

Groundwater Application Review Summary Form

Application # G- 18594

GW Reviewer D. BOSCHMANN Date Review Completed: 8/30/2018

Summary of GW Availability and Injury Review:

Groundwater for the proposed use is either over appropriated, will not likely be available in the amounts requested without injury to prior water rights, OR will not likely be available within the capacity of the groundwater resource per Section B of the attached review form.

Summary of Potential for Substantial Interference Review:

There is the potential for substantial interference per Section C of the attached review form..

Summary of Well Construction Assessment:

The well does not appear to meet current well construction standards per Section D of the attached review form. Route through Well Construction and Compliance Section.

at 8/30/18

This is only a summary. Documentation is attached and should be read thoroughly to understand the basis for determinations and for conditions that may be necessary for a permit (if one is issued).



MEMO

To: Kristopher Byrd, Well Construction and Compliance Section Manager
From: Joel Jeffery, Well Construction Program Coordinator
Subject: Review of Water Right Application G-18594
Date: August 31, 2018

The attached application was forwarded to the Well Construction and Compliance Section by Water Rights. Darrick Boschmann reviewed the application. Please see Darrick's Groundwater Review and the Well Information Reports.

Applicant's Well SVE #1 (LAKE 52530): The only reports that exist for this well are a Department generated information report and an oil or gas well lithographic description. A Water Supply Well Report does not exist. Because there is no water supply well report certified by a licensed well constructor for this well, the Department is not able to determine if the construction of the well meets minimum well construction standards. (See OAR 690 Division 210).

My recommendation is that the Department **not issue** a permit for Applicant's Well SVE #1 (LAKE 52530) unless it is brought into compliance with current minimum well construction standards or information is provided showing that it is in compliance with current minimum well construction standards.

Applicant's Well SVE #2 (LAKE 52529): The only reports that exist for this well are a Department generated information report and an oil or gas well lithographic description. A Water Supply Well Report does not exist. Because there is no water supply well report certified by a licensed well constructor for this well, the Department is not able to determine if the construction of the well meets minimum well construction standards. (See OAR 690 Division 210).

My recommendation is that the Department **not issue** a permit for Applicant's Well SVE #2 (LAKE 52529) unless it is brought into compliance with current minimum well construction standards or information is provided showing that it is in compliance with current minimum well construction standards.

Applicant's Well SVE #3 (LAKE 52812): The only reports that exist for this well are a Department generated information report, an oil or gas well lithographic description, and an oil or gas well summary report. A Water Supply Well Report does not exist. Because there is no water supply well report certified by a licensed well constructor for this well, the Department is not able to determine if the construction of the well meets minimum well construction standards. (See OAR 690 Division 210).

My recommendation is that the Department **not issue** a permit for Applicant's Well SVE #3 (LAKE 52812) unless it is brought into compliance with current minimum well construction standards or information is provided showing that it is in compliance with current minimum well construction standards.

Bringing Applicant's Wells SVE #1, SVE #2 and SVE #3 into compliance with minimum well construction standards may not satisfy hydraulic connection issues.

PUBLIC INTEREST REVIEW FOR GROUNDWATER APPLICATIONS

TO: Water Rights Section Date 08/30/2018
 FROM: Groundwater Section Darrick E. Boschmann
Reviewer's Name
 SUBJECT: Application G-18594 Supersedes review of N.A.
Date of Review(s)

PUBLIC INTEREST PRESUMPTION; GROUNDWATER

OAR 690-310-130 (1) *The Department shall presume that a proposed groundwater use will ensure the preservation of the public welfare, safety and health as described in ORS 537.525. Department staff review groundwater applications under OAR 690-310-140 to determine whether the presumption is established. OAR 690-310-140 allows the proposed use be modified or conditioned to meet the presumption criteria. This review is based upon available information and agency policies in place at the time of evaluation.*

A. GENERAL INFORMATION: Applicant's Name: Surprise Valley Electrification Corp County: Lake

A1. Applicant(s) seek(s) 6.68 cfs from 2 well(s) in the Goose & Summer Lakes Basin,
Summer Lake/Lake Abert subbasin

A2. Proposed use: 6.68cfs (3000gpm)* INDUSTRIAL/POWER DEVELOPMENT FROM GEOTHERMAL FLUID
 Seasonality: year round

A3. Well and aquifer data (attach and number logs for existing wells; mark proposed wells as such under logid):

Well	Logid	Applicant's Well #	Proposed Aquifer*	Proposed Rate(cfs)	Location (T/R-S QQ-Q)	Location, metes and bounds, e.g. 2250' N, 1200' E fr NW cor S 36
1	LAKE 52530 (production well)	SVE#1	Volcanic rock aquifer unit	2.67 (1200gpm)**	33.00S-18.00E-23-NW SW	2090 FT N AND 1275 FT E FROM SW CORNER OF SECTION 23
2	LAKE 52529 (production well)	SVE#2	Volcanic rock aquifer unit	5.12 (2300gpm)**	33.00S-18.00E-23-SW NE	2665 FT N AND 1725 FT W FROM SE CORNER OF SECTION 23
3	LAKE 52812 (injection well)	SVE#3	Volcanic rock aquifer unit	-6.68(3000gpm)***	33.00S-18.00E-24-SW NW	2220 FT S AND 1190 FT E FROM NW CORNER OF SECTION 24
4						
5						

* Alluvium, CRB, Bedrock

Well	Well Elev ft msl	First Water ft bls	SWL ft bls	SWL Date	Well Depth (ft)	Seal Interval (ft)	Casing Intervals (ft)	Liner Intervals (ft)	Perforations Or Screens (ft)	Well Yield (gpm)	Draw Down (ft)	Test Type
****1	4490	75-105	140	?	1360	0-900	0-900	806-1310	806-1310	1300	?	?
****2	4472	?	131	?	1260	0-495	0-495	445-1210	445-1210	2500	?	?
****3	4417	?	106	?	2705	0-602	0-602	490-2692	2580-2692	2200	?	?

Use data from application for proposed wells.

A4. **Comments:** _____

Note: This application is generally identical to LL-1726.

This application proposes to produce low-temperature geothermal fluids (bottom hole temperature <250°F) from two wells in the Goose and Summer Lakes Basin. The application states that all fluids produced from the two proposed wells (4838 acre feet annually) will be supplied to a binary cycle geothermal power plant by way of pipelines from the well to the plant, and after passing through the plant will be delivered by way of pipelines to an injection well and returned to the same source aquifer from which they were produced, resulting in an open-loop non-consumptive cycle.

The proposed wells are located in Lake County just outside the city of Paisely along the Chewaucan River. The area immediately underlying the wells was mapped by Walker (1963) as QTs (sedimentary deposits) which are described as lacustrine, fluvialite, and aeolian sedimentary rocks, interstratified tuff, ash diatomite, and unconsolidated clay, sand, silt, and gravel. Proposed production well SVE#1 is located very near the contact with the underlying unit TvB (basalt flows). Also mapped in the vicinity of the wells underlying the QTs unit are Ttf (tuff of rhyolitic and dacitic composition, tuffaceous sedimentary rocks, and aerially restricted rhyodacitic and andesitic rocks), and Taf (tuff, tuff, breccia, tuffaceous sedimentary rocks, gray and reddish claystones, hornblende andesite flows and less abundant altered basalt flows). Walker's 1963 map explanation indicates that the stratigraphic relation between unit TvB and the Ttf/Taf units cannot be implied by stratigraphic position; therefore their relative stratigraphic relation is unknown.

The two production wells are located within the Summer Lake Hot Springs Known Geothermal Resource Area (KGRA) (Muffler, 1979) and the injection well just outside of the KGRA boundary. The geothermal system discharges to the surface at several natural hot springs and has an estimated mean reservoir temperature of $118 \pm 6^\circ\text{C}$ ($\sim 245^\circ\text{F}$) (Muffler, 1979). The geologic and structural setting of the area strongly suggests the geothermal system here is analogous to other structurally-controlled geothermal systems of the Great Basin, wherein upwelling of geothermal fluids in most systems is not related to upper crustal magmatic heat sources, but is instead related to crustal extension, faulting, and high heat flow (e.g. Coolbaugh, 2005; Faulds, 2015).

SVE#1: Formation descriptions for proposed production well SVE#1 (LAKE 52530) depict an interval from 0 to 530 comprised of predominantly unconsolidated gravels, sands, and clay which is likely correlative with Walker's QTs unit. This interval is underlain from 530 to 1360 (TD) by a series of altered/mineralized volcanic deposits including basalt, andesite, rhyolite, tuff, ash, pumice, and cinders, which is likely correlative with Walker's Ttf/Taf and/or Tvb unit. Note that the interval from 1080 to 1360 (TD) was a lost circulation zone with intermittent sample recovery from uncertain depths, however all samples recovered through this interval are volcanic. The well is continuously cased and continuously sealed through the QTs sedimentary unit into the underlying volcanic rock aquifer unit.

Proposed production well SVE#1 (LAKE 52530) has a reported bottom-hole temperature of 239.2°F .

SVE#2: Formation descriptions for proposed production well SVE#2 (LAKE 52529) depict an interval from 0 to 410 feet comprised of predominantly volcanic rocks and rounded volcanic sediments herein interpreted as unconsolidated sedimentary deposits on the basis of mapped stratigraphy and comparison with nearby well logs (LAKE 52506; LAKE 52683; LAKE 1628/LAKE 1626), which is likely correlative with Walker's QTs unit. This interval is underlain from 410 to 1070 by a series of altered/mineralized volcanic deposits including basalt, andesite, rhyolite, and tuff, with minor sand which is likely correlative with Walker's Ttf/Taf and/or Tvb unit. Note that the interval from 530 to 1070 is described entirely as basalt and/or andesite. Note also that the interval from 1070 to 1260 was a lost circulation zone with no samples recovered. Based on mapped stratigraphy and intermittent sample recovery from the lost circulation zone in LAKE 52530 it is reasonable to assume that this interval is a continuation of the Ttf/Taf and/or Tvb unit. The well is continuously cased and continuously sealed through the QTs sedimentary unit into the underlying volcanic rock aquifer unit.

Proposed production well SVE#2 (LAKE 52529) has a reported bottom-hole temperature of 225.4°F .

