PACIFIC groundwater GROUP

UPPER MOSES COULEE PUMPING IMPACT ANALYSIS
WRIA 44/50 PLANNING UNIT

March 2009

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UMC Impact Analysis Report.doc

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SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.

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1.0 INTRODUCTION

The industry in the Upper and Lower Moses Coulee is primarily irrigated agriculture. Therefore, the availability of groundwater is critical the local economy. Groundwater elevations in the Lower Moses Coulee and spring flow in the Upper Moses Coulee have been impacted in the past by over-pumping in the Upper Moses Coulee. The purpose of this report is to evaluate whether the impacts of ongoing pumping in the Upper Moses Coulee is affecting groundwater elevations and spring flow.

This project was authorized by the Foster Creek Conservation District. The work was completed under Phase 4 Watershed Planning Grant No G0500121. This work was performed, and this report prepared, in accordance with hydrogeologic practices generally accepted at this time in this area, for the exclusive use of the Foster Creek Conservation District and the WRIA 44/50 Planning Unit and their agents. No other warranty, express or implied, is made.

2.0 DATA SOURCES

Data used for this report include precipitation, groundwater elevations, and groundwater pumping data. Precipitation data was downloaded from the interagency-managed Remote Automated Weather Stations (RAWS) website. The closest station to the study area was the Douglas, Washington station. Daily precipitation since 1996 was obtained.

All groundwater elevation data was collected as part of the WRIA 44/50 groundwater monitoring program. The monitoring system records groundwater elevations at 26 locations in Douglas County beginning as early as 2003 in some wells. Details about the monitoring system are included in WRIA 44/50 Groundwater Elevation Monitoring Report (PGG, 2009). Monitored locations used for this report are presented in **Figure 1**.

Annual irrigation pumping estimates were derived from air photos of the Upper Moses Coulee taken on June 28, 2004, July 26, 2005, and July 1, 2006 (**Appendix A**). Irrigated acreage appears to be similar for all years, approximately 485 acres. Therefore, no differentiation in annual irrigation can be made using this method.

The air photos indicate some color variation between circles, suggesting that water usage per acre varies between circles. However, reliable water usage data is only available for the Peterson well. Therefore, water usage per acre estimates from the Peterson well were extrapolated to the adjacent crop circles to estimate total irrigation use in the Upper Moses Coulee. The Peterson well is operated at 600 gallons per minute (gpm) for four periods during the summer:

- Early April to Early May – Two days (48 hours) a week, until the first cutting June 5 to June 20.
- June 21 to July 15 - Two days (48 hours) a week, until the second cutting July 15 to July 30
- August 1 to September 3 - Three days a week, every other week, until third cutting September 3 – 16

- September 17 – October 6 - Three days a week, every other week, water added into dormant season

Under this pumping regime, the Peterson well pumps approximately 100 acre feet per year. The Peterson well irrigates approximately 60 acres or 12 percent of the irrigated acreage in the Upper Moses Coulee. If all acreage is planted with the same crop and uses a similar amount of water, a total of 820 acre feet of water is used in the Upper Moses Coulee each year.

A total domestic water use of 106 acre feet per year was estimated using the following assumptions:

- There are approximately 40 domestic wells in Rimrock Meadows, only three of which are used year-round (PGG, February, 2007)
- There are an additional 10 domestic wells in the Upper Moses Coulee
- 20 wells are used full time and 30 are used one quarter of the time
- Full time usage is 460 gallons per day (PGG, , 2003), Phase 1 Exempt Well Water Use Study

3.0 ANALYSIS

The primary influences on groundwater elevations and stream flow in the Moses Coulee are likely precipitation and pumpage. In order to evaluate the effects of pumping, the onset of groundwater decline is evaluated in pumping and observation wells. To evaluate whether seasonal variation is likely due to pumping, correlation to an Antecedent Precipitation Analysis (API) was performed.

3.1 ONSET OF GW DECLINE

According to the water level plots in the 2008 Water Year Monitoring Report (PGG, 2009), pumping at the Peterson well began on April 14 in 2007 and on April 28 in 2008. The water level plot for the Peterson well is included as **Figure 2**. The closest monitored well to the Peterson irritation well is The Nature Conservancy (TNC) well. The precise timing of the onset of groundwater decline in TNC is not clear because of the natural variability in groundwater levels. However, in 2008, the groundwater decline appears to begin between April 22 and 27 (**Figure 3**). Total annual decline in the Peterson well is approximately 3 feet (drawdown is approximately 6 feet) compared to approximately 2 feet in the TNC well. The synchronicity of the declines combined with the larger seasonal decline in the Peterson well suggests that the Peterson well is likely the source of the groundwater decline seen in the TNC well.

The onset of groundwater level decline in the Johncox well is also in mid-April in 2007 (**Figure 4**), no data is available in 2008. Groundwater elevation data from the Downes well (**Figure 5**) is inconclusive but may be influenced by pumping. The Johncox and Downes wells are likely too far south to be influenced by the Peterson well but are likely influenced by other nearby irrigation wells in the coulee. There is no apparent onset of decline in 2007 or 2008 in the Mayer wells (**Figure 6**).

