

Technical Memorandum



To: Mr. Reggie Lamson
City of Big Bear Lake Department of Water and Power

From: Thomas Harder, P.G., C.HG.
Thomas Harder & Co.

Date: 16-Mar-20

Re: Analysis of the Potential for Hydrologic Connection Between Groundwater Pumped by the City of Big Bear Lake Department of Water Division Wells and Surface Water in Big Bear Lake

This Technical Memorandum (TM) presents an analysis of the potential for hydrologic connection between groundwater pumped by the City of Big Bear Lake Department of Water and Power's (BBLDWP's) Division wells and surface water in Big Bear Lake. The Division wells are located at the east end of Big Bear Lake near what is referred to as Stanfield Marsh (see Figure 1). Stanfield Marsh is an overflow area that currently only contains water during occasional periods of high lake levels.

The wells analyzed as part of this study included:

Division Well	Total Depth (ft bgs)	Perforation Interval(s) (ft bgs)
2	>612	50 - >612
5	471	50 - 60; 125 - 152; 169 - 275; 307 - 314; 330 - 365; 420 - 430
6	400	50 - 400
7	400	50 - 400
8	289	198 - 219; 259 - 279

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All of the Division wells analyzed are currently, or have been recently, utilized by the BBLDWP as sources of groundwater supply.

The purpose of this analysis is to assess if any of the Division wells are pumping groundwater that is in direct hydrologic communication with surface water in Big Bear Lake/Stanfield Marsh.

Analysis Methodology

TH&Co conducted the analysis using a variety of methods:

- Analysis of subsurface soil profiles, well perforated intervals, and groundwater levels in the vicinity of the Division Wells.
- Analysis and comparison of groundwater levels in the Division Wells with surface water levels in the lake.

All groundwater levels, borehole lithology, and well construction details were provided by BBLDWP. BBLDWP also provided downhole video logs of Division Well 2 to confirm the perforation interval. Surface water levels for the lake were obtained from the Big Bear Municipal Water District (BBMWD).

Hydrogeological Setting

Thomas Harder & Company (TH&Co) prepared two hydrogeological cross sections through the Division wells, as shown on Figures 1 through 3. The cross sections show subsurface lithology, well perforation intervals, and recent groundwater levels. Data for the lithology was obtained from driller's logs and one detailed geologic log from Well 8. Sediments across the area consist of interbedded sand, gravel and clay. At Wells 6 and 7 on the north side of Stanfield Marsh, the upper approximately 100 feet of sediments are logged as clay. Sediments below that depth are primarily sand and gravel that comprise the aquifer from which these wells pump groundwater. On the south side of Stanfield Marsh where Wells 2, 5 and 8 are located, the upper 60 to 80 feet of subsurface sediments consist primarily of sand (see Figures 2 and 3). Below this depth, the sediments consist primarily of clay with relatively thin interbedded sand layers.

Groundwater levels in the area of the Division wells vary from well to well and differences are based on perforation interval and location with respect to Stanfield Marsh. Groundwater levels in wells with shallow perforations (starting at 50 ft bgs) that are located on the south side of Stanfield Marsh tend to rise closer to measured surface water levels in Big Bear Lake during high groundwater conditions. In Division Well 8, which was constructed with perforations starting at 198 ft bgs, groundwater levels tend to be deeper, more variable, and lower than measured surface water levels in Big Bear Lake (see Figure 4). In Division Wells 6 and 7, which



are on the north side of Stanfield Marsh, groundwater levels are also deeper and more variable than groundwater levels measured in Division Wells 2 and 5. These data indicate that the aquifer from which Wells 6, 7 and 8 pump is confined beneath overlying clay layers.

Groundwater Level Analysis

TH&Co conducted a comparative analysis of groundwater levels in the Division wells and surface water levels in Big Bear Lake.

Division Wells 2 and 5

Groundwater levels in Division Wells 2 and 5, located on the south side of Stanfield Marsh and constructed with shallow perforations (i.e. starting at 50 ft bgs), tend to rise to similar elevations as surface water in Big Bear Lake during periods of time corresponding to relatively wet hydrologic conditions (e.g. 1998, 2005, and 2011) (see Figure 4). During dry hydrologic conditions (e.g. 2004, and 2012 through 2018), groundwater levels in Wells 2 and 5 drop as much as approximately 60 feet below surface water levels in Big Bear Lake.¹ A graph of Division Well 2 groundwater levels versus lake levels (see Figure 5) shows that they are more correlated above a groundwater level elevation of approximately 6,720 feet above mean sea level (ft amsl). At Division Well 5, groundwater levels are more correlated with surface water levels in the lake at a groundwater elevation of approximately 6,732 ft amsl (see Figure 6). These analyses suggest when ground water levels rise above 6,720 ft amsl (Well 2) to 6,732 ft amsl (Well 5), groundwater and surface water become interconnected (correlated). These elevations are above the top of perforations in both wells and within the sandy sediments that are logged in the upper 80 feet of the subsurface in this area.