SVE#3: Formation descriptions for proposed injection well SVE#3 (LAKE 52812) depict an interval from 0 to 560 feet comprised of predominantly unconsolidated gravels, sands, silt and clay which is likely correlative with Walker's QTs unit. This interval is underlain from 560 to 1350 feet by a sequence of tuffaceous sedimentary rocks dominated by clay, ash and tuff with subordinate gravel, sand and cinders, which is likely correlative with Walker's Ttf/Taf unit. Below this from 1350-2705 (TD) is a sequence dominated by a variety of tuffaceous rocks described as tuff; lithic tuff; ash tuff; vitric tuff and partially welded tuff, which is also likely correlative with Walker's Ttf/Taf unit. The interval from 1660 to 2705 (TD) was a zone of lost circulation. The well is continuously cased and continuously sealed through the QTs sedimentary unit into the underlying volcanic rock aquifer unit.

Proposed injection well SVE#3 (LAKE 52812) has a reported bottom-hole temperature of 225°F .

*The application states that all fluids produced from the two proposed production wells will be supplied to a binary cycle geothermal power plant by way of pipelines from the well to the plant, and after passing through the plant will be delivered by way of pipelines to an injection well and returned to the same source aquifer from which they were produced, resulting in an open-loop non-consumptive cycle.

**Total combined rate from both production wells not to exceed 6.68 cfs (3000gpm).

***Proposed well 3 LAKE 52812 (SVE#3) is the intended injection well. The rate listed here is the proposed reinjection rate.

****All information from application materials and available DOGAMI permit files.

Note that all proposed wells are currently authorized under the DOGAMI geothermal permitting process (LAKE 52530/SVE#1 under DOGAMI API# 36-037-90009; LAKE 52529/SVE#2 under DOGAMI API# 36-037-90032; LAKE 52812/SVE#3 under DOGAMI API# 36-037-9032).

Note: proposed production wells LAKE 52530 and LAKE 52529 currently serve as authorized POD 2 and POD 3, respectively, under transfer T-11894. As such, some portion of the groundwater produced from these wells may be diverted for supplemental irrigation of up to 400 acres during the irrigation season. Any use authorized under this limited license must be coordinated with the water right holder for T-11894. See section B3.

A5. Provisions of the Goose & Summer Lake Basin rules relative to the development, classification and/or management of groundwater hydraulically connected to surface water are, or are not, activated by this application. (Not all basin rules contain such provisions.)

Comments: _____

A6. Well(s) # _____, _____, _____, _____, _____, tap(s) an aquifer limited by an administrative restriction. Name of administrative area: _____

Comments: Currently no administrative area.

B. GROUNDWATER AVAILABILITY CONSIDERATIONS, OAR 690-310-130, 400-010, 410-0070

B1. Based upon available data, I have determined that groundwater* for the proposed use:

- a. is over appropriated, is not over appropriated, or cannot be determined to be over appropriated during any period of the proposed use. * This finding is limited to the groundwater portion of the over-appropriation determination as prescribed in OAR 690-310-130;
- b. will not or will likely be available in the amounts requested without injury to prior water rights. * This finding is limited to the groundwater portion of the injury determination as prescribed in OAR 690-310-130;
- c. will not or will likely to be available within the capacity of the groundwater resource; or
- d. will, if properly conditioned, avoid injury to existing groundwater rights or to the groundwater resource:
 - i. The permit should contain condition #(s) _;
 - ii. The permit should be conditioned as indicated in item 2 below.
 - iii. The permit should contain special condition(s) as indicated in item 3 below;

- B2. a. Condition to allow groundwater production from no deeper than _____ ft. below land surface;
- b. Condition to allow groundwater production from no shallower than _____ ft. below land surface;
- c. Condition to allow groundwater production only from the _____ groundwater reservoir between approximately _____ ft. and _____ ft. below land surface;
- d. Well reconstruction is necessary to accomplish one or more of the above conditions. The problems that are likely to occur with this use and without reconstructing are cited below. Without reconstruction, I recommend withholding issuance of the permit until evidence of well reconstruction is filed with the Department and approved by the Groundwater Section.

Describe injury –as related to water availability– that is likely to occur without well reconstruction (interference w/ senior water rights, not within the capacity of the resource, etc): _____

B3. Groundwater availability remarks: _____

The proposed production wells produce groundwater from the predominantly volcanic rock unit underlying the predominantly basin fill sediment unit. As proposed the injection well is intended to inject 100% of the produced fluids back into the predominantly volcanic unit underlying the predominantly basin fill sediment unit resulting in an open-loop non-consumptive cycle. The proposed injection well is located within one mile of both proposed production wells.

The nearest state observation well to the proposed location is State Observation Well 374 (LAKE 1633) located ~1.5 miles to the northeast which has a period of record from 1963 to 2017. The long term annual groundwater level trend in this well indicates an overall year-year water level decline of about 19 feet from 1980 to 2017, or roughly 0.5 feet per year since 1980. Formation descriptions on the well log for LAKE 1633 indicate the well is completed in the basin fill sediments.

Observation well LAKE 52683 (permit condition obs well under permit G-17434; 380ft TD/115°F) located within the project area has a period of record from 2015 to 2018. No long term annual groundwater level trend can be identified in this well due to the short period of record; however there are no immediate signs of water level decline. Formation descriptions on the well log for LAKE 52683 indicate the well is completed in the basin fill sediments.

March static water levels reported to the department under the permit condition program for LAKE 1628 (“Little Hot Well”; 432 ft TD/175°F) indicate a 73 foot water level decline over the period 3/2015 – 30/2017. March static water levels reported to the department under the permit condition program for LAKE 52506 (“SVE#4” industrial use/cooling water; 378 ft

TD/118°F) indicate a 20 foot water level decline over the period 3/2015 – 3/2016. These reported records suggest significant rates of decline in the immediate vicinity of proposed production well LAKE 52529 (see following paragraphs).

Miscellaneous water level data made available to this reviewer by the applicant supplement the data available from the OWRD GWIS database. Review of these data presents an alternate interpretation from that made based on the permit condition program data alone for LAKE 1628 and LAKE 52506.

It is clear from the supplemental data that the “static” water level reported to the department for 03/01/2016 and 03/22/2017 for LAKE 1628 was affected by a recent period of pumping either in that well, or in LAKE 52506, or possibly both, and that the water level reported represents a pumping or recovery/rising level, rather than a true static water level which could be directly compared to the March level from the previous year. Due to the year-round pumping/recovery cycles at this well it is difficult to determine whether or not any year-to-year water level declines are occurring, however since regular pumping began in 2015 the well has never fully recovered to its pre-2015 static water levels, and the full record does seem to indicate that declines may be occurring.

It is clear from the supplemental data that the “static” water level reported to the department for 03/01/2016 for LAKE 52506 was affected by a recent period of pumping in that well; and that the water level reported represents a pumping or recovery/rising level, rather than a true static water level which could be directly compared to the March level from the previous year. The period of record for LAKE 52506 provided in the supplemental data covers 05/12/2014 – 01/16/2018. Due to the year-round pumping/recovery cycles at this well it is difficult to determine whether or not any year-to-year water level declines are occurring; although from October 2014 to October 2017 (two periods for which there appears to be no direct pumping influence), the record does indicate approximately 7-8 feet of overall decline; or approximately 2.5 ft/yr.

The supplemental water level data made available to this reviewer by the applicant also includes the two proposed production wells and several other nearby wells:

Proposed production well LAKE 52530 (SVE#1) has a period of record from 6/6/2014 to 1/16/2018. Due to the year-round pumping/recovery cycles at this well it is difficult to determine whether or not any year-to-year water level declines are occurring, however there are no apparent signs of significant water level declines.

Proposed production well LAKE 52529 (SVE#2) has a period of record from 6/17/2014 to 1/16/2018. Due to the year-round pumping/recovery cycles at this well it is difficult to determine whether or not any year-to-year water level declines are occurring, however there are no apparent signs of significant water level declines.

LAKE 1638 (“Mud Well”; unused irrigation well/livestock?; 775 ft TD/120°F) has a period of record from 3/28/2014 to 5/2/2017. The hydrograph for this reportedly unused irrigation well shows a clear and consistent decline trend from 2014 through spring of 2017 of approximately 6-10 feet over the period of record; or approximately 2 – 3.3 ft/yr. Formation descriptions on the well log for LAKE 1638 indicate the well is completed in the basin fill sediments.

LAKE 1625 (“Corky’s”; unused irrigation well; 610 ft TD/175°F) has a period of record from 3/28/2014 to 5/2/2017. The hydrograph for this reportedly unused irrigation well shows a clear and consistent decline trend from 2014 through spring of 2017 of approximately 6-7 feet over the period of record; or approximately 2 ft/yr. Formation descriptions on the well log for LAKE 1625 indicate the well is completed in the basin fill sediments.

LAKE 1637 (“Trailer Court”; livestock; 153 ft TD/~75°F) has a period of record from 3/28/2014 to 5/2/2017. Due to the year-round pumping/recovery cycles at this well it is difficult to determine whether or not any year-to-year water level declines are occurring. Formation descriptions on the well log for LAKE 1637 indicate the well is completed in the volcanic rock unit.

LAKE 4278 (“Paisley”; unused; 515 ft TD/115°F) has a period of record from 3/28/2014 to 1/16/2018. The hydrograph for this well does not indicate any apparent signs of significant water level declines. Formation descriptions on the well log for LAKE 4278 indicate the well is completed in the volcanic rock unit.

LAKE 51059 (“ZX”; unused; 1412 ft TD/78°F) has a period of record from 3/28/2014 to 1/16/2018. The hydrograph for this well indicates a decline trend from spring of 2014 through spring of 2017 of approximately 3.25 feet over the period of record; or approximately 1 ft/yr. Formation descriptions on the well log for LAKE 51059 indicate the well is completed in the volcanic rock unit.

Although all produced fluids are intended to be reinjected in an open-loop, non-consumptive cycle (no net groundwater use), local interference with existing nearby wells may occur as a result of pumping from the production wells. Nearby wells with

elevated temperatures are presumably hydraulically connected to the deep geothermal reservoir. Additionally, public comment received by the department asserts that direct interference between the SVE production wells and existing authorized irrigation wells is occurring.

Firstly, proposed production wells LAKE 52530 and LAKE 52529 currently serve as authorized POD 2 and POD 3, respectively, under transfer T-11894. As such, some portion of the groundwater produced from these wells may be diverted for supplemental irrigation of up to 400 acres during the irrigation season. Any use authorized under this limited license must be coordinated with the water right holder for T-11894.

