Tom Nance Water
Resource Engineering

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MEMORANDUM

To: John Stubbart – Pulama Lanai

From: Tom Nance

Subject: Results of the Test of the Effects of Pumping Lanai Well 1 on the Upgradient Lanai Well 2

Introduction

A test was conducted to document whether pumping Well 1 in the Palawai Basin produces a detectable effect on the water level in Well 2. This memo and its attachments present the data and interpretations of this test. The ground elevation at Well 1 is 1263 feet. At Well 2, the ground elevation is 1905 feet. The static water level in Well 1 stands at 640 feet above sea level. The static water level in Well 2, standing at 1447 feet above sea level, is 807 feet higher. The wells are about 5250 feet (roughly a mile) apart. There are an unknown number of intruded dikes in the parent lavas between the two wells, but there is likely to be a significant number.

Given these circumstances, it is highly unlikely that pumping Well 1 over a practical test duration would produce a water level decline in Well 2. Nevertheless, such a test was conducted to see if such an impact could be documented.

Description of the Test

Water Level Recording of Lanai Well 2. On September 6, 2016, a Solinst F30 Edge Levelogger suspended on a stainless steel cable was installed in Well 2. The level in the well, measured with an electric sounder just prior to installation of the logger, was 1446.87 feet (MSL). The Edge Levelogger measures absolute pressure (the weight of water above the logger plus barometric pressure). To correct for the semi-diurnal barometric pressure variations, a Solinst Barologger was also suspended in the well to measure the barometric pressure in the column of air in the well.

Exhibit 43K

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On October 3, 2016, both the F30 Edge Levelogger and the Barologger were removed from the well. The well's water level, measured at 9:57 AM which was about five minutes after the logger retrievals, was 1446.99 feet (MSL), about 0.12 feet higher than measured on September 6th.

Monitoring the Operation and Pumped Water Salinity of Well 1. The operating record of Well 1 is monitored by a SCADA System and also by the water company staff. The staff's record is logged by Curtis Ginoza, utility lead man for the water company. These sources provided pump start and stop times and pumping rates of Well 1. In addition, daily water samples and flow meter totalizer readings were taken by Patrick Untalan, utility meter reader, at 7:35 AM on each day that Well 1 was pumped.

The start of pumping Well 1 was at 7:30 AM on September 12th. It had not been run for more than a week prior to this start up. On September 17th at 11:20 PM (a Saturday night), the pump tripped off due to voltage imbalance. This was not discovered until Monday morning on September 19th. The pump was restarted at 9:00 AM on that morning and ran continuously until 8:08 AM on September 26th. It was not restarted until after the data loggers had been removed from Well 2 on October 3rd.

Presentation of the Collected Test Data

Figure 1 presents the recorded water level in Well 2 and the barometric pressure in the column of air inside the well. The scales on the graph have been selected to clearly show the semi-diurnal barometric pressure variations and the changes of the water level in Well 2 in response to this. The water level changes in Well 2 were on the order of 0.15 to 0.30 of the magnitude barometric pressure changes. The water level variations also, quite surprisingly, lag behind the barometric changes by one to six hours. The variable water level response to the barometric changes make it virtually impossible to satisfactorily "correct" the water level variations by applying a linear scale factor and time lag to the barometric data. As such, the "uncorrected" recorded water levels are used herein.

On Figure 2, the operating periods and pumping rates of Well 1 are superimposed on the recorded water level of Well 2. Initially, Well 1 pumped continuously for five days and 16 ours at an average of 237 GPM before the unscheduled shut down due to a voltage imbalance. After being off for 33 hours and 40 minutes, Well 1 was restarted and ran continuously for six days and 23 hours at an average of 245 GPM.