Division Wells 6, 7 and 8

Groundwater levels in Division Wells 6 and 7, located on the north side of Stanfield Marsh and constructed with shallow perforations starting at 50 ft bgs, do not rise to the level of surface water levels in Big Bear Lake (see Figure 7). Except for the first six months of 1996, groundwater levels in these wells typically range from approximately 40 to 150 ft bgs, well below the lake bottom. For the first six months of 1996, groundwater levels were reported to be within 10 feet of the lake bottom. From review of the plots, groundwater levels at Division Wells 6 and 7 do not tend to track very closely with surface water levels in the lake and there is no clear demarcation of a change in condition (see Figures 8 and 9). One possible exception is

¹ It is noted that some groundwater levels in Division Wells 6 and 7 measured prior to 2004 spiked more than 60 feet below land surface. These very deep groundwater levels were likely indicative of pumping levels rather than static water levels, as strict measurement and reporting protocols had not been in place prior to 2004 and were therefore not considered relevant to this analysis.



the first six months of 1996 (circled on Figures 8 and 9). These data are completely separated from most of the dataset and are considered outliers (possibly measurement errors). The most plausible explanation for the separation between the groundwater levels and surface water levels at Wells 6 and 7 is the presence of approximately 100 feet of clay that separates the surface water from the aquifer from which the wells pump groundwater (see Figures 2 and 3). The relatively large seasonal fluctuations in groundwater levels at these two wells indicates that this aquifer is confined beneath the clay.

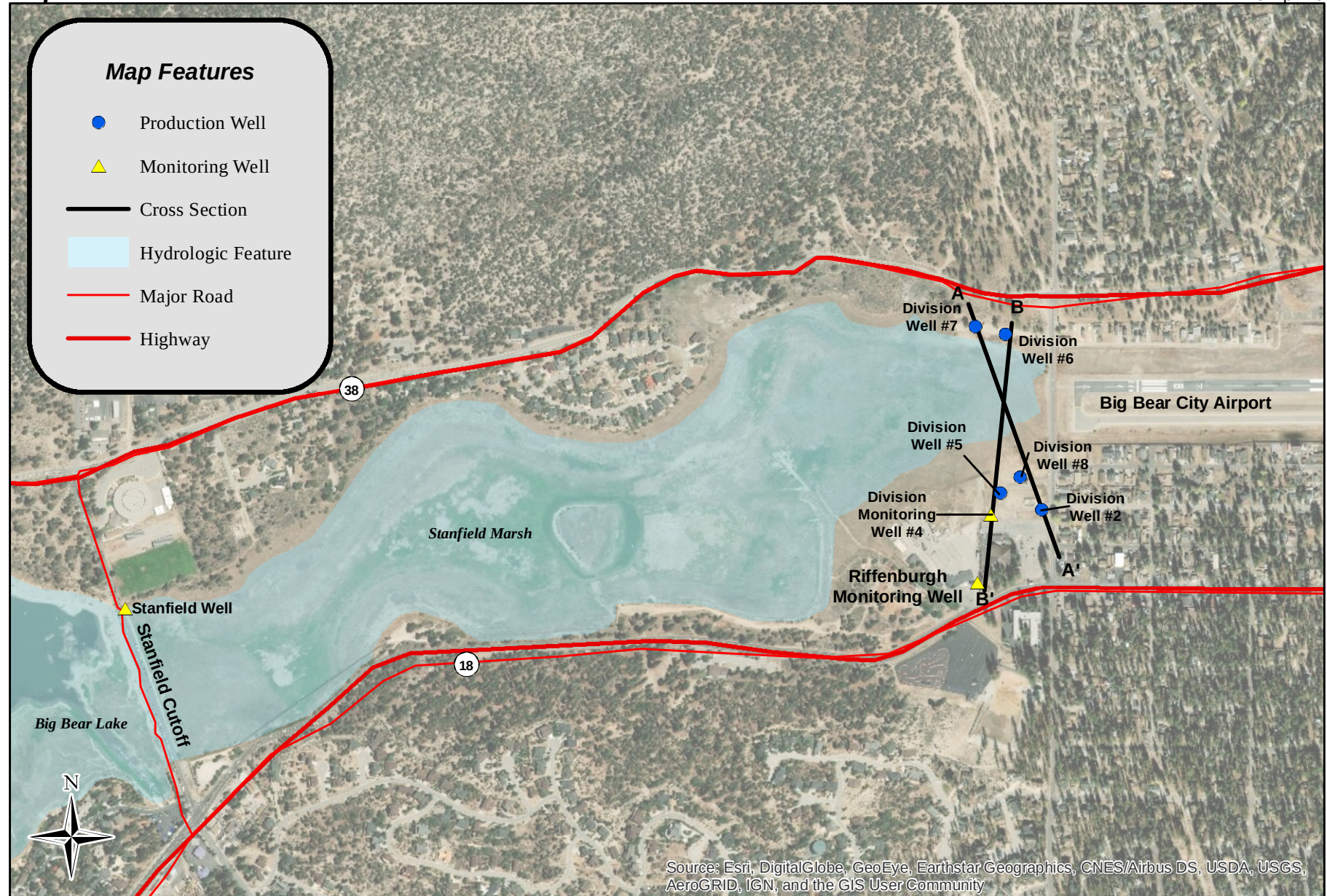
Groundwater levels at Well 8, located on the south side of Stanfield Marsh and constructed with perforations starting at 198 ft bgs, are also below the surface water levels of the lake. There are multiple clay layers in the upper 198 feet of the subsurface that separate the top of perforations from nearby surface water in Stanfield Marsh. Groundwater levels in this well also fluctuate significantly with seasonal pumping patterns indicating the aquifer(s) in which it is perforated is confined beneath the overlying clay layers.