Proposed production well LAKE 52530 is located ~445 feet north of POD 1 under transfer T-11894 (LAKE 1627 "Hot Well"). LAKE 1627 (reconditioning log LAKE 4448) has a reported water temperature of 212 degrees F. The potential increase in interference at LAKE 1627 was calculated using the Theis equation (see attachment). The values for the calculation are conservative and appropriate until better values become available. The calculations use an intermediate storage coefficient (0.001). The transmissivity used in the calculation (5,050 ft²/day [1ft²/day ≈0.37 darcy-ft]) is the transmissivity of the deep geothermal aquifer derived from the Geologica multi-well interference test (report dated 04/19/2018). At the maximum proposed pumping rate for LAKE 52530 (2.67 cfs), the results show an increase in drawdown of ~36 feet after 365* days.

Some degree of relief will be provided by reinjection of produced fluids into LAKE 52812, which is located 5,310 feet northeast of LAKE 1627. The potential decrease in interference at LAKE 1627 resulting from reinjection of fluids produced from LAKE 52530 was calculated using the Theis equation (see attachment). The values for the calculation are conservative and appropriate until better values become available. The calculations use an intermediate storage coefficient (0.001). The transmissivity used in the calculation (5,050 ft²/day [1ft²/day ≈0.37 darcy-ft]) is the transmissivity of the deep geothermal aquifer derived from the Geologica multi-well interference test (report dated 04/19/2018). At the maximum proposed pumping rate for LAKE 52530 (2.67 cfs – reinjected into LAKE 52812), the results show a decrease in drawdown of ~18 feet after 365* days, for a net drawdown of 18 feet, which begins to approach the 25 foot interference limit imposed by condition 7N. See notes below.

*Note: interference will continue to increase after the 365 day calculated value for this proposed year-round use.

*Note: the interference resulting from a combined pumping rate of 3,000 gpm from both production wells will increase the magnitude of interference at these wells.

If this permit is approved the following conditions are recommended:

7A:Monitoring Plan: The water user shall develop a plan to monitor and report the impact of water use under this permit. The plan shall be submitted to the Department before water use begins under this permit and shall be subject to the approval of the Department.

7I Injection Well Condition: Prior to use of water under this permit, the permit holder must register the injection activity with the Oregon Department of Environmental Quality's Underground Injection Control Program, which can be contacted at 2020 SW 4th Ave, Ste 400, Portland OR 97201, or 503-229-5263.

7P: Well Tag Condition

Flow meter condition: Apply the "Large" water use reporting condition to all production and injection wells to monitor and report both the total volume produced and total volume reinjected at each well. An additional flow meter is required at any diversion points that supply groundwater for irrigation authorized under any other water right, or any other consumptive use authorized from these wells under LL-11727 or any other water right.

As well as the following special conditions:

Special condition for no net groundwater use under this permit: This permit is valid if and only if 100 percent of the groundwater extracted from the production wells for use under this permit (that is not diverted under another previously authorized groundwater right), is reinjected back into the authorized injection well in a manner that can be confirmed by the reported flow meter data. Any volume of groundwater diverted from these wells for use under any other water right must be measured with a dedicated flowmeter at the point where diversion takes place. If this condition is not met the use is invalid and subject to regulation, including possible immediate cancellation of the permit.

Conduct a mechanical integrity test at least once every five years on all injection wells to determine that there is no leak in the casing, and no fluid movement into an underground source of water other than that from which the fluid was produced, unless otherwise approved by the Department. The Department may require surveys to detect movement of fluid in adjacent rock formations, cement bond logs, special wellhead equipment, or other methods employed by industry to monitor re-injection operations.

C. GROUNDWATER/SURFACE WATER CONSIDERATIONS, OAR 690-09-040

C1. **690-09-040 (1):** Evaluation of aquifer confinement:

Well	Aquifer or Proposed Aquifer	Confined	Unconfined
1	Volcanic Rock Aquifer Unit	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	Volcanic Rock Aquifer Unit	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	Volcanic Rock Aquifer Unit	<input checked="" type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>

Basis for aquifer confinement evaluation: _____

No detailed studies of the groundwater system in this part of the Summer Lake Subbasin have been reported, but numerous studies within the broader Goose and Summer Lakes Basin serve as analogues for understanding the general characteristics of the groundwater flow system regionally. Reports across the Goose and Summer Lakes Basin indicate that groundwater generally occurs in a basin fill sediment unit overlying a predominantly volcanic/volcaniclastic rock unit under both confined and unconfined conditions (e.g. Brown, 1957 – upper Summer Lake subbasin; Hampton, 1964 – Fort Rock Basin; Miller, 1986 – Fort Rock Basin; Morgan, 1988 – Goose Lake Basin; McFarland, 1991 – Fort Rock Basin). In the Ana Springs area in the northern Summer Lake Basin Brown (1957) describes the occurrence of groundwater under both confined and unconfined conditions, and describes flowing wells producing groundwater from the volcanic rock aquifer unit. In the Fort Rock Basin Miller (1986) indicates that the Quaternary unconsolidated deposits constitute an upper groundwater reservoir reflecting a somewhat higher head system with lower transmissivities than the underlying main ground water reservoir. In the Goose Lake Basin Morgan (1988) found that regionally the volcanic units and basin fill deposits together comprise a single groundwater flow system; unconfined groundwater commonly occurs within the upper 10-20 feet of saturated sediments; confined conditions prevail with increasing depth; and that 100 feet below the water table, groundwater is confined nearly everywhere in the basin fill deposits. Hampton (1964), Miller (1986), and McFarland (1991) all describe natural discharge of groundwater from the volcanic unit to surface water at the northern end of the Summer Lake Subbasin at Ana Springs. Hampton (1964), Morgan (1988) and McFarland (1991) all indicate that given the lithology and depositional environment within both the basin fill and the underlying volcanic section, a high degree of anisotropy is characteristic of the groundwater flow system - vertical hydraulic conductivity is less than horizontal hydraulic conductivity. Within the volcanic section Morgan argues for a ratio of vertical to horizontal hydraulic conductivity of 1:1000; and suggests ratios from 1:2 up to 1:170 within the basin fill.

Several thermal springs occur approximately 5 miles to the northwest of the proposed location. Additionally, numerous wells in the vicinity of the proposed location with elevated temperatures (>80°F) range in depth from 130 to 983 feet, suggesting groundwater from the deep thermal reservoir has some degree of vertical connection with the shallower parts of the groundwater flow system in this area, possibly to some degree by way of sub-vertical faults behaving as conduits for vertical fluid migration.

A 10-day, multi-well interference test completed by the applicant involved pumping ~1300 gpm from production well SVE#1 (LAKE 52530) while simultaneously reinjecting the produced fluids into injection well SVE#3 (LAKE 52812). Aquifer response was monitored during the test by measuring water levels in SVE#2 (LAKE 52529) as well as 4 shallower wells nearby (“Mud Well” – LAKE 1638; “Corky’s” – LAKE 1625; “ZX” – LAKE 51059; “City Well” – unknown well log). Production well SVE#2 (LAKE 52529) exhibited a clear pressure response both to pumping from production well SVE#1 (LAKE 52530) and to injection into SVE#3(LAKE 52812). The four shallower wells did not exhibit any significant pressure response.

Given the above considerations, the deep thermal reservoir appears to exist under confined to semi-confined conditions, resulting from both the vertical heterogeneity of aquifer materials, and the anisotropy of hydraulic conductivity within the various geologic materials comprising the aquifer system; some degree of vertical hydraulic connection between the deeper and shallower parts of the system is apparent as described above, possibly to some degree by way of sub-vertical faults behaving as conduits for vertical fluid migration.

C2. 690-09-040 (2) (3): Evaluation of distance to, and hydraulic connection with, surface water sources. All wells located a horizontal distance less than ¼ mile from a surface water source that produce water from an unconfined aquifer shall be assumed to be hydraulically connected to the surface water source. Include in this table any streams located beyond one mile that are evaluated for PSI.

Well	SW #	Surface Water Name	GW Elev ft msl	SW Elev ft msl	Distance (ft)	Hydraulically Connected?			Potential for Subst. Interfer. Assumed?	
						YES	NO	ASSUMED	YES	NO
1	1	Chewaucan River	4,350	*4,350	*7,500	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2	1	Chewaucan River	4,340	*4,340	*7,000	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Basis for aquifer hydraulic connection evaluation: _____

The application states that all fluids produced from the two proposed wells will be supplied to a binary cycle geothermal power plant by way of pipelines from the well to the plant, and after passing through the plant will be delivered by way of pipelines to an injection well and returned to the same source aquifer from which they were produced, resulting in an open-loop non-consumptive cycle. The special condition for no net groundwater use requires that 100 percent of the groundwater extracted from the production wells (that is not diverted under another previously authorized groundwater right) is reinjected back into the authorized injection well. As such the potential for substantial interference with surface water is expected to be fully mitigated.

The reach of the Chewaucan River closest to proposed well HARN 52530 (SVE#1) is about 2,020 feet away at an elevation of about 4,415 feet. The reach of the Chewaucan River closest to proposed well HARN 52529 (SVE#2) is about 995 feet away at an elevation of about 4,395 feet.

*At these closest reaches the river appears to be above the static groundwater level in these wells; however the river quickly drops in elevation downstream to the elevation of the static groundwater level. The 4,350 river elevation is about 7,500 feet away from HARN 52530. The 4,340 river elevation is about 7,000 feet away from HARN 52529. The reaches at these distances are presumed to be where hydraulic connection with the Chewaucan River begins, and as such are the distances used in the table above.

Water Availability Basin the well(s) are located within: CHEWAUCAN R > L ABERT - AT MOUTH

C3a. **690-09-040 (4):** Evaluation of stream impacts for each well that has been determined or assumed to be **hydraulically connected and less than 1 mile** from a surface water source. Limit evaluation to instream rights and minimum stream flows that are pertinent to that surface water source, and not lower SW sources to which the stream under evaluation is tributary. Compare the requested rate against the 1% of 80% *natural* flow for the pertinent Water Availability Basin (WAB). If Q is not distributed by well, use full rate for each well. Any checked box indicates the well is assumed to have the potential to cause PSI.

Well	SW #	Well < ¼ mile?	Qw > 5 cfs?	Instream Water Right ID	Instream Water Right Q (cfs)	Qw > 1% ISWR?	80% Natural Flow (cfs)	Qw > 1% of 80% Natural Flow?	Interference @ 30 days (%)	Potential for Subst. Interfer. Assumed?
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
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		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>

C3b. **690-09-040 (4):** Evaluation of stream impacts by total appropriation for all wells determined or assumed to be **hydraulically connected and less than 1 mile** from a surface water source. **Complete only if Q is distributed among wells.** Otherwise same evaluation and limitations apply as in C3a above.