3.2 ANTECEDENT PRECIPITATION ANALYSIS

Groundwater elevations were correlated with precipitation to evaluate whether the effects of precipitation and recharge could be simulated and therefore removed. API was used to modify precipitation data into a form that could be correlated with precipitation. A good correlation with API would suggest a high degree of influence from precipitation. The API could then be used to remove the influence of precipitation, leaving pumping and other influences.

The API is a mathematical predictor of groundwater elevations based on historical (antecedent) precipitation (Swope, 1990). The influence of precipitation decreases with its age; therefore, precipitation that is more recent is given greater weight by use of a decay coefficient. The decay coefficient causes API to be a function of the current day's precipitation and the precipitation that has fallen in the past several hundred days (with recent precipitation events weighted more). These slow decay rates reflect fact that groundwater drainage is slow and that infiltrating precipitation accumulates over a long period.

API is applicable to regions where groundwater elevations are dominated by the effects of direct precipitation rather than by surface- water or tidal interactions or by infiltration of snow melt.

The following equation was used to calculate daily APIs:

$$API_d = (API_{d-1}\,C)+P_d \qquad \text{(Equation 1)}$$

Where:

API_d = antecedent precipitation index for day d

API_{d-1} = antecedent precipitation index for day d-1

C = decay coefficient

P_d = precipitation for day d

To calculate API, the decay coefficient, C, was derived by trial and error and resulting values ranged between 0.97 and 0.99 (Table 1). The C value in Equation 3 that resulted in the best linear correlation or "match" between API_d and $Head_d$ was used to represent each well. The best match between API_d and $Head_d$ was identified when the linear correlation coefficient (r) between API_d and $Head_d$ was greatest.

Because of its cumulative aspect, the first few years of the API should not be correlated with heads to derive C, the decay coefficient. In this case, no arbitrary initial value of API was used; rather, the early values of API were low and inaccurate because of API's cumulative nature, and were therefore not used to establish correlations and C values. Precipitation values back to 1996 were used whereas water level data began in 2001, allowing a 5 year start up time.

3.2.1 API Findings

Correlation coefficient values ranged widely between 0.11 and 0.95. The best correlation occurred in the Downes well (Figure 5), which had a correlation coefficient of 0.95. The Downes well is a seldom pumped domestic well located in Rimrock Meadows development.

Other wells generally correlated poorly. The poor correlations are likely due to the greater influence of pumping, generally low precipitation, and on the long groundwater flow paths in the study area. The influence of pumping is apparent in the Peterson and TNC wells as dicused in Section 3.1. The low precipitation and long groundwater flow paths mean that individual precipitation events are not evident in the groundwater elevation record. The effects of snow melt and the distance of the Douglas precipitation station may also be factors.

Creek stage for Douglas, McCartney, and Rattlesnake Creeks (Figures 7-9) also correlated poorly. The rising limbs of the creek stages rise much more gradually than predicted by the API. API assumes immediate addition of recharging precipitation to the water table.

4.0 RECOMMENDATIONS

Analysis of the effects of pumping can be categorized by the duration of time over which an analysis is performed. Intra-annual analyses are performed using short duration data and multiple data points per year – eg weekly or monthly. Inter-annual analyses are performed with longer data sets using only a few data points per year (eg annual average, minimum, and/or maximum). The data sets currently available lend themselves to intra-annual analyses because of the short groundwater elevation records (2 yrs) and frequent daily groundwater elevation and precipitation data. However, the lack of resolution in the pumping data greatly reduces the accuracy of this analysis. Inter-annual analysis is likely more appropriate given the accuracy of the pumping data. Aggregation of data into annual data would reduce the effects of higher frequency data variability such as pumping. However, a longer data record is required for inter-annual analysis. It is also important that variations in annual precipitation and pumpage be captured within the data record. Without variations in pumpage, its effects on groundwater elevations cannot be evaluated. Requirements for inter-annual analysis are given below:

- Collect actual pumping data or develop a method to more accurately monitor irrigation water use.
- Collect a longer groundwater elevation record
- Install a tipping bucket precipitation gauge in the Upper Moses Coulee.
- Perform an inter-annual analysis, with precipitation and pumpage aggregated by year, and compared to annual maximum and minimum groundwater levels
- Add snow melt function to API.

5.0 REFERENCES

Pacific Groundwater Group, April 2003. WRIA 44/50 Final Phase 2 Basin Assessment. Consultants Report to the Foster Creek Conservation District and WRIA 44/50 Planning Unit.

Pacific Groundwater Group, February 2006. Phase 1 Exempt Well Water Use Study. Consultants Report to the Foster Creek Conservation District and WRIA 44/50 Planning Unit.

Pacific Groundwater Group. February 2007. Rimrock Meadows Groundwater Assessment. Consultants Report to the Foster Creek Conservation District and WRIA 44/50 Planning Unit.