Conclusions

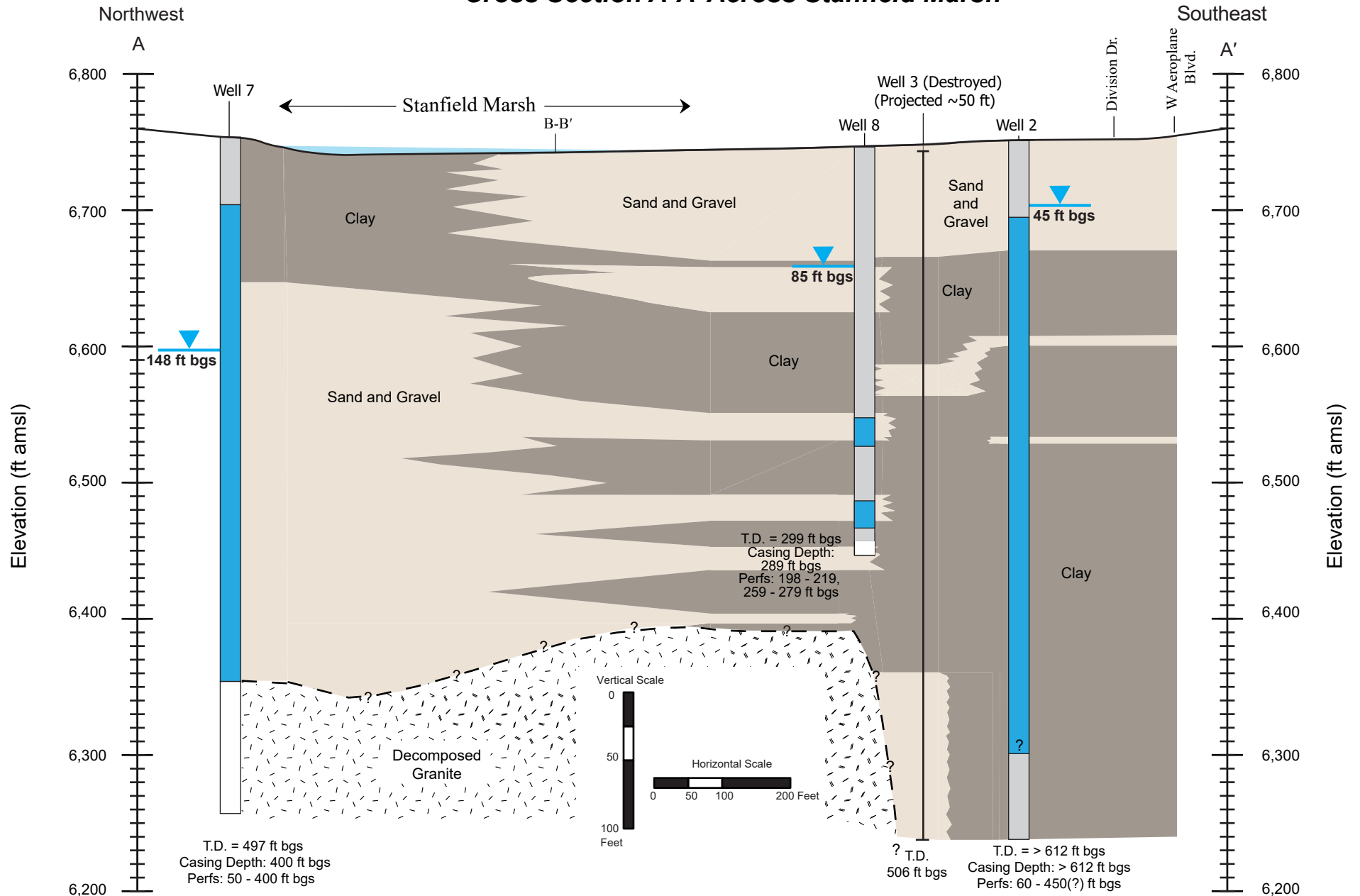
Based on an analysis of the perforation intervals of the Division Wells in relation to the subsurface lithology and a comparative analysis of groundwater levels and surface water levels in Big Bear Lake, we have developed the following conclusions:

- At Division Wells 2 and 5, there is likely a hydrologic connection between groundwater in the wells and surface water in Stanfield Marsh when the marsh is full and groundwater levels are high. The groundwater levels at which the correlation becomes apparent in these wells is between 6,720 and 6,732 ft amsl.
- At Division Wells 6 and 7 on the north side of Stanfield Marsh, clay in the upper 100 feet of sediments provides a hydraulic barrier between surface water in the marsh and the groundwater aquifer from which Wells 6 and 7 are pumping even though the perforated intervals for Wells 6 and 7 begin at 50 ft bgs. The effectiveness of this barrier is supported by the groundwater levels measured in these wells, which are significantly deeper than the surface water in the marsh and seasonally variable, indicating confined aquifer conditions. The groundwater level data indicate that the clay layer is an effective hydraulic barrier between the surface water in the lake and the groundwater system from which Wells 6 and 7 pump.
- Division Well 8 was constructed with the top of perforations beginning 198 ft bgs. There are multiple clay layers in the upper 198 feet of the subsurface that separate the top of perforations from nearby surface water in Stanfield Marsh. Groundwater levels in this well also fluctuate significantly with seasonal pumping patterns indicating the aquifer(s) in which it is perforated is confined beneath the overlying clay layers.