	SW #		Qw > 5 cfs?	Instream Water Right ID	Instream Water Right Q (cfs)	Qw > 1% ISWR?	80% Natural Flow (cfs)	Qw > 1% of 80% Natural Flow?	Interference @ 30 days (%)	Potential for Subst. Interfer. Assumed?
			<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
			<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
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			<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>

Comments: _____

This section does not apply. See comment in C2 above.

C4a. **690-09-040 (5):** Estimated impacts on hydraulically connected surface water sources greater than one mile as a percentage of the proposed pumping rate. Limit evaluation to the effects that will occur up to one year after pumping begins. This table encompasses the considerations required by 09-040 (5)(a), (b), (c) and (d), which are not included on this form. Use additional sheets if calculated flows from more than one WAB are required.

Non-Distributed Wells													
Well	SW#	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		%	%	%	%	%	%	%	%	%	%	%	%
Well Q as CFS													
Interference CFS													
Distributed Wells													
Well	SW#	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		%	%	%	%	%	%	%	%	%	%	%	%
Well Q as CFS													
Interference CFS													
		%	%	%	%	%	%	%	%	%	%	%	%
Well Q as CFS													
Interference CFS													
		%	%	%	%	%	%	%	%	%	%	%	%
Well Q as CFS													
Interference CFS													
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Well Q as CFS													

C4b. 690-09-040 (5) (b) The potential to impair or detrimentally affect the public interest is to be determined by the Water Rights Section.

- C5. If properly conditioned, the surface water source(s) can be adequately protected from interference, and/or groundwater use under this permit can be regulated if it is found to substantially interfere with surface water:
 - i. The permit should contain condition #(s) 7I, 7N, 7P, Water Use Reporting-Large, special conditions. ;
 - ii. The permit should contain special condition(s) as indicated in "Remarks" below;

C6. SW / GW Remarks and Conditions: _____

If this permit is approved the following conditions are recommended:

7A:Monitoring Plan: The water user shall develop a plan to monitor and report the impact of water use under this permit. The plan shall be submitted to the Department before water use begins under this permit and shall be subject to the approval of the Department.

7I Injection Well Condition: Prior to use of water under this permit, the permit holder must register the injection activity with the Oregon Department of Environmental Quality's Underground Injection Control Program, which can be contacted at 2020 SW 4th Ave, Ste 400, Portland OR 97201, or 503-229-5263.

7P: Well Tag Condition

Flow meter condition: Apply the "Large" water use reporting condition to all production and injection wells to monitor and report both the total volume produced and total volume reinjected at each well. An additional flow meter is required at any diversion points that supply groundwater for irrigation authorized under any other water right, or any other consumptive use authorized from these wells under LL-11727 or any other water right.

As well as the following special conditions:

Special condition for no net groundwater use under this permit: This permit is valid if and only if 100 percent of the groundwater extracted from the production wells for use under this permit (that is not diverted under another previously authorized groundwater right), is reinjected back into the authorized injection well in a manner that can be confirmed by the reported flow meter data. Any volume of groundwater diverted from these wells for use under any other water right must be measured with a dedicated flowmeter at the point where diversion takes place. If this condition is not met the use is invalid and subject to regulation, including possible immediate cancellation of the permit.

Conduct a mechanical integrity test at least once every five years on all injection wells to determine that there is no leak in the casing, and no fluid movement into an underground source of water other than that from which the fluid was produced, unless otherwise approved by the Department. The Department may require surveys to detect movement of fluid in adjacent rock formations, cement bond logs, special wellhead equipment, or other methods employed by industry to monitor re-injection operations.

References Used:

Walker, G.W., 1963. Reconnaissance geologic map of the eastern half of the Klamath Falls (AMS) quadrangle. Lake and Klamath Counties, Oregon. U.S. Geological Survey Mineral Investigations Field studies Map MF-260, 1:250000.

Davis, L., et al., 2013. Multi-well interference test of the Paisley geothermal reservoir. Industry report.

Brown, S.G., 1957. Occurrence of ground water near Ana Springs, Summer Lake basin, Lake County, Oregon: US Geol. Survey open-file report.

Miller, D.W., 1986. Ground Water Conditions in Fort Rock Basin, Northern Lake County, Oregon. State of Oregon, Water Resources Department.

Morgan, D.S., 1988. Geohydrology and numerical model analysis of ground-water flow in the Goose Lake Basin, Oregon and California (Vol. 87, No. 4058). US Department of the Interior, US Geological Survey.

Muffler, L. J. P., 1979. Assessment of geothermal resources of the United States, 1978 (No. USGS-CIRC-790). Geological Survey, Reston, VA (USA). Geologic Div.

Faulds, J.E. and Hinz, N.H., 2015, April. Favorable tectonic and structural settings of geothermal systems in the Great Basin region, western USA: Proxies for discovering blind geothermal systems. In Proceedings of the World Geothermal Congress, Melbourne, Australia (pp. 19-25).

Coolbaugh, M. F., Arehart, G. B., Faulds, J. E., Garside, L. J., Rhoden, H. N., Steininger, R. C., & Vikre, P. G. (2005). Geothermal systems in the Great Basin, western United States: Modern analogues to the roles of magmatism, structure, and regional tectonics in the formation of gold deposits. In Geological Society of Nevada Symposium (pp. 1063-1081).

OWRD water well reports, water level data, and/or hydrographs.

Oregon Administrative Rules.

DOGAMI permit files.

Supplemental data provided by the applicant.

D. WELL CONSTRUCTION, OAR 690-200

D1. Well #: 1-3 Logid: LAKE 52530; LAKE 52529; LAKE 52812

D2. **THE WELL does not appear to meet current well construction standards based upon:**

- a. review of the well log;
- b. field inspection by _____;
- c. report of CWRE _____;
- d. other: (specify) _____

D3. **THE WELL construction deficiency or other comment is described as follows:** _____

D4. **Route to the Well Construction and Compliance Section for a review of existing well construction.**

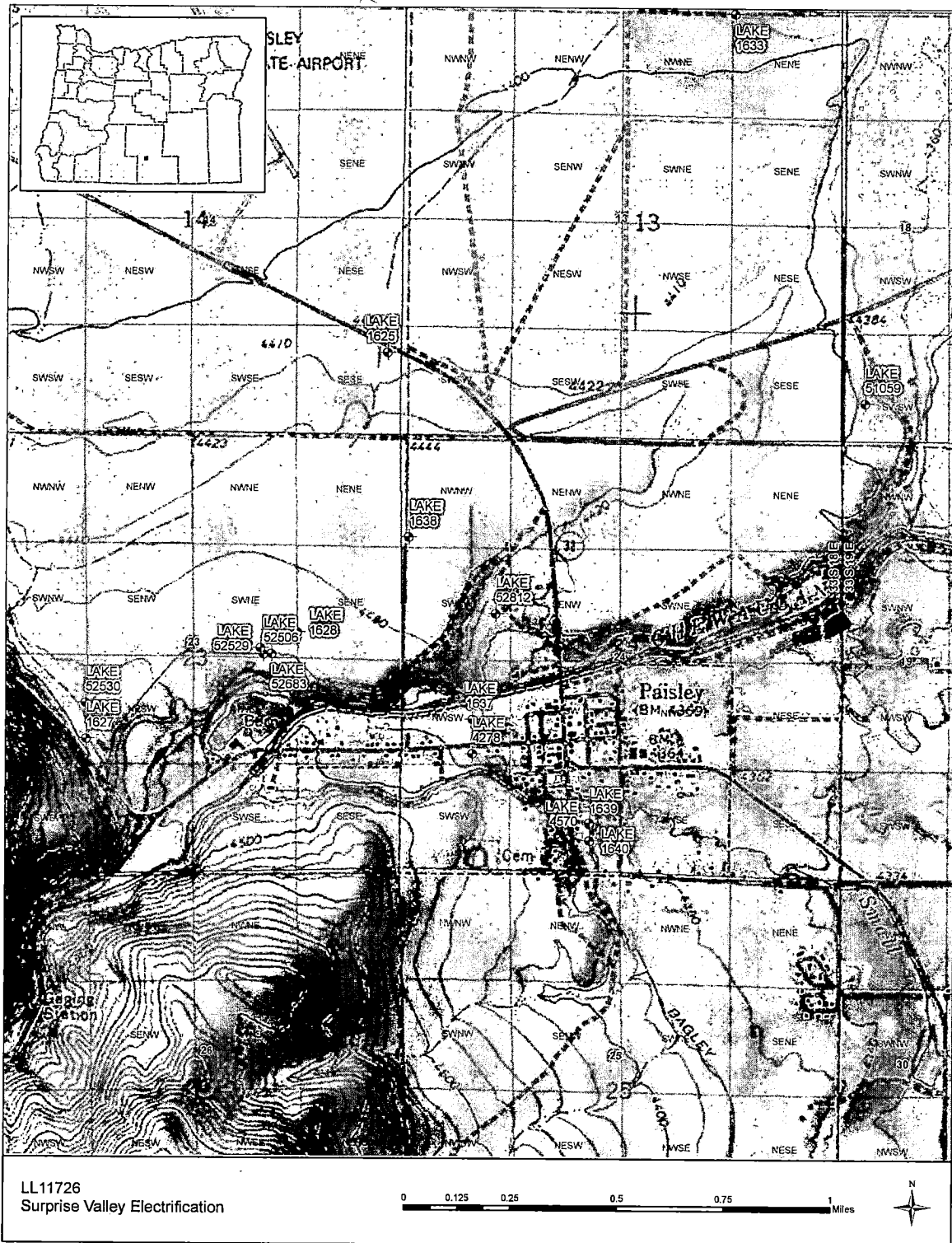


Figure 1: Location map.