Pacific Groundwater Group, 2009. WRIA 44/50 Groundwater Elevation Monitoring Report, 2008 Water Year, Exempt Well Water Use Study, Phase 2. Consultants Report to the Foster Creek Conservation District and WRIA 44/50 Planning Unit.

Table 1. Antecedent Precipitation Analysis Results

Location	Decay	R
Creek Stage		
Douglas Creek	0.708	0.476
McCartney Creek	0.979	0.448
Rattlesnake Creek	0.992	0.107
Wells		
Downes	0.999	**0.951**
Johncox	0.990	**0.677**
Mayer	0.999	0.142
Peterson	0.986	0.592
TNC	0.999	0.573

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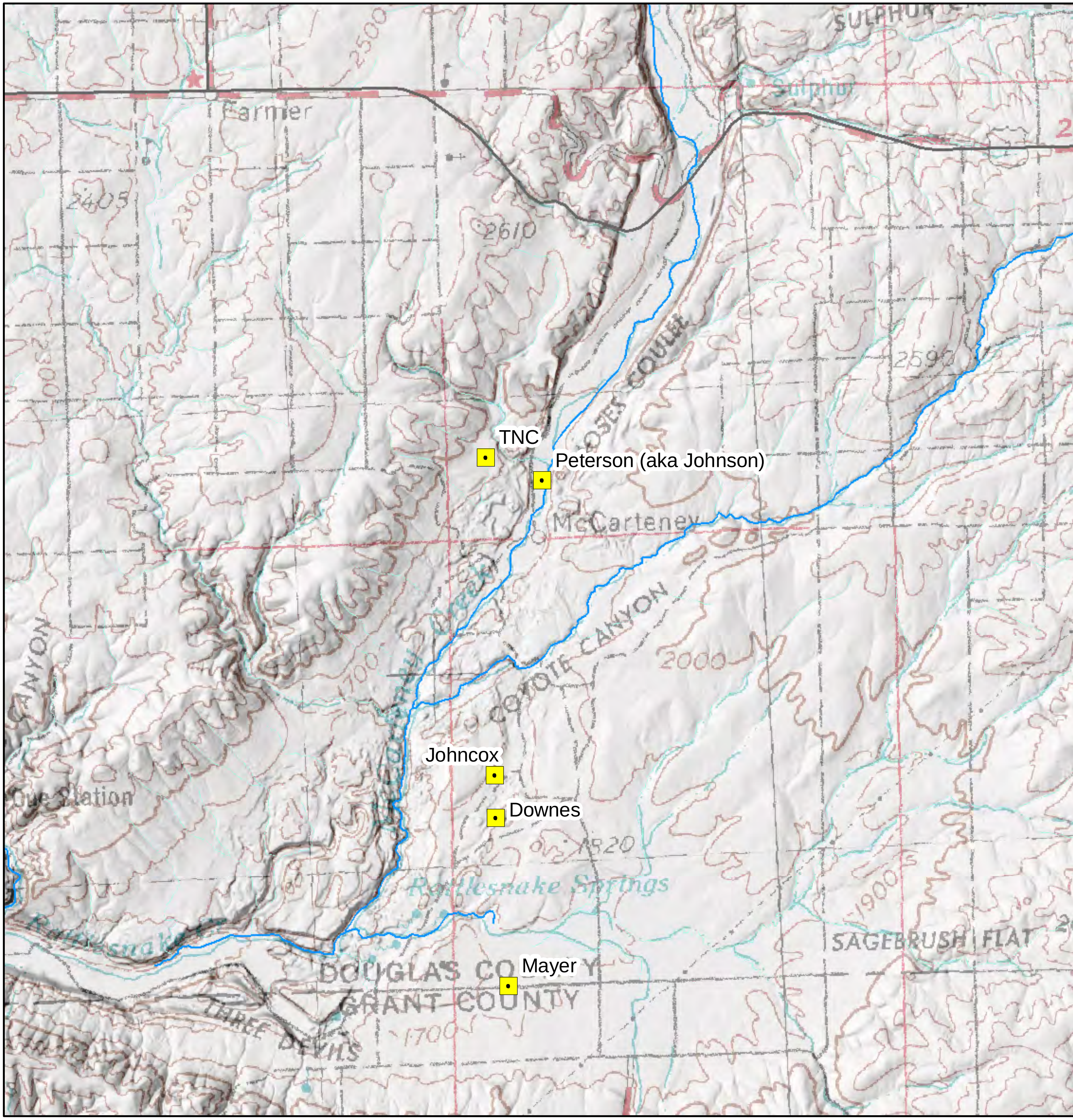
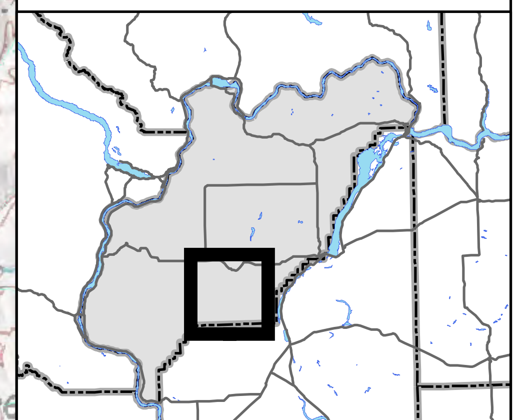
FIGURE 1