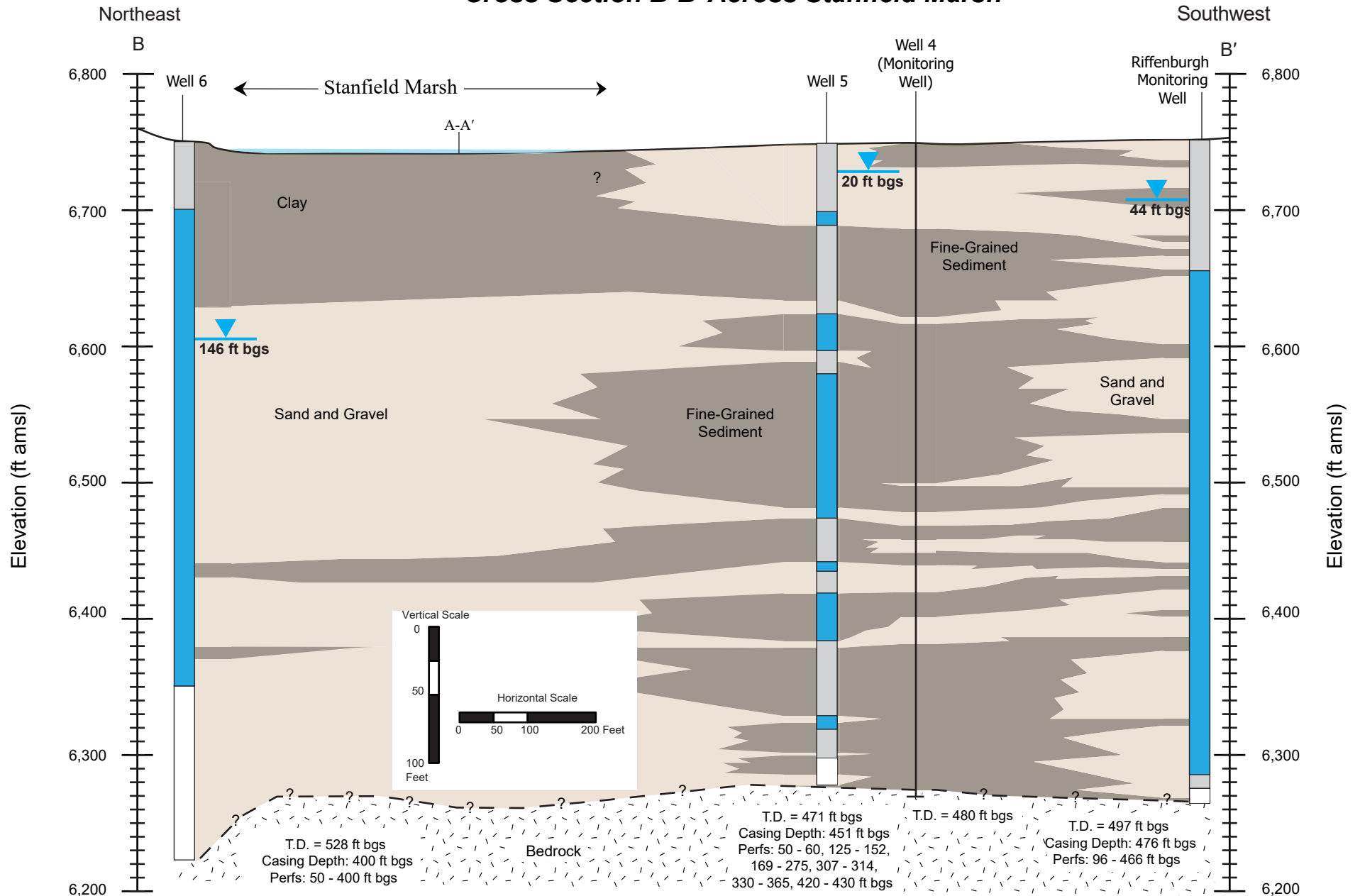




Cross Section A-A' Across Stanfield Marsh



Cross Section B-B' Across Stanfield Marsh



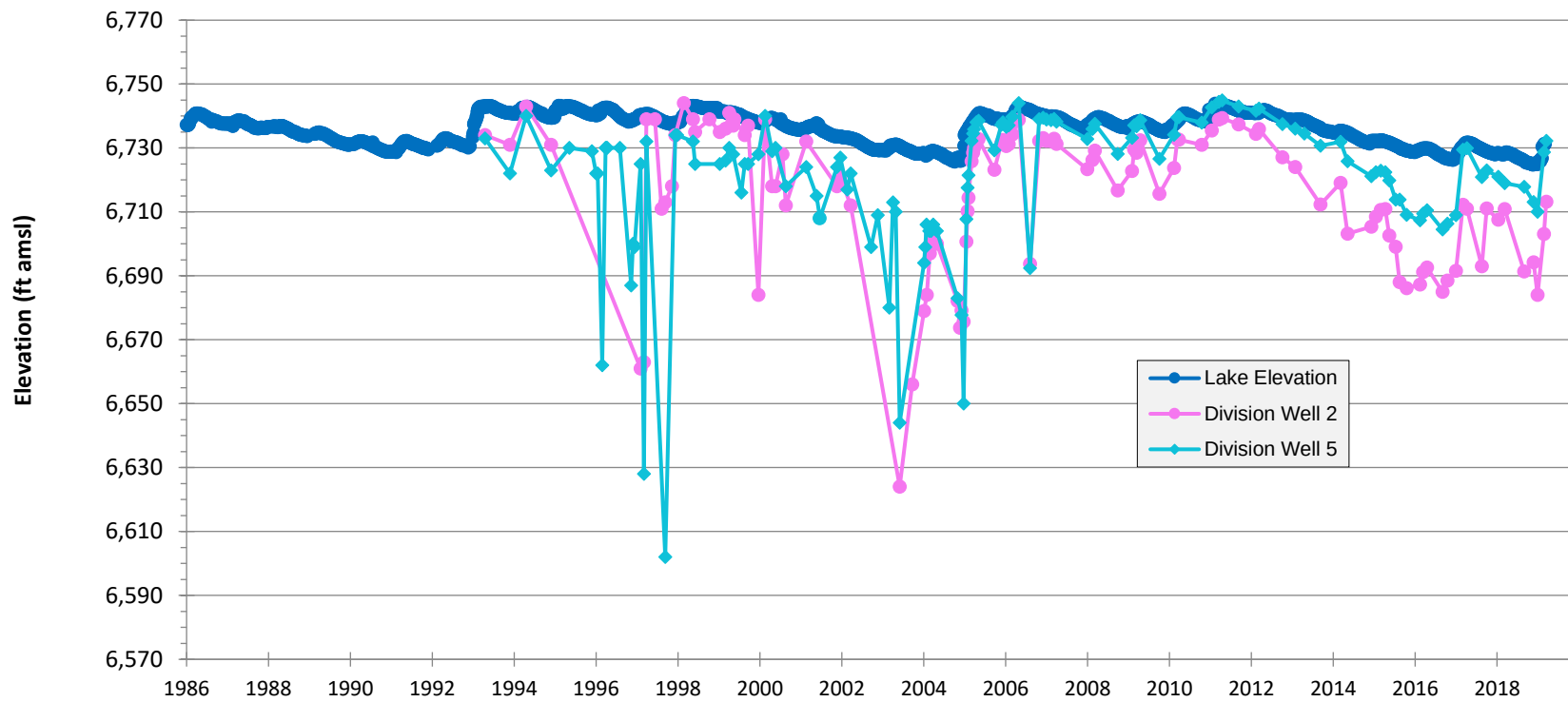
Notes:

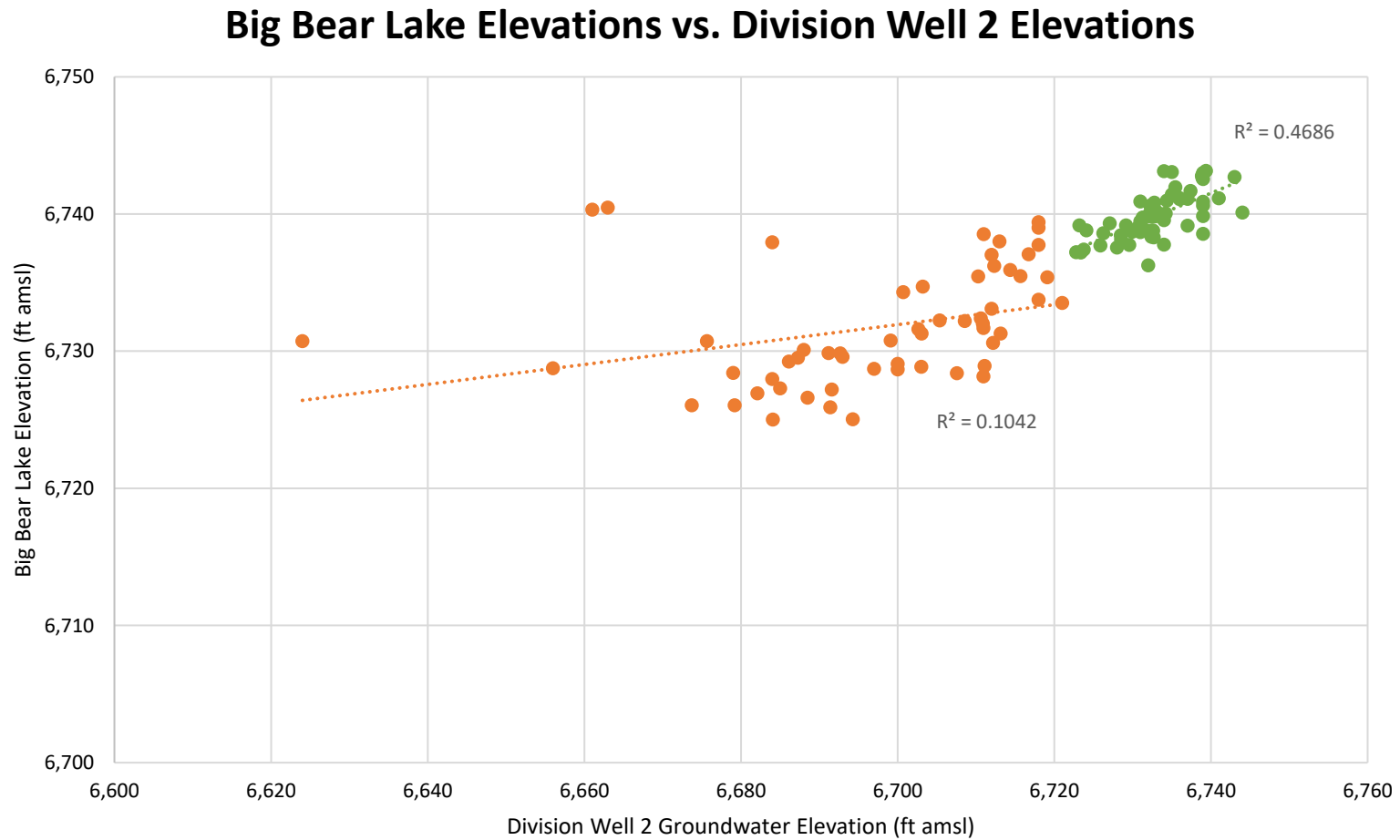
Lithology generalized from Drillers Logs and well completion reports (various).
 Groundwater levels measured in March 2019.