Water-Level Trends in Nearby Wells

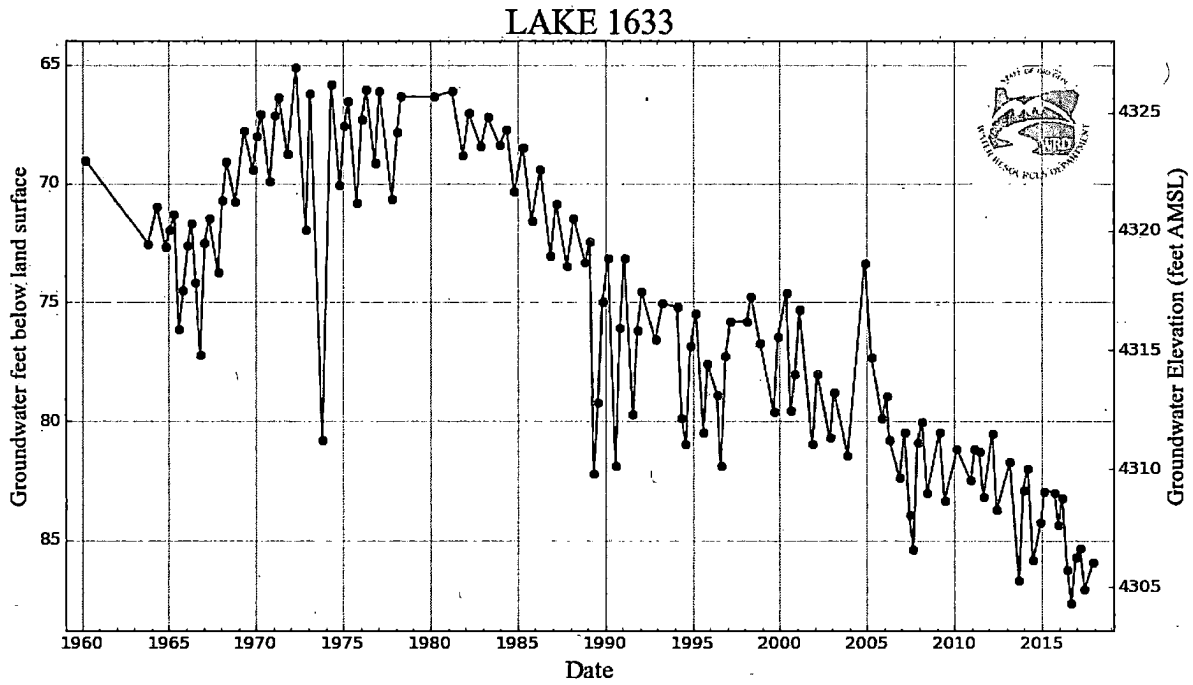


Figure 2: Hydrograph for LAKE 1633.

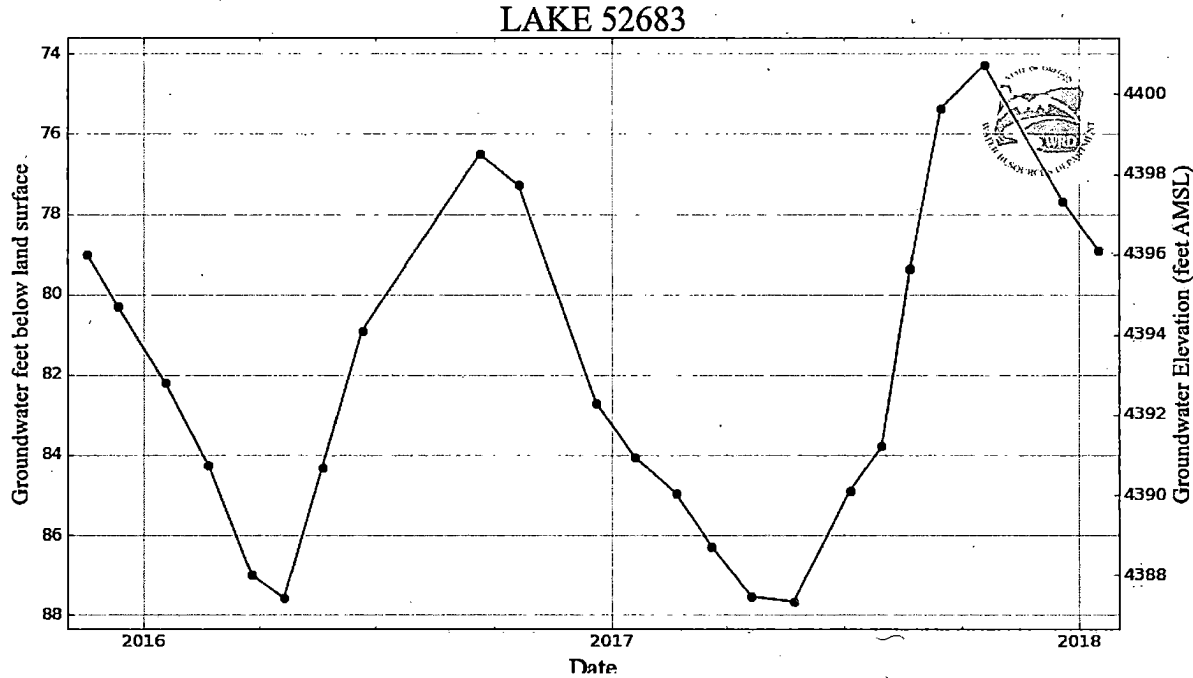


Figure 3: Reported permit condition water level data for LAKE 52683.

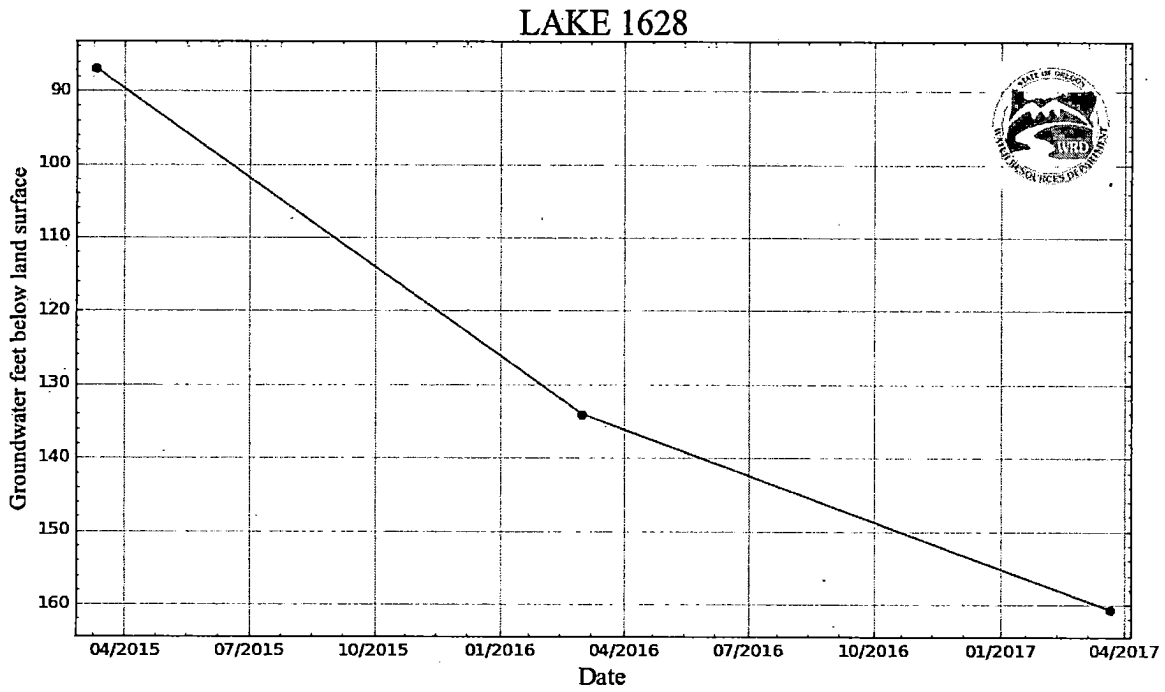


Figure 4: Reported permit condition water level data for LAKE 1628.

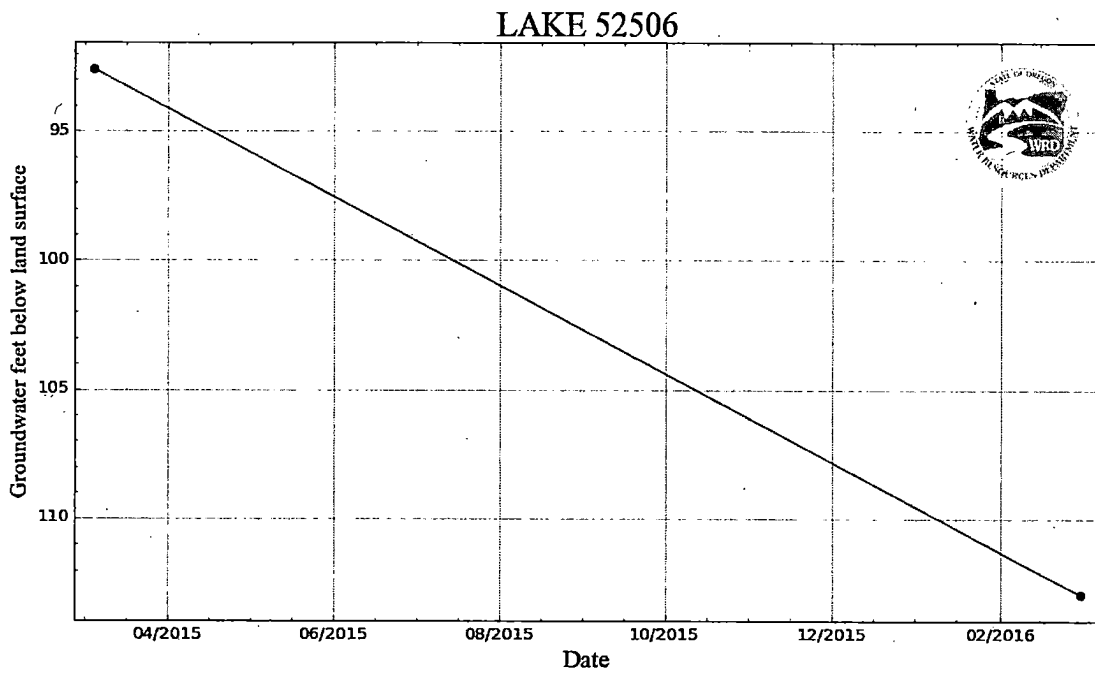


Figure 5: Reported permit condition water level data for LAKE 52506.