Upper Moses Coulee Monitoring Sites



Groundwater Level Monitored Well



N
W E
S

0 10,000 Feet
0 2 Miles
1:120,000

PGG

K:\Steve\DouglasCoData\gis\mxd\Douglas_County_EU_P2_U_MC_Monitoring_Sites.mxd - 03/2009

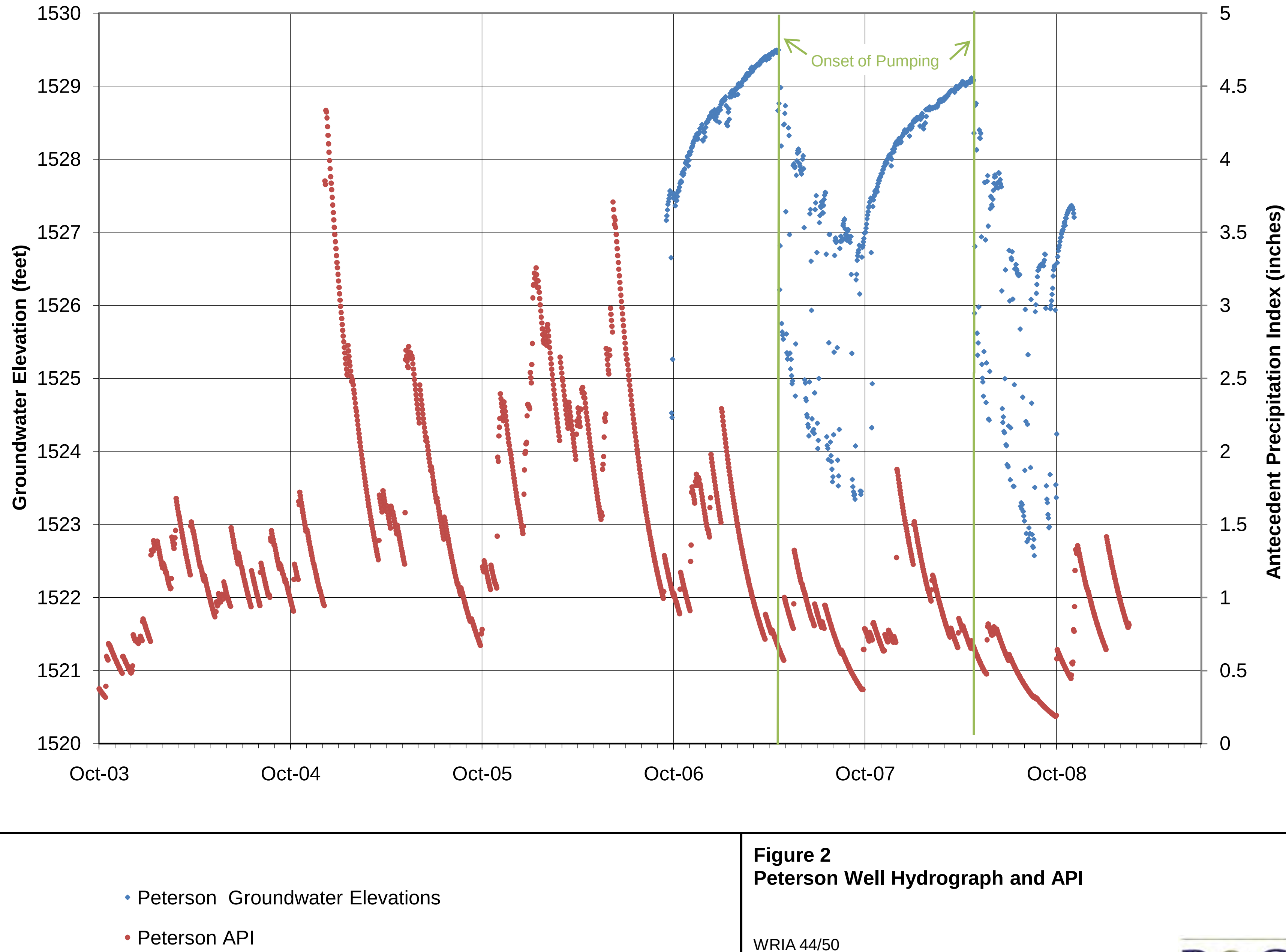


Figure 2
Peterson Well Hydrograph and API

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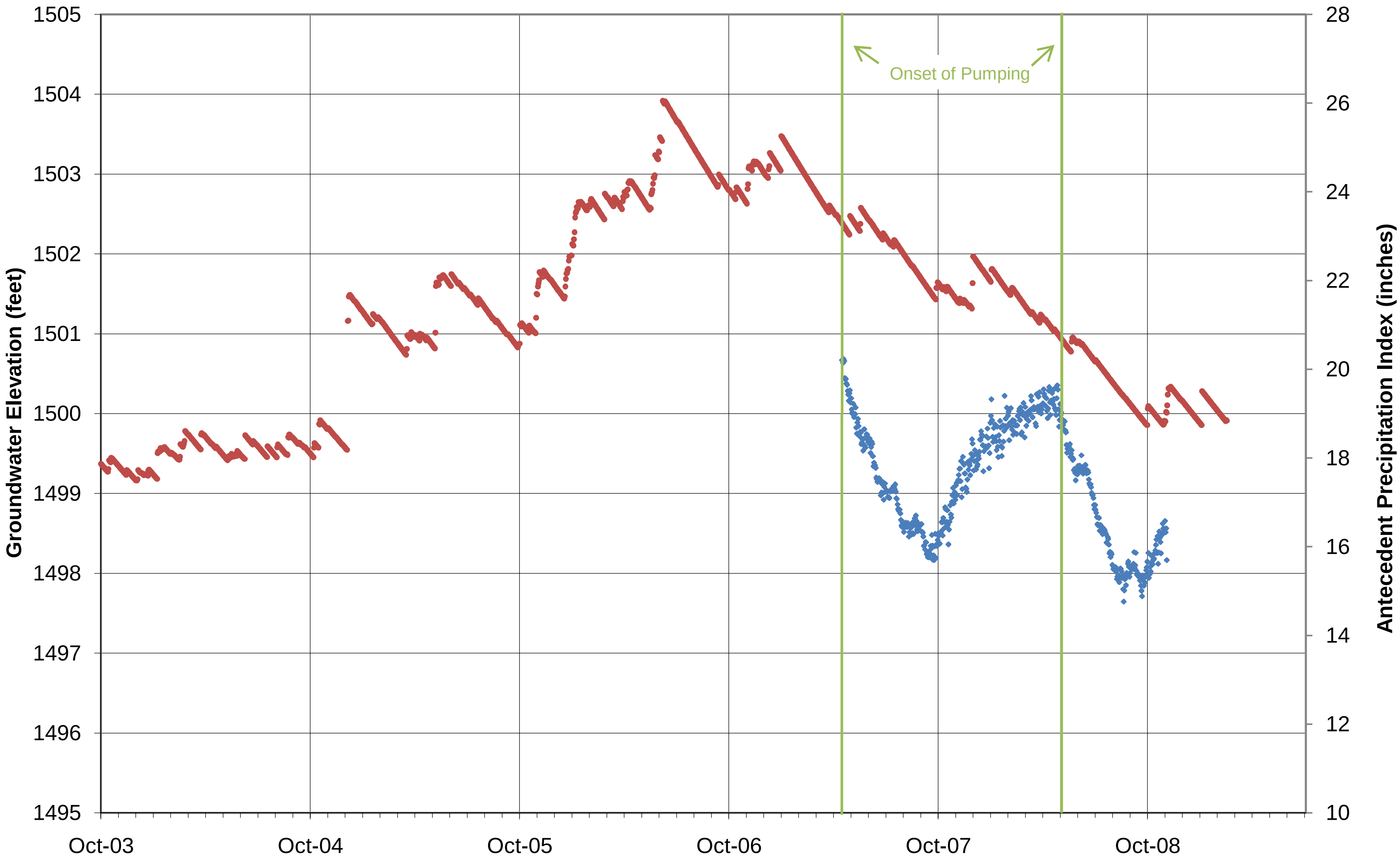