Figure 3



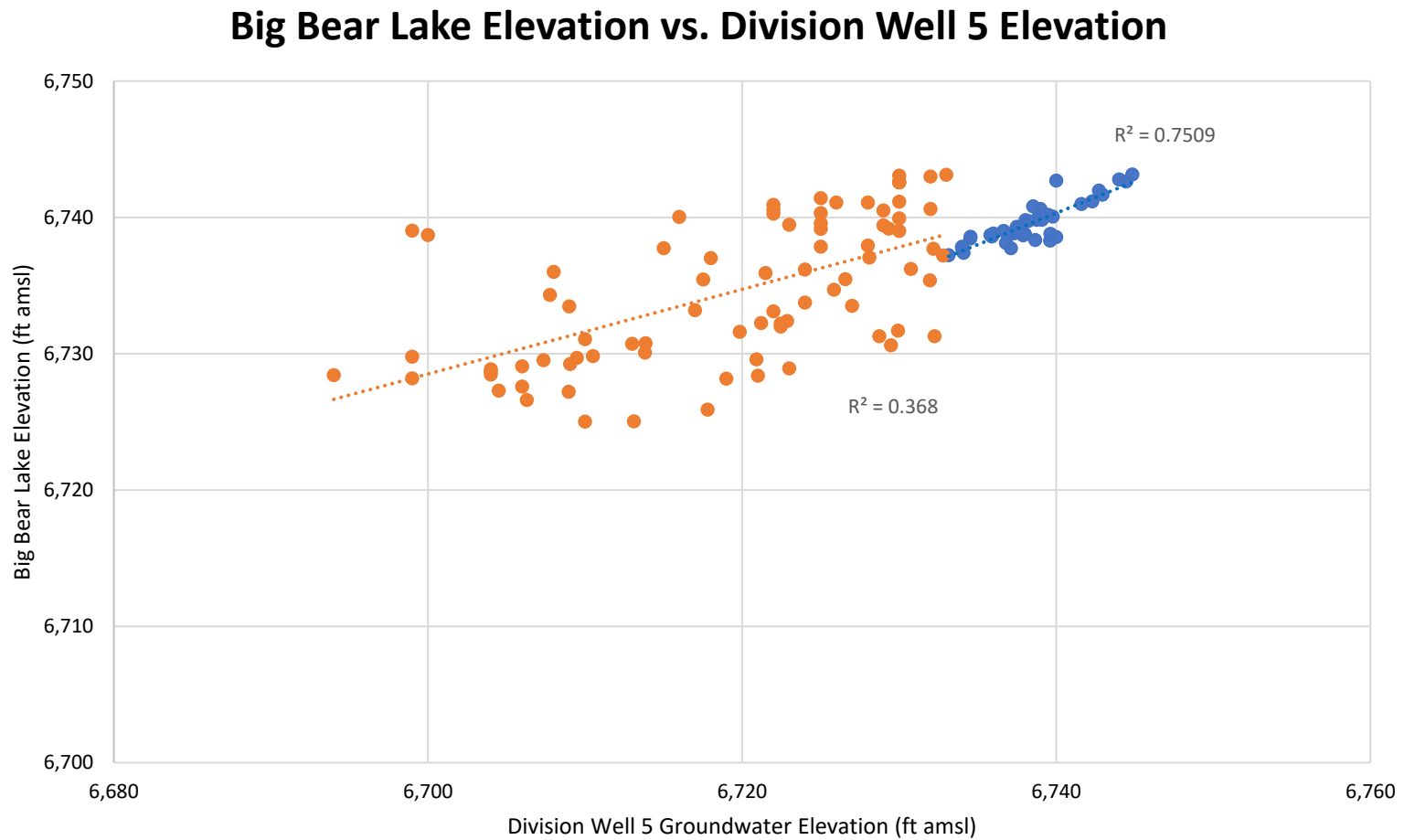
Groundwater Elevation vs. Big Bear Lake Elevation





Note : Time period for the data is April 1993 through March 2019.