Figures 3 and 4 and Table 1 present the specific conductance and chlorides of the daily samples collected by Patrick Untalan. There are two aspects of these sample results to note. First, as recently discovered, the check valve on the discharge pipeline of Well 1 does not seat completely. When Well 1 is not running, a nominal amount of more saline water from Well 15 and/or the Manele Reservoir leaks back through the check valve and down into Well 1. For this reason, samples collected at the start up of Well 1, if it has been off for a period of time, include this more saline leaked back water. That is the reason why the salinity of water collected at the initial start up on September 12th and again at the restart on September 19th is anomalously high. Once the nominal amount of leaked back water is removed by pumping, the actual salinity of water from Well 1 is reflected in the subsequent samples.

The second aspect to note is the very gradual but definitely measurable salinity increase as Well 1 was continued to be pumped. The trend of increasing salinity with pumping duration, albeit not dramatic, was unmistakable and quite significant.

Interpretation of the Test Results

Recorded Water Leve in Well 2. Very clearly, no impact on the water level in Well 2 in response to pumping Well 1 was recorded. It can be reasonably argued, however, given the distance between the wells and the likelihood of multiple separate dike-(or fault-) confined groundwater compartments between them, that the test duration was far too short to prove that pumping Well 1 does not induce greater leakage from the groundwater compartment tapped by Well 2 than would otherwise occur naturally absent the use of Well 1.

I have carefully examined the available records of all wells drilled into high level groundwater on Lanai, as documented by Keith Anderson for the period from 1948 through 1984 and by the Periodic Water Reports from 1985 to the present. Except for replacement Well 3A which is about 25 feet from the collapsed Well 3, every well drilled into high level groundwater on Lanai taps into its own, separate groundwater compartment, even wells such as Well 2 and Shaft 3 which are only about 150 feet apart and Wells 4 and 5 which had almost identical static water levels when they were originally developed in 1950. There is not one instance in this available record where the pumping of one well produced a water level drawdown in another well. The reality is that the confining dikes (and/or fault surfaces) that create the separate groundwater compartments are very tight. That the water levels stand as high above sea level as they do with the very modest recharge that occurs provides pragmatic evidence of this.

Gradually Increasing Salinity of the Water Pumped by Well 1. In my opinion, the gradually increasing salinity in the water pumped by Well 1 is a far more significant result of the test than the lack of a water level response in Well 2. If the pumping of Well 1 actually increases the leakage from adjacent, higher head compartments containing lower salinity water than in the compartment tapped by Well 1, the expectation is that the salinity of water pumped by Well 1 would gradually decrease as Well 1 is continued to be pumped. That clearly did not occur.

Attachments

ec: Greg Fukumitsu and Todd Yonamine – TNWRE, Inc.

Figure 1
Recorded Water Level and Barometric Pressure at Lanai Well 2 from September 6 to October 3, 2016