TNC Groundwater Elevations

TNC API

Figure 3

TNC Well Hydrograph and API

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JS0901

PGG

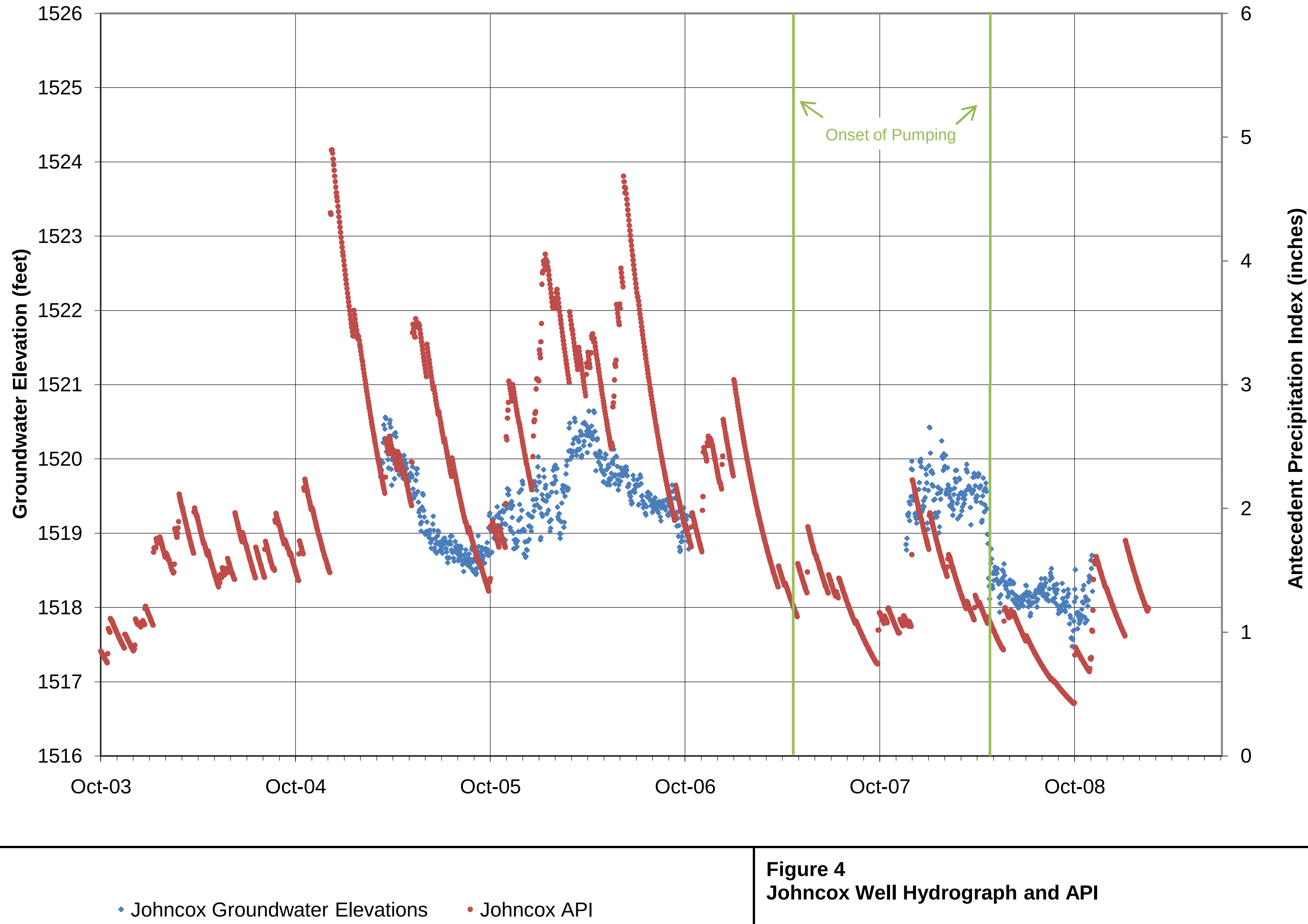

Figure 4
Johncox Well Hydrograph and API

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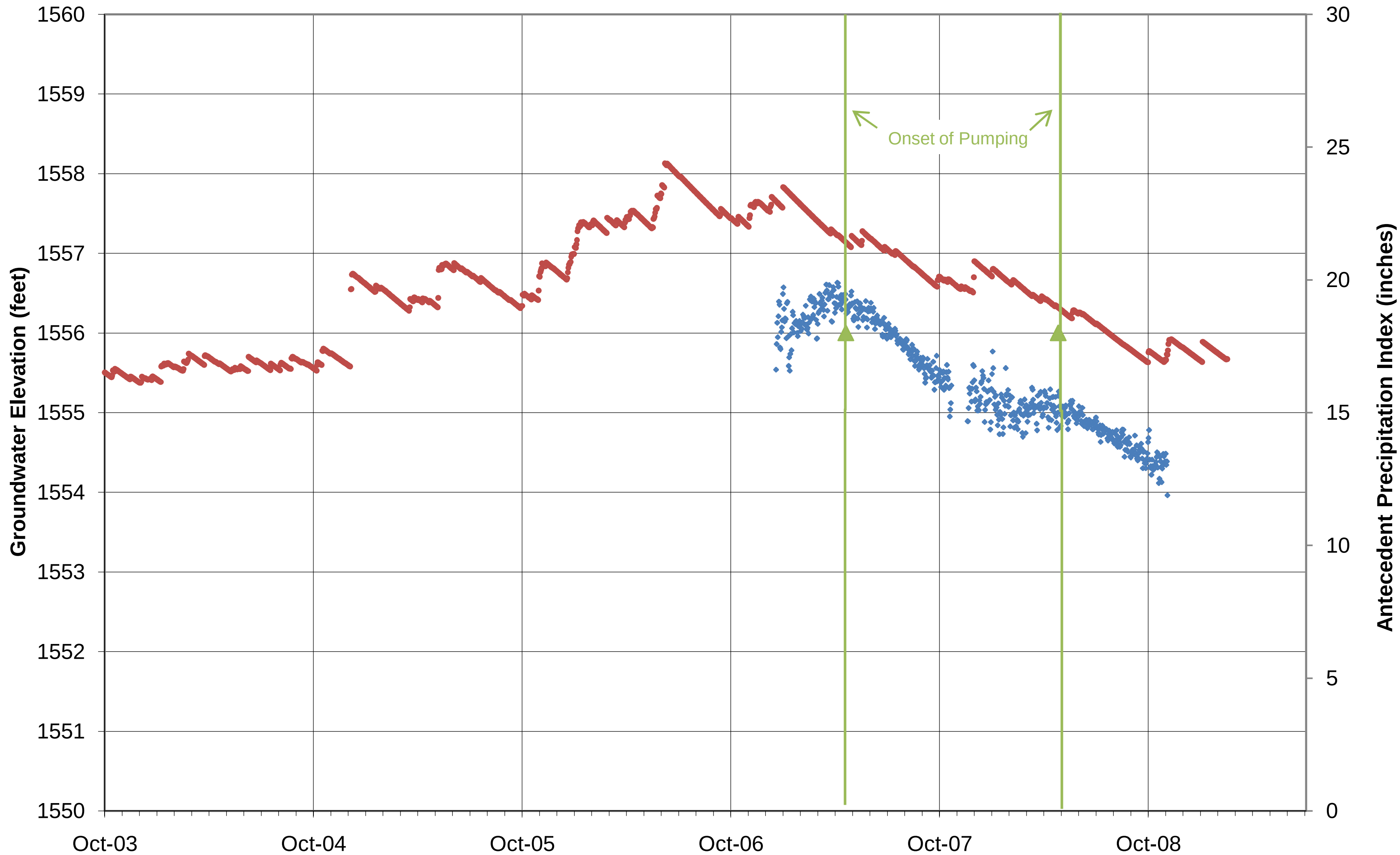
JS0901