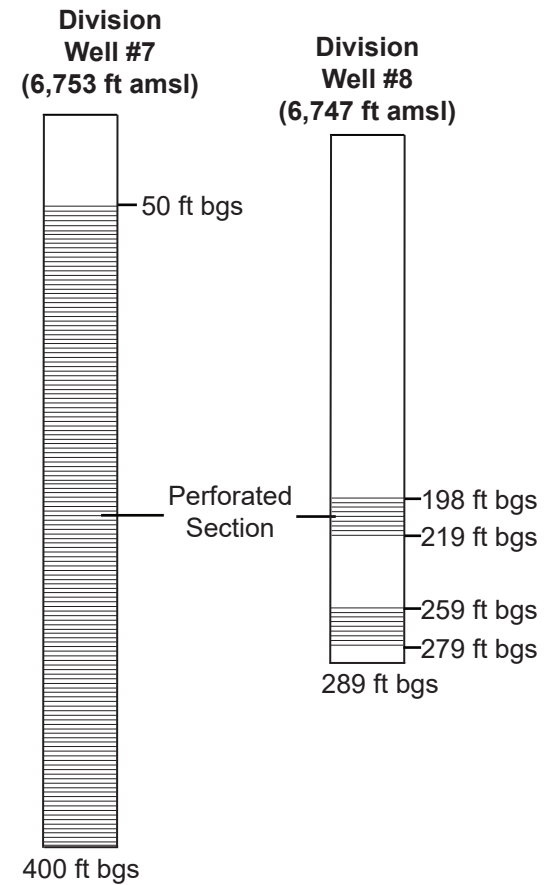
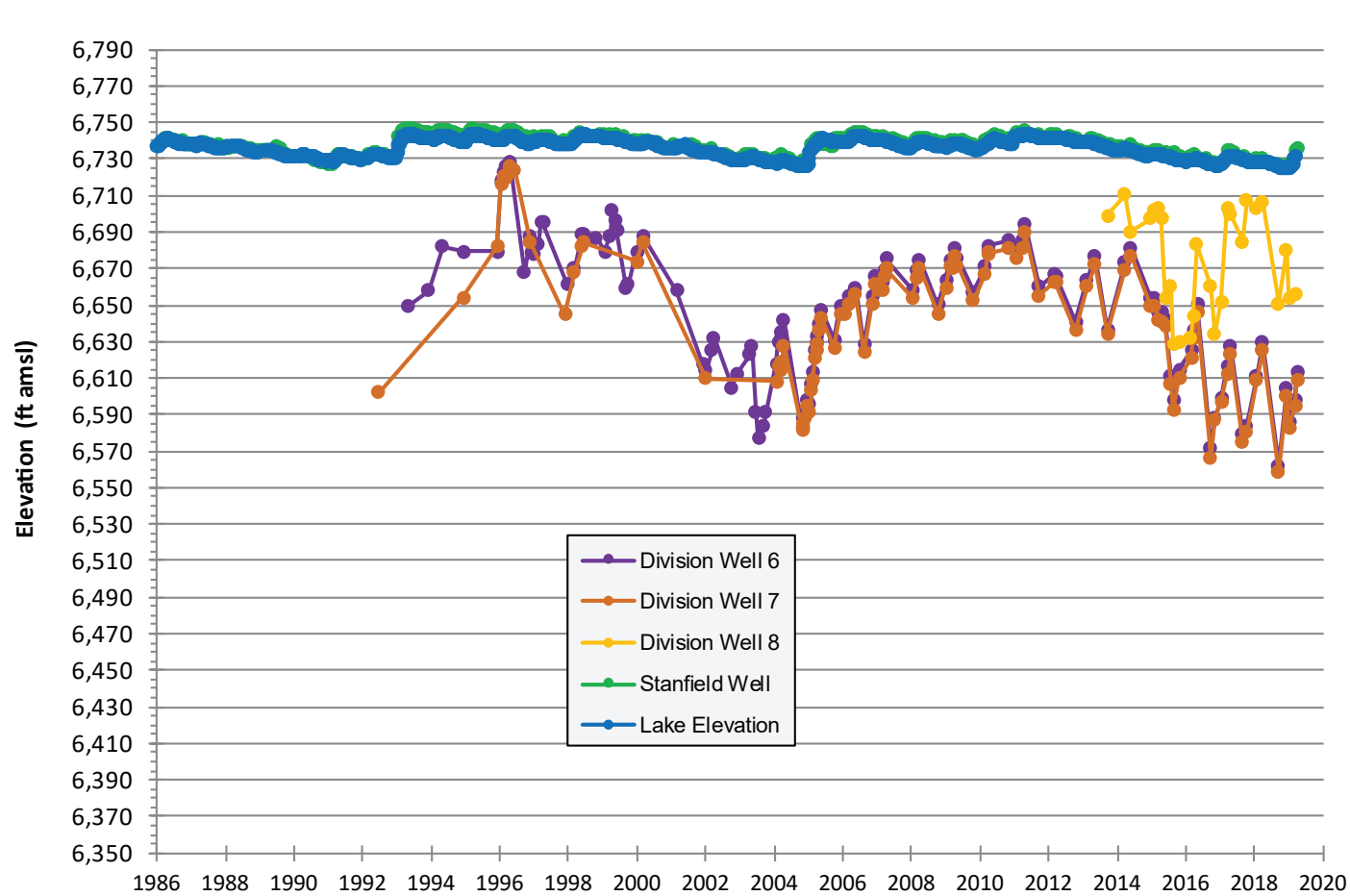


Note : Time period for the data is April 1993 through March 2019.