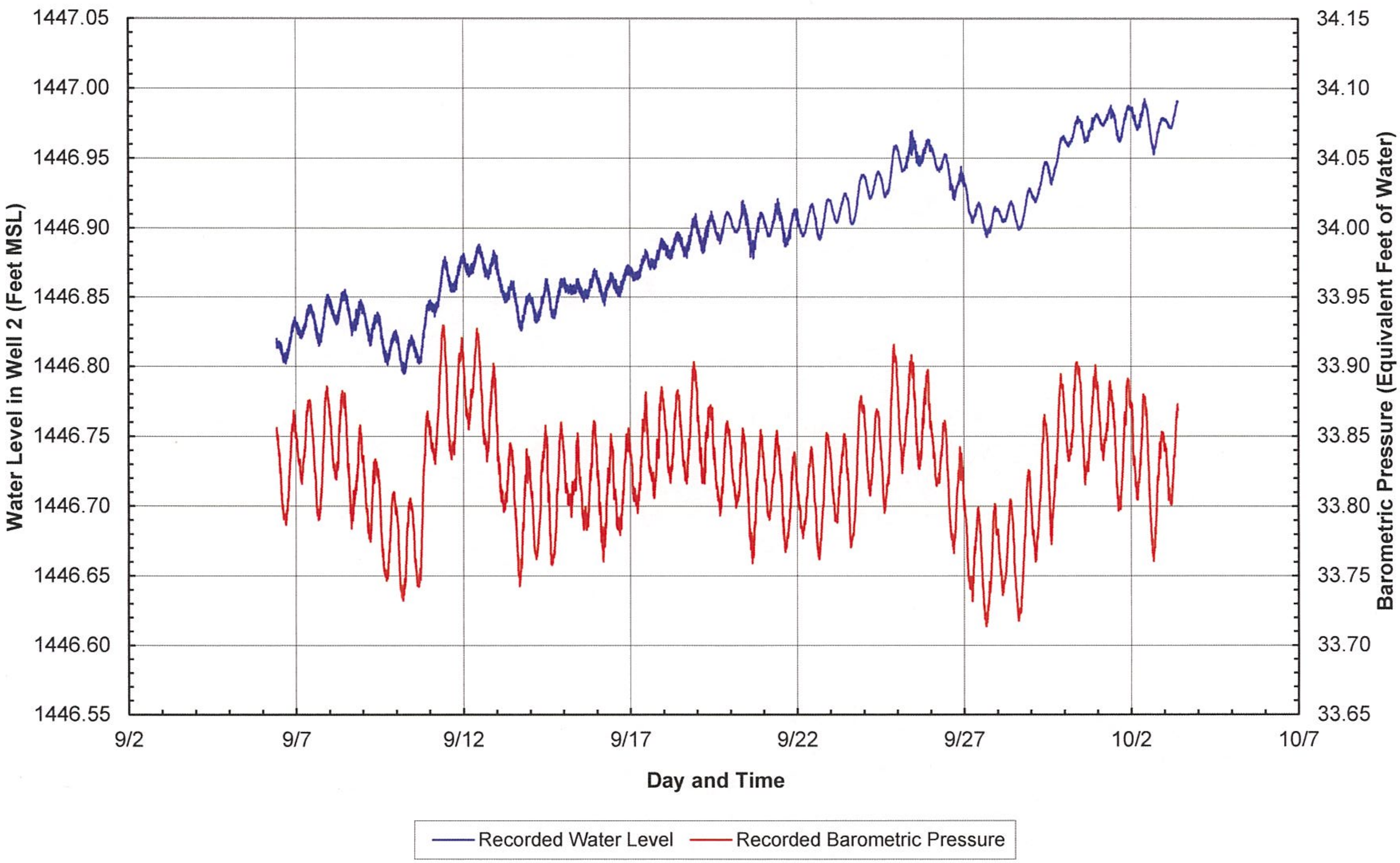

Figure 2
Operation of Lanai Well 1 Superimposed on the Recorded Water Level in Lanai Well 2