PgG



- Downes Groundwater Elevations
- Downes API
- Pumping Onset

Figure 5
Downes Well Hydrograph and API

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PgG

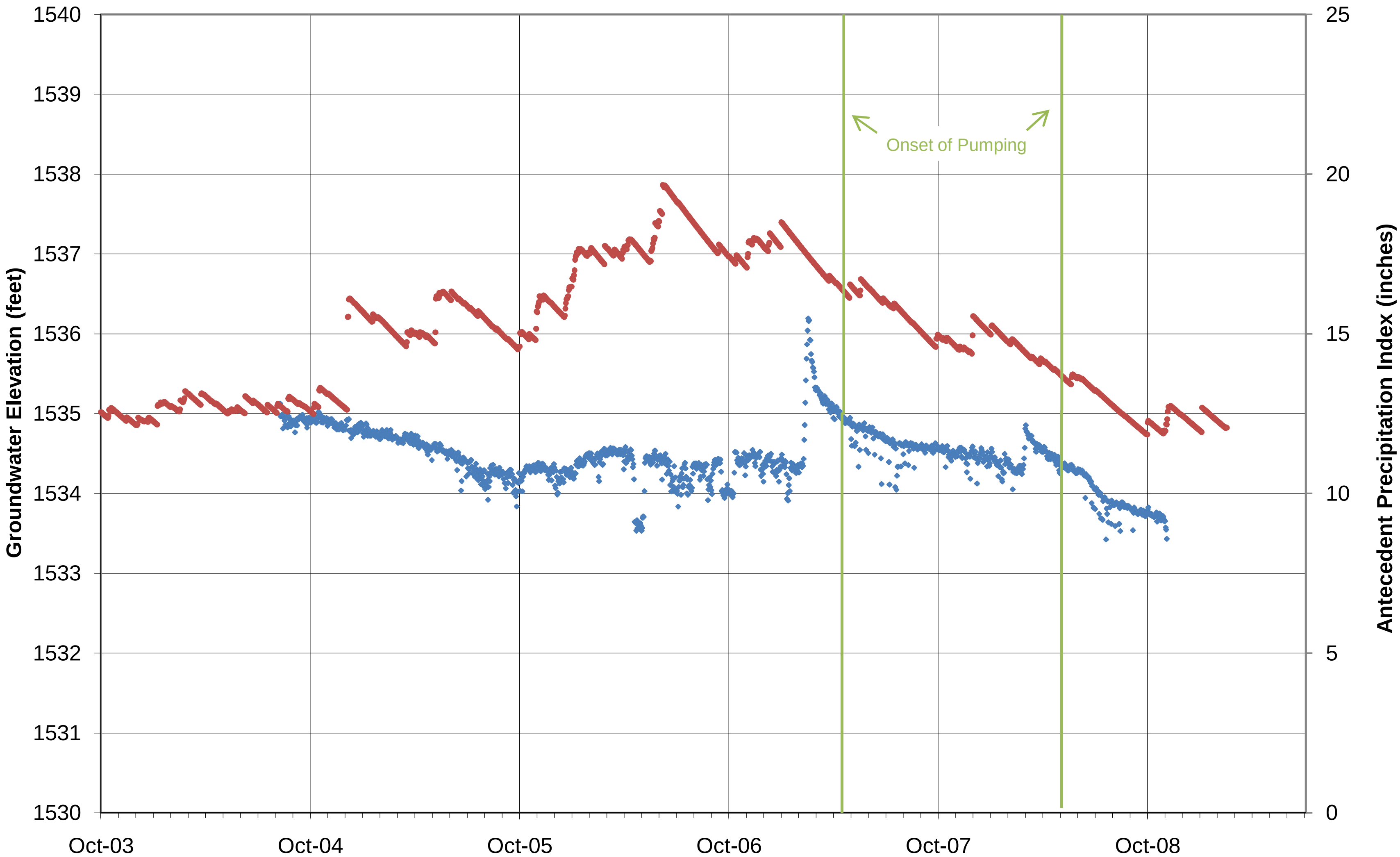

Figure 6
Mayer Well Hydrograph and API