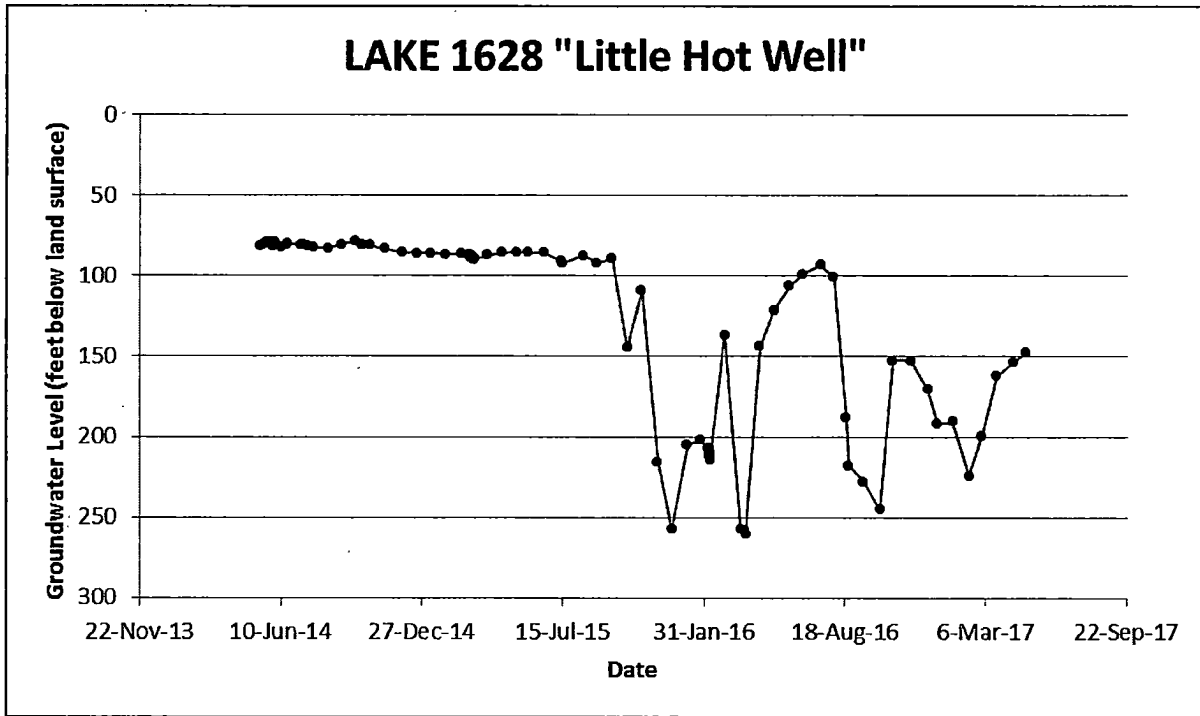


Figure 6: Supplemental data provided by the applicant - LAKE 1628.

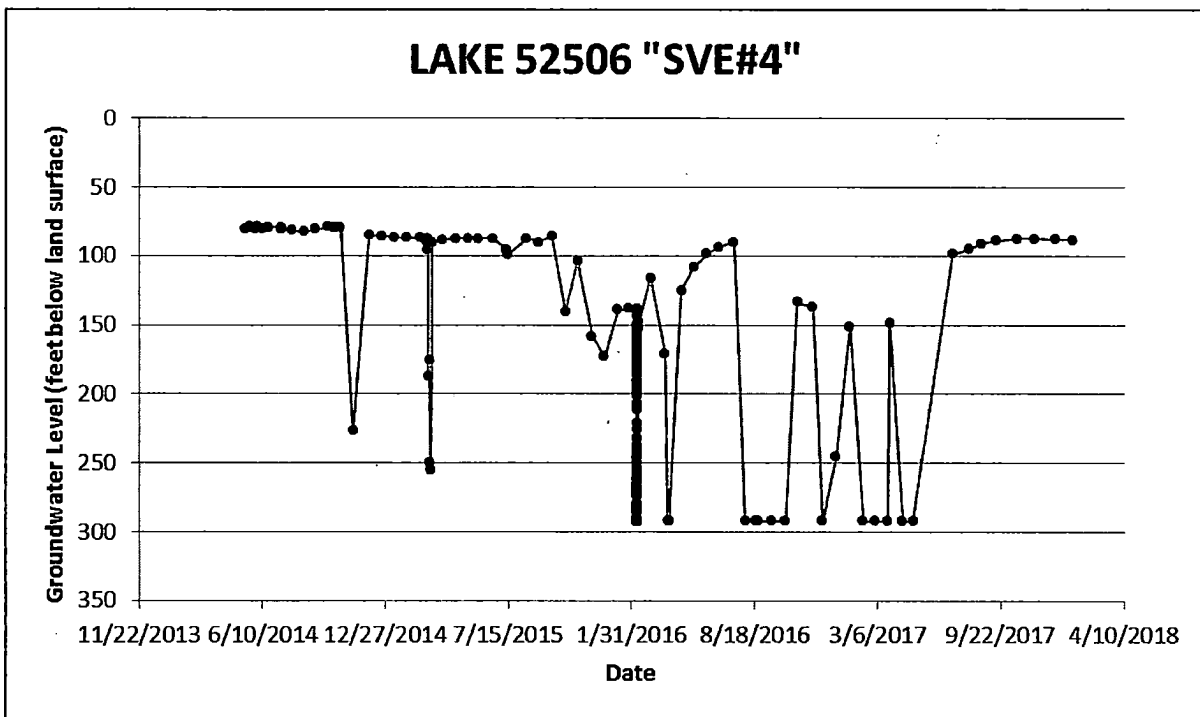


Figure 7: Supplemental data provided by the applicant - LAKE 52506.

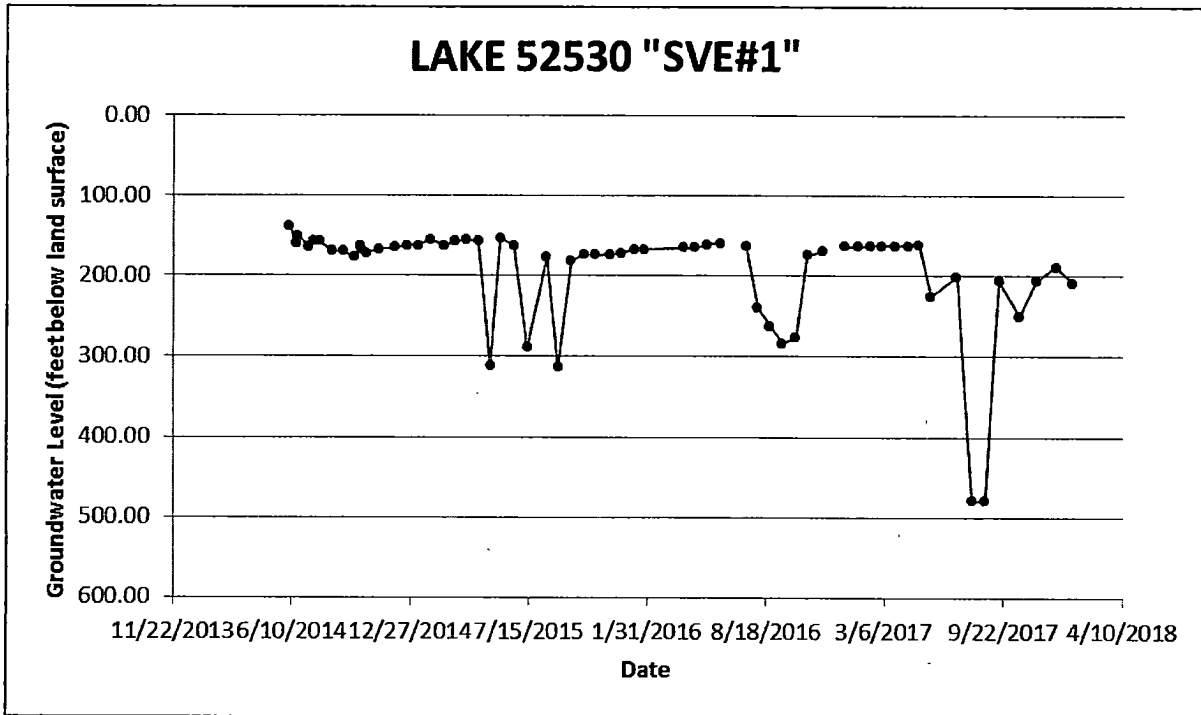


Figure 8: Supplemental data provided by the applicant - LAKE 52530.

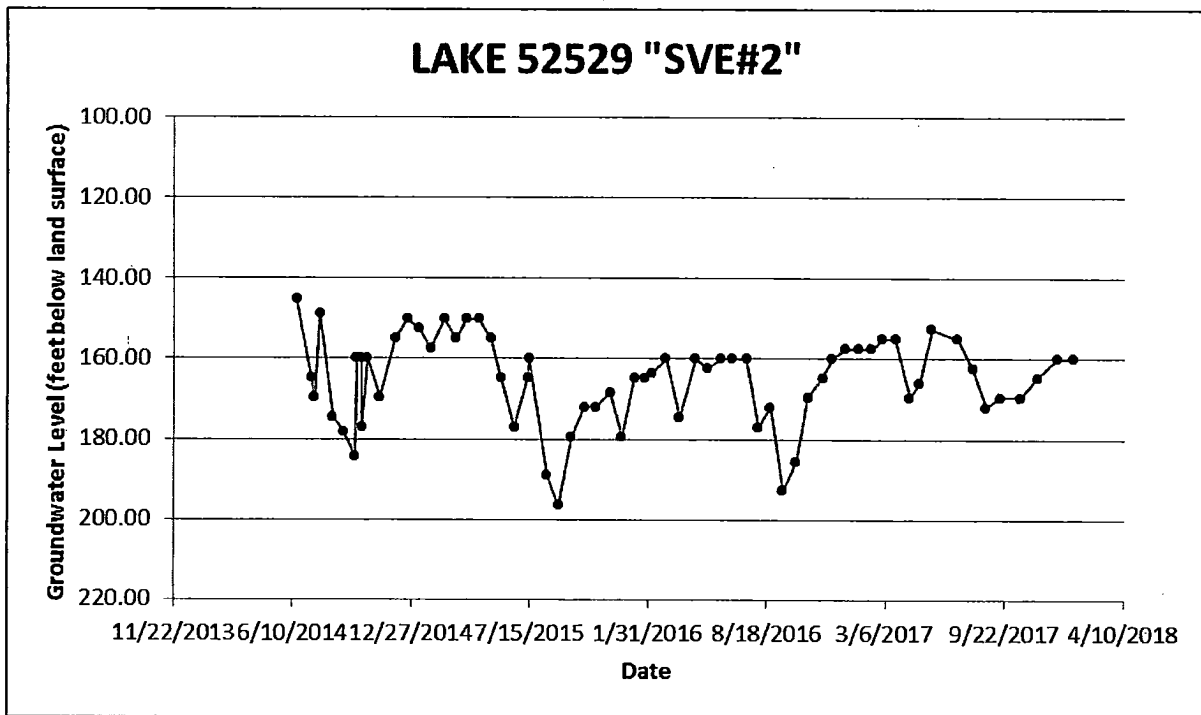


Figure 9: Supplemental data provided by the applicant - LAKE 52529.