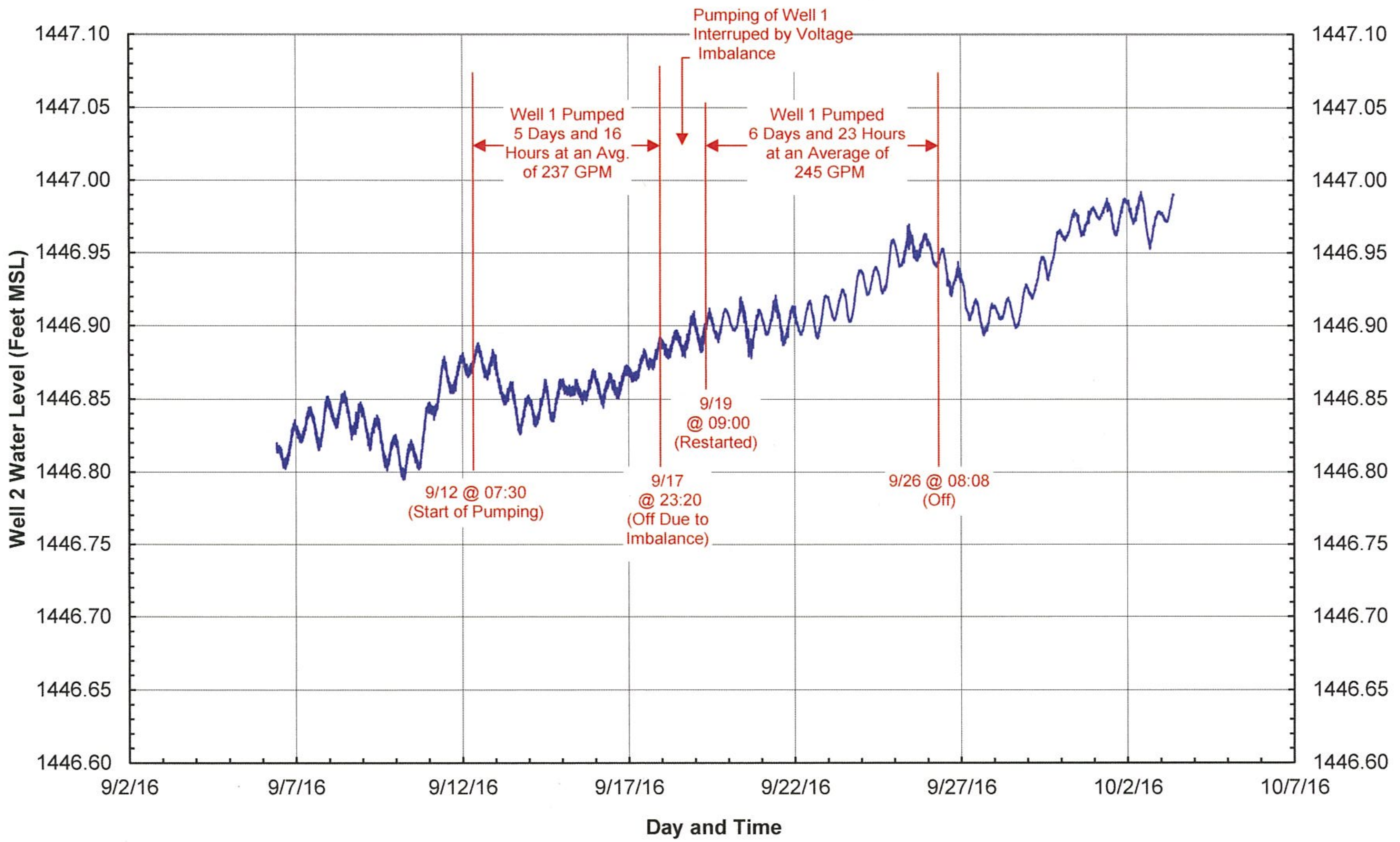

Figure 3. Specific Conductance of the Water Pumped by Well 1

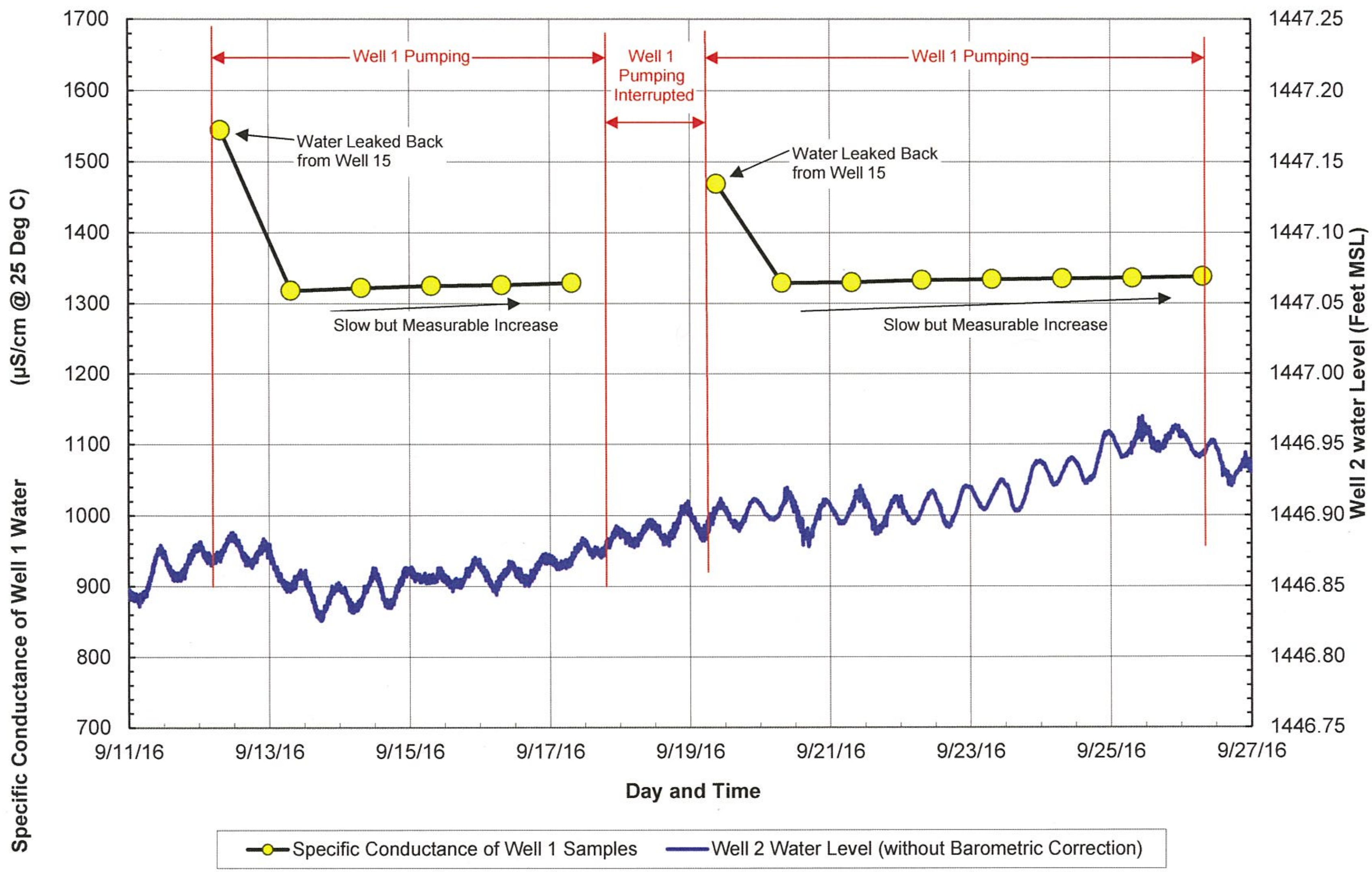

Figure 4. Chlorides of the Water Pumped by Well 1

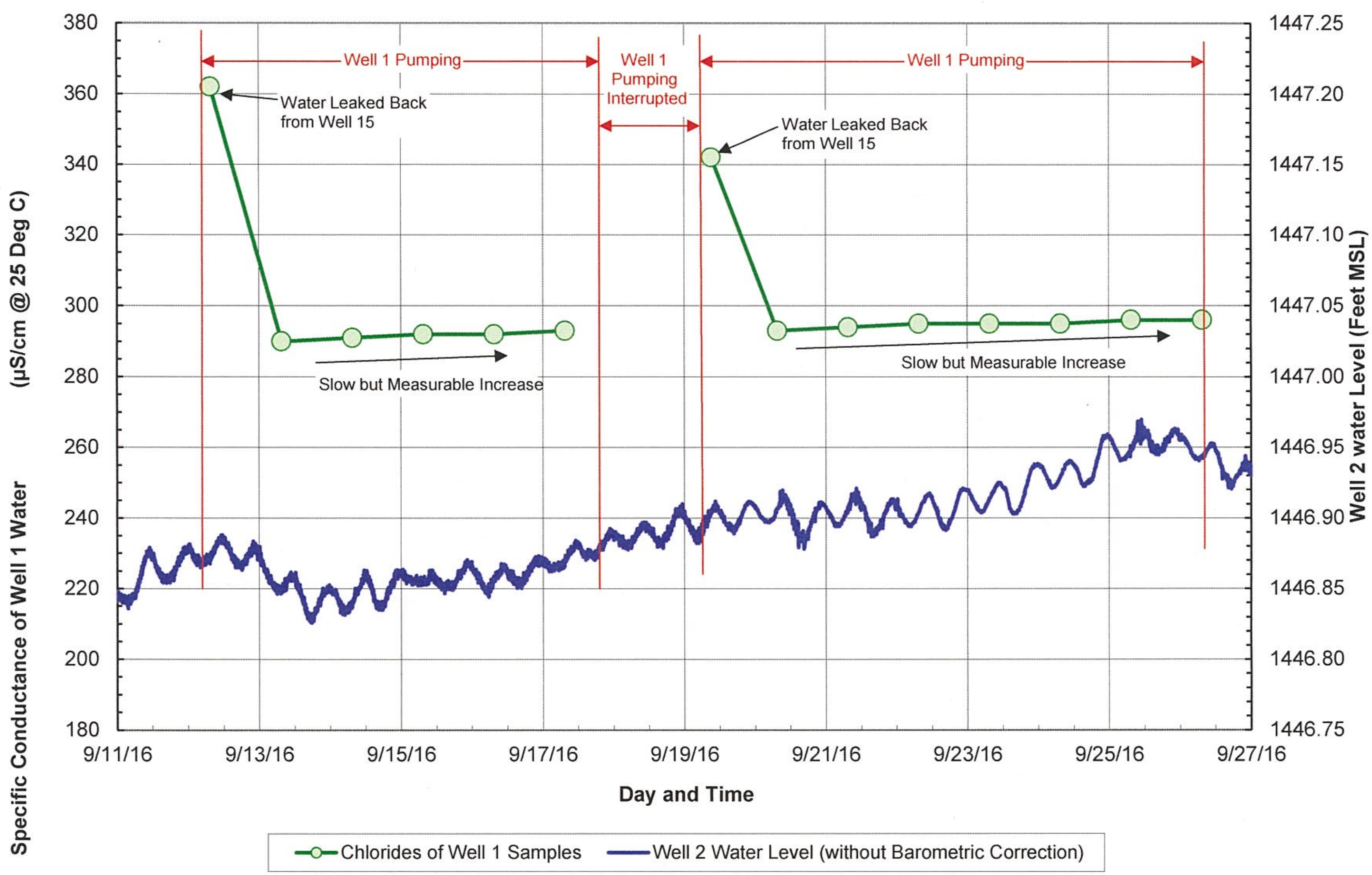

Table 1

Specific Conductance and Chlorides of Samples
from Lanai Well 1, September 12 to 26, 2016

Sample		Specific Conductance (µS/cm @ 25° C.)	Chlorides (MG/L)
Day	Time		
9/12	07:35	1544	364
9/13	07:35	1318	290
9/14	07:35	1322	291
9/15	07:35	1325	292
9/16	07:35	1326	292
9/17	07:35	1329	293
9/19	09:10	1469	339
9/20	07:35	1329	293
9/21	07:35	1330	294
9/22	07:35	1333	295
9/23	07:35	1334	295
9/24	07:35	1335	295
9/25	07:35	1336	296
9/26	07:35	1338	296

Notes:
1. Samples collected on September 12 and 19 were after periods when Well 1 was off. More saline water from Well 15 leaks back into Well 1 (past a check valve) when Well 1 is not pumping.
2. Specific conductance was measured in the TNWRE office using a HACH HQ30d meter calibrated with a 1413 µS/cm standard.
3. Chlorides determined by mercuric nitrate titration in the TNWRE office.