent ppg	
8/31/2000	3.10		
11/16/2000	3.23		
1/4/2001	3.08		
3/22/2001	3.07		
5/8/2001	3.83		
7/24/2001	6.50		
8/30/2001	4.76		
10/20/2001	4.95		
1/9/2002	3.15		
4/5/2002	3.71		
5/22/2002	2.92		
8/8/2002	2.92		

KLAM 51611 - McVay Shasta View Produce - T41S/R12E-09ba

DATE	WL BLSD	COMMENTS	WL ELEV
6/12/1998	55.52	Oil - use Steel Tape	4029.7
10/1/1998	53.49	No Oil	4031.7
11/18/1998	54.91		4030.3
2/4/1999	56.00		4029.2
4/1/1999	55.61		4029.6
5/12/1999	55.02		4030.2
10/13/1999	52.46	Flow meter removed	4032.7
1/6/2000	55.45		4029.8
3/17/2000	56.03		4029.2
4/13/2000	55.88		4029.3
4/28/2000	55.80		4029.4
6/26/2000	54.76	Flow meter installed	4030.4
8/31/2000	53.57		4031.6
11/16/2000	53.88		4031.3
1/11/2001	54.72		4030.5
3/23/2001	55.91		4029.3
5/4/2001	58.18		4027.0
6/14/2001	64.22		4021.0
7/24/2001	70.44		4014.8
9/11/2001	73.75		4011.5
10/22/2001	73.92	TID #6 ppg	4011.3
11/8/2001	75.59		4009.6
12/4/2001	72.86		4012.3
1/9/2002	70.02		4015.2
2/27/2002	67.75		4017.5
4/5/2002	66.79		4018.4
5/20/2002	63.05		4022.2
6/26/2002	59.92		4025.3
8/21/2002	67.89	TID #6 ppg	4017.3
10/1/2002	75.34	TID #6 ppg	4009.9