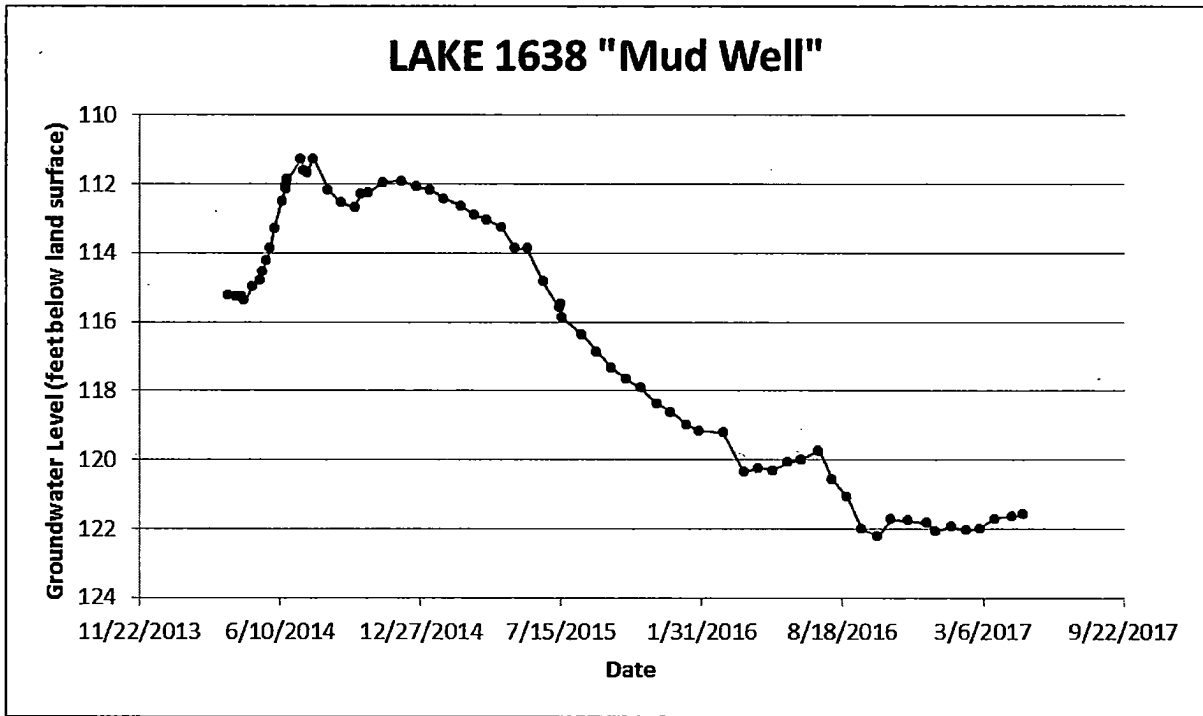


Figure 10: Supplemental data provided by the applicant - LAKE 1638.

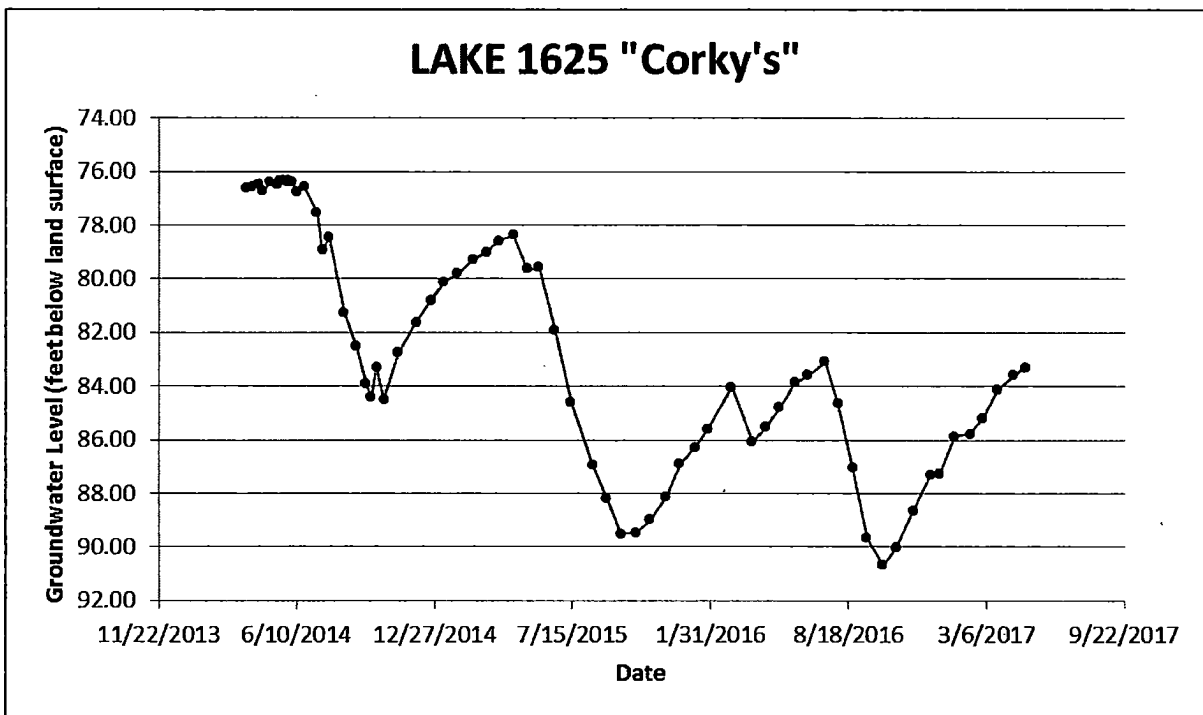


Figure 11: Supplemental data provided by the applicant - LAKE 1625.

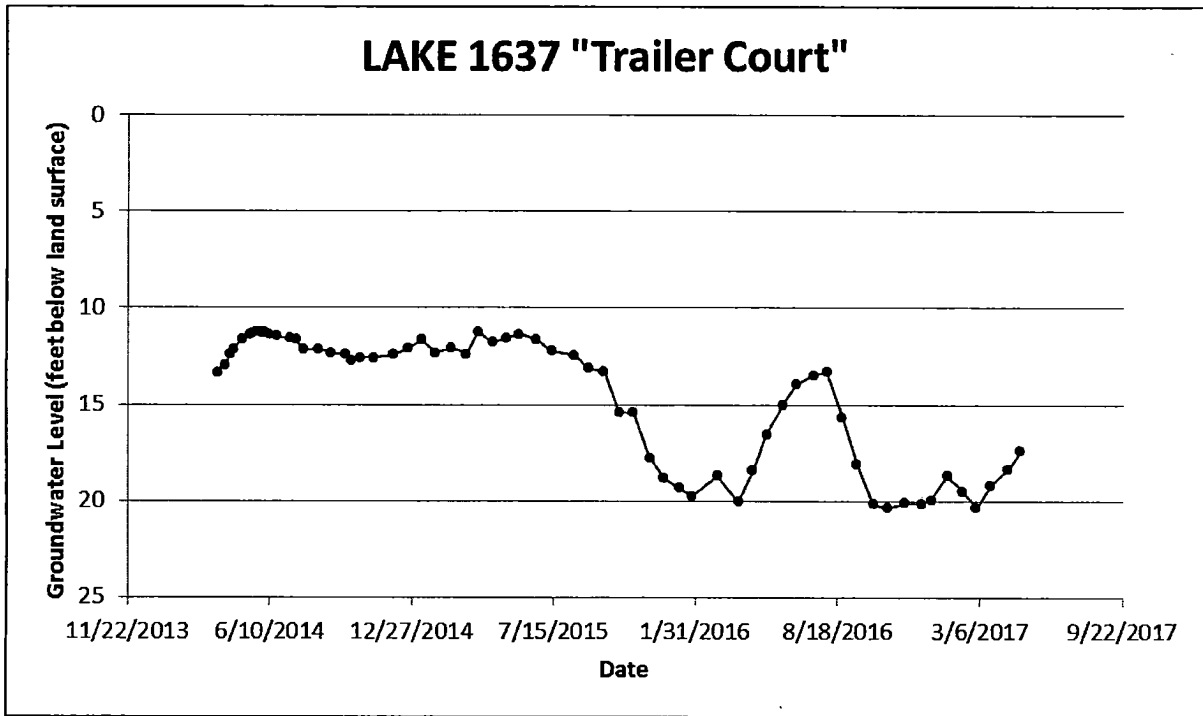


Figure 12: Supplemental data provided by the applicant - LAKE 1637.

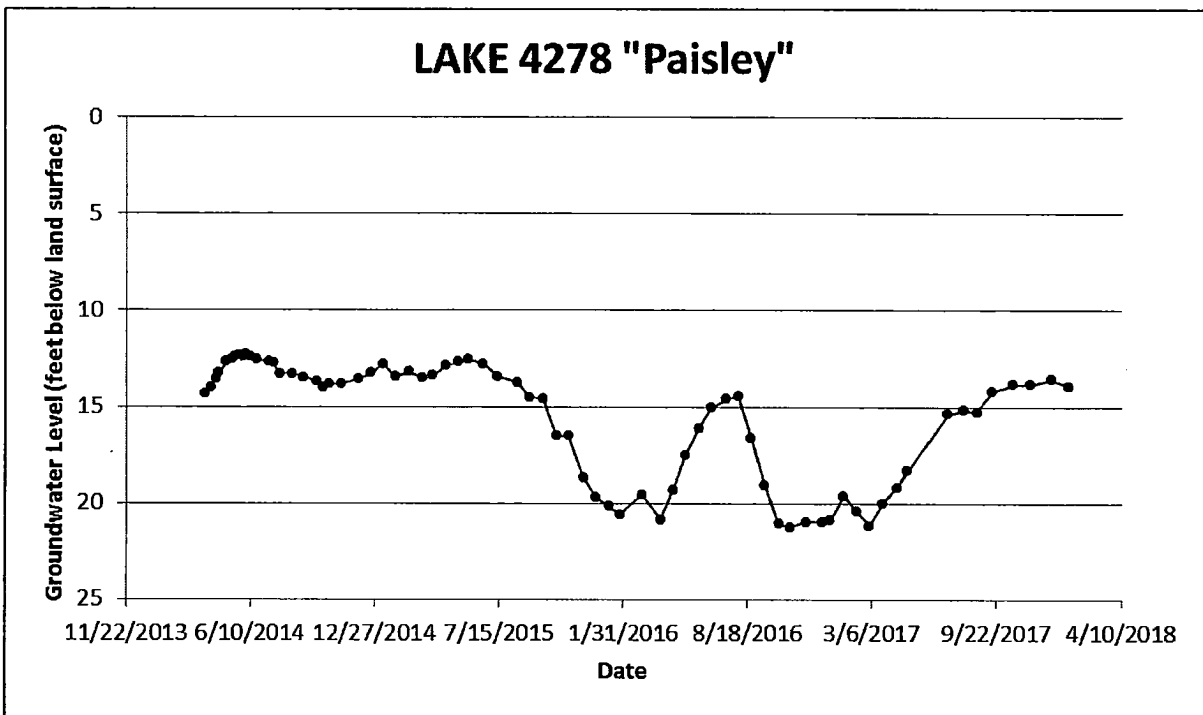


Figure 13: Supplemental data provided by the applicant - LAKE 4278.