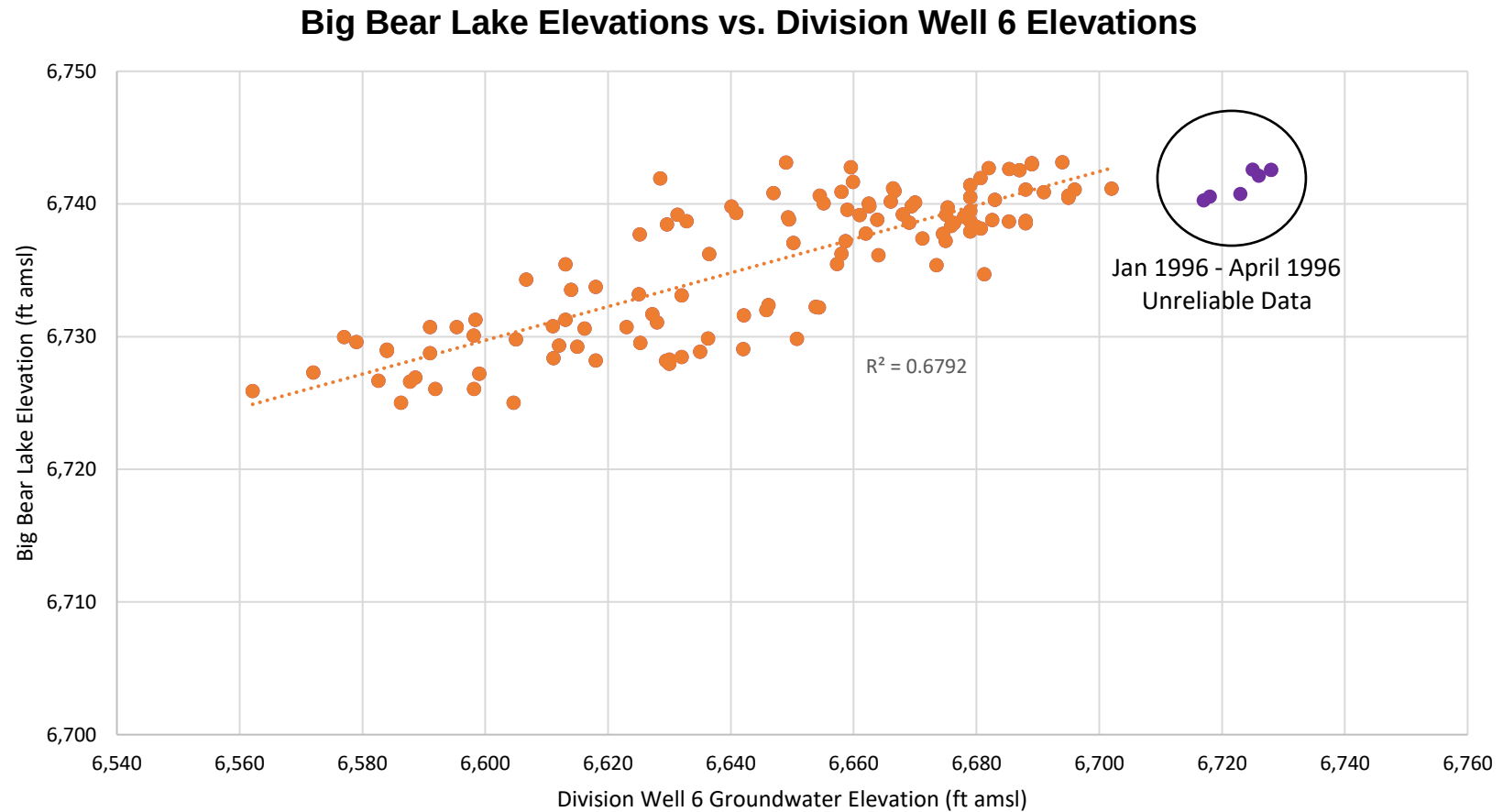
Figure 7

Groundwater Elevation vs. Big Bear Lake Elevation

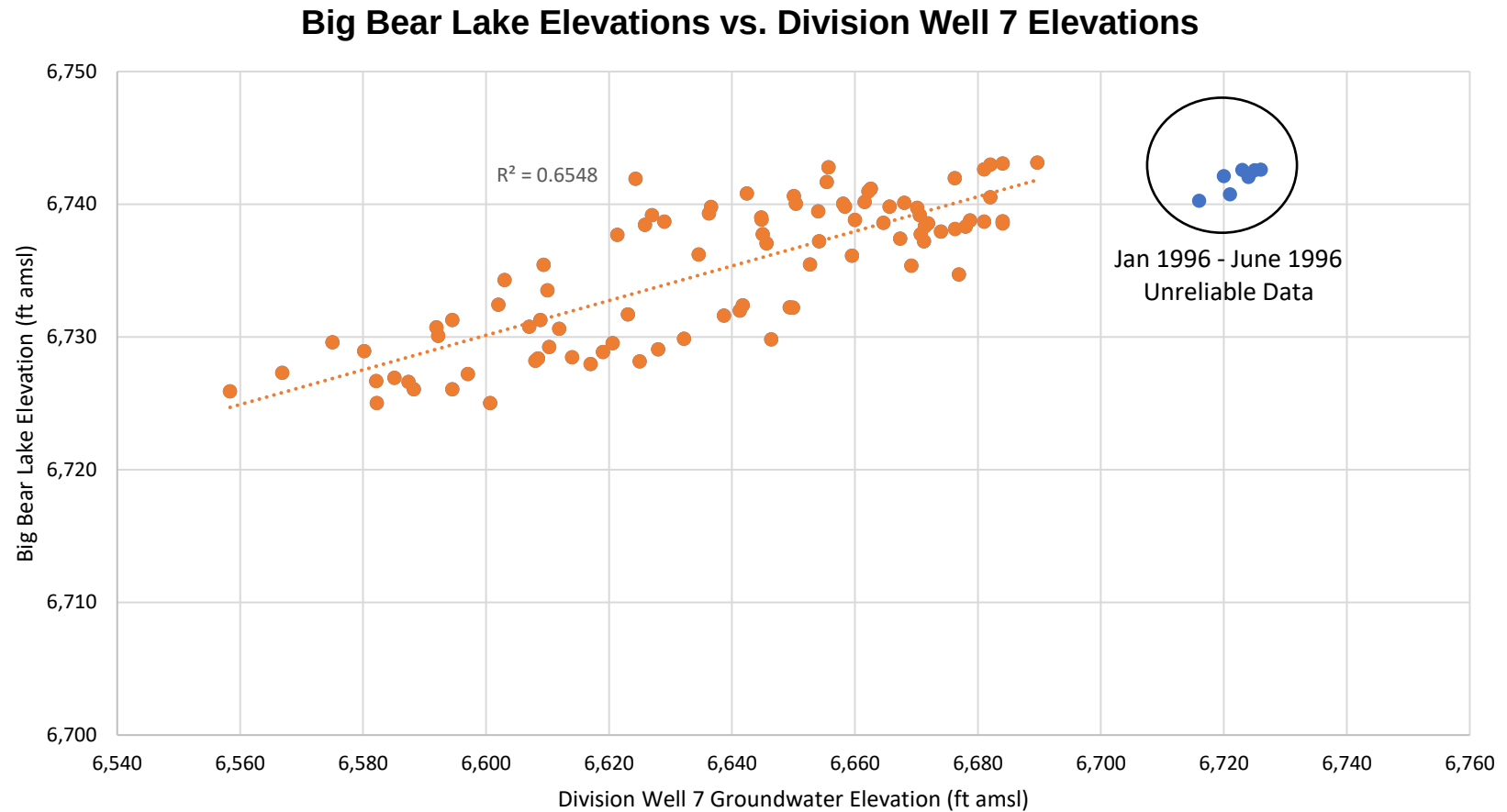


Notes:

ft bgs = feet below ground surface
ft amsl = feet above mean sea level



Note : The time period for the data is April 1993 through March 2019.



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