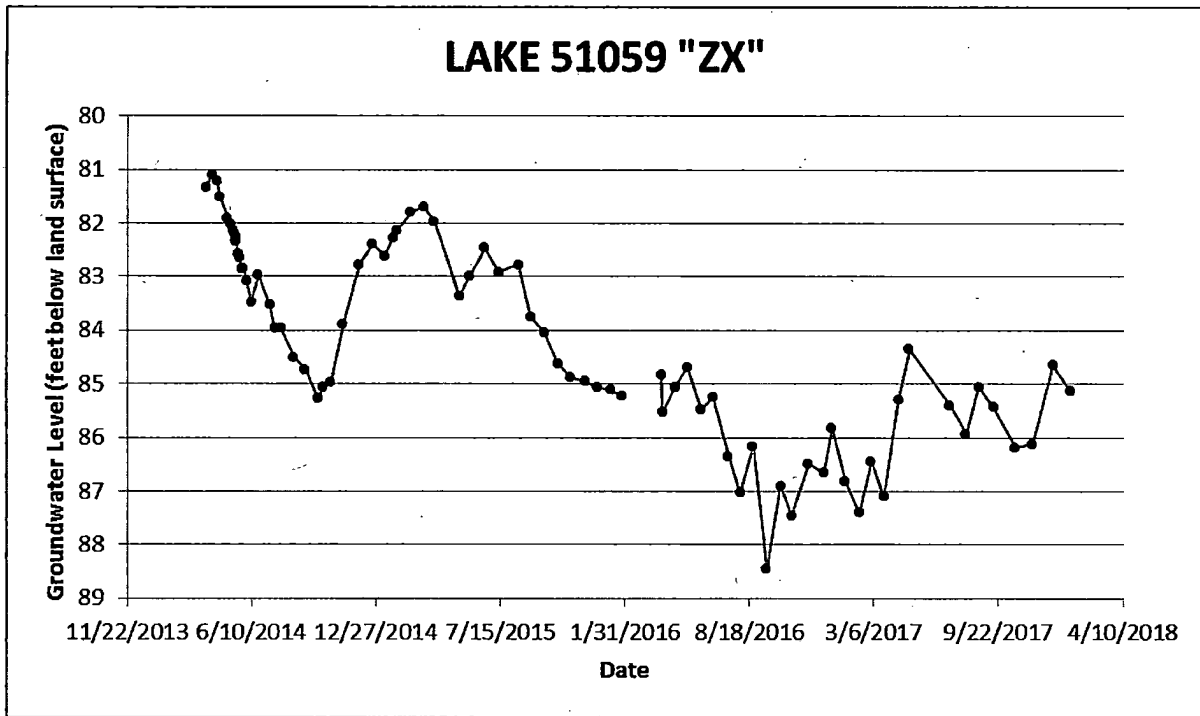


Figure 14: Supplemental data provided by the applicant - LAKE 51059.

This Time-Drawdown Worksheet v.3.00
 Calculates Theis nonequilibrium drawdown and recovery at any arbitrary radial distance, r, from a pumping well for 3 different T values and radial distance, r, from a pumping well for 3 different T values and 2 different S values.
 Written by Karl C. Wozniak September 1992. Last modified December 30, 2014

Input Data:	Var Name	Scenario 1	Scenario 2	Scenario 3	Units
Total pumping time	t		365		d
Radial distance from pumped well:	r		445.00		ft
Pumping rate	Q		2.7		g/s
Hydraulic conductivity	K	51	51	51	ft/day
Aquifer thickness	b		100		ft
Storativity	S 1	0.00100			
	S 2	0.00100			
Transmissivity Conversions	T Qpd	5.050	5.050	5.050	ft ² /day
	T ft ² /pm	3.5069	3.5069	3.5069	ft ² /min
	T qpd/ft	37.774	37.774	37.774	gpd/ft

Recalculate Use the Recalculate button if recalculation is set to manual

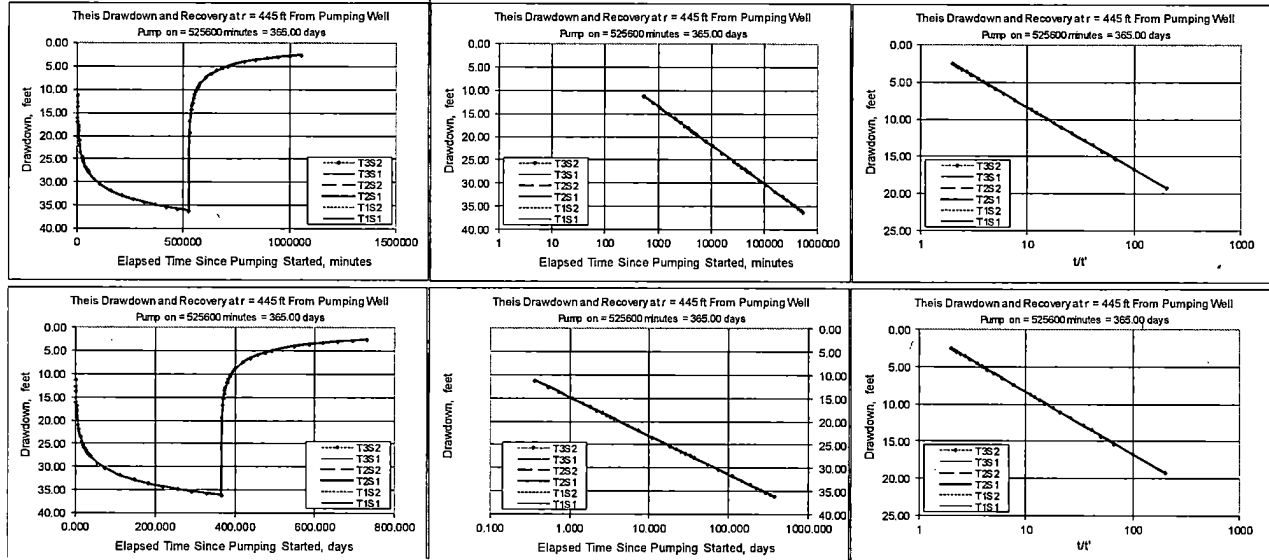


Figure 15: Interference calculation: LAKE 52530-LAKE 1627 (pumping).

This Time-Drawdown Worksheet v.3.00
 Calculates Theis nonequilibrium drawdown and recovery at any arbitrary radial distance, r, from a pumping well for 3 different T values and radial distance, r, from a pumping well for 3 different T values and 2 different S values.
 Written by Karl C. Wozniak September 1992. Last modified December 30, 2014

Input Data:	Var Name	Scenario 1	Scenario 2	Scenario 3	Units
Total pumping time	t		365		d
Radial distance from pumped well:	r		5310.00		ft
Pumping rate	Q		2.7		g/s
Hydraulic conductivity	K	51	51	51	ft/day
Aquifer thickness	b		100		ft
Storativity	S 1	0.00100			
	S 2	0.00100			
Transmissivity Conversions	T Qpd	5.050	5.050	5.050	ft ² /day
	T ft ² /pm	3.5069	3.5069	3.5069	ft ² /min
	T qpd/ft	37.774	37.774	37.774	gpd/ft

Recalculate Use the Recalculate button if recalculation is set to manual

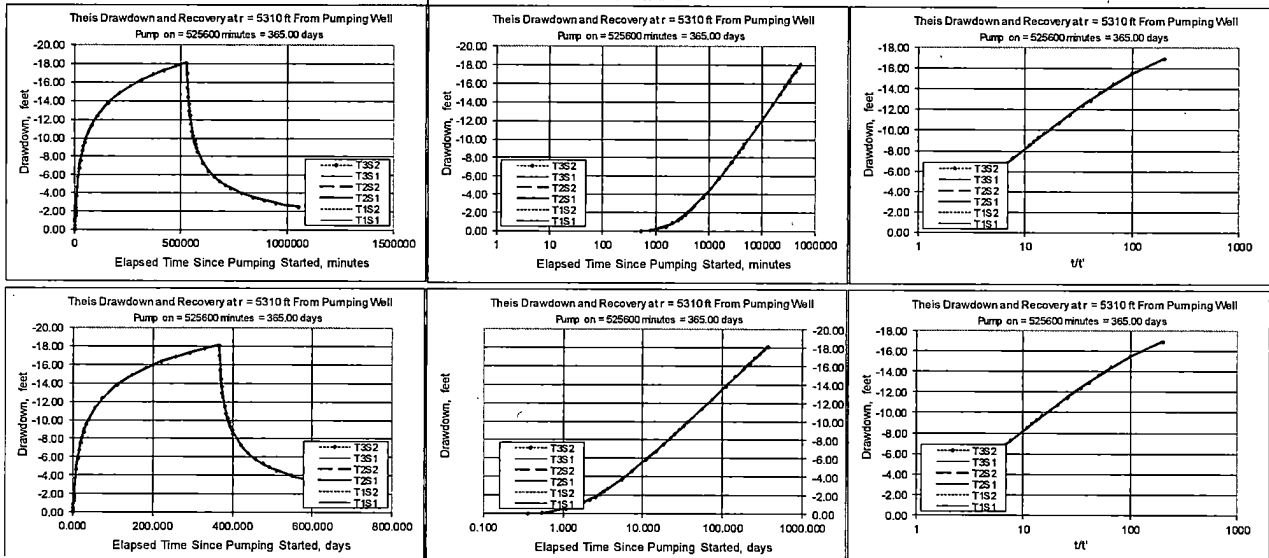


Figure 16: Interference Calculation: LAKE 52529-LAKE 1627 (injection).