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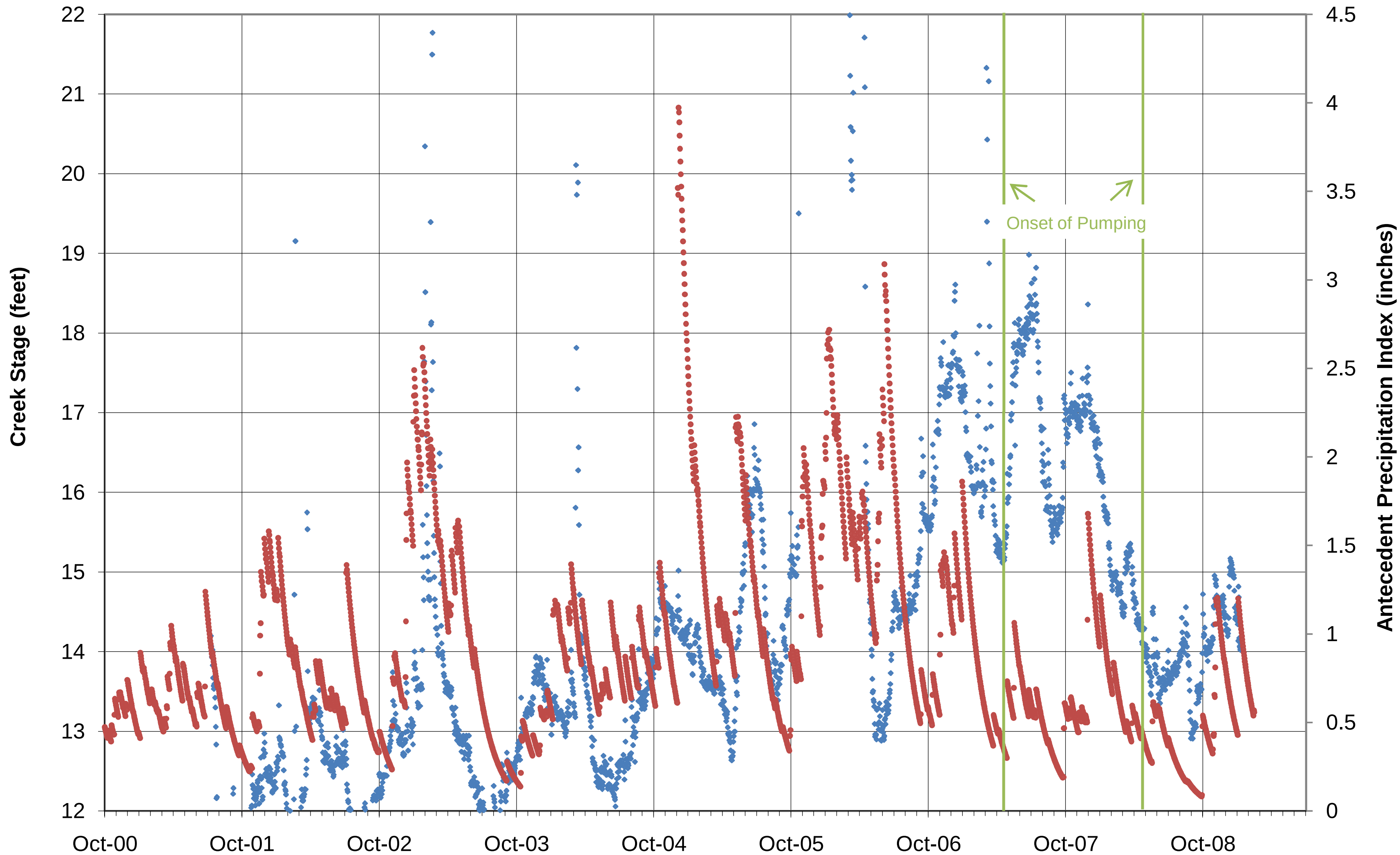

Douglas Creek Stage

Douglas API

Figure 7
Douglas Creek Hydrograph and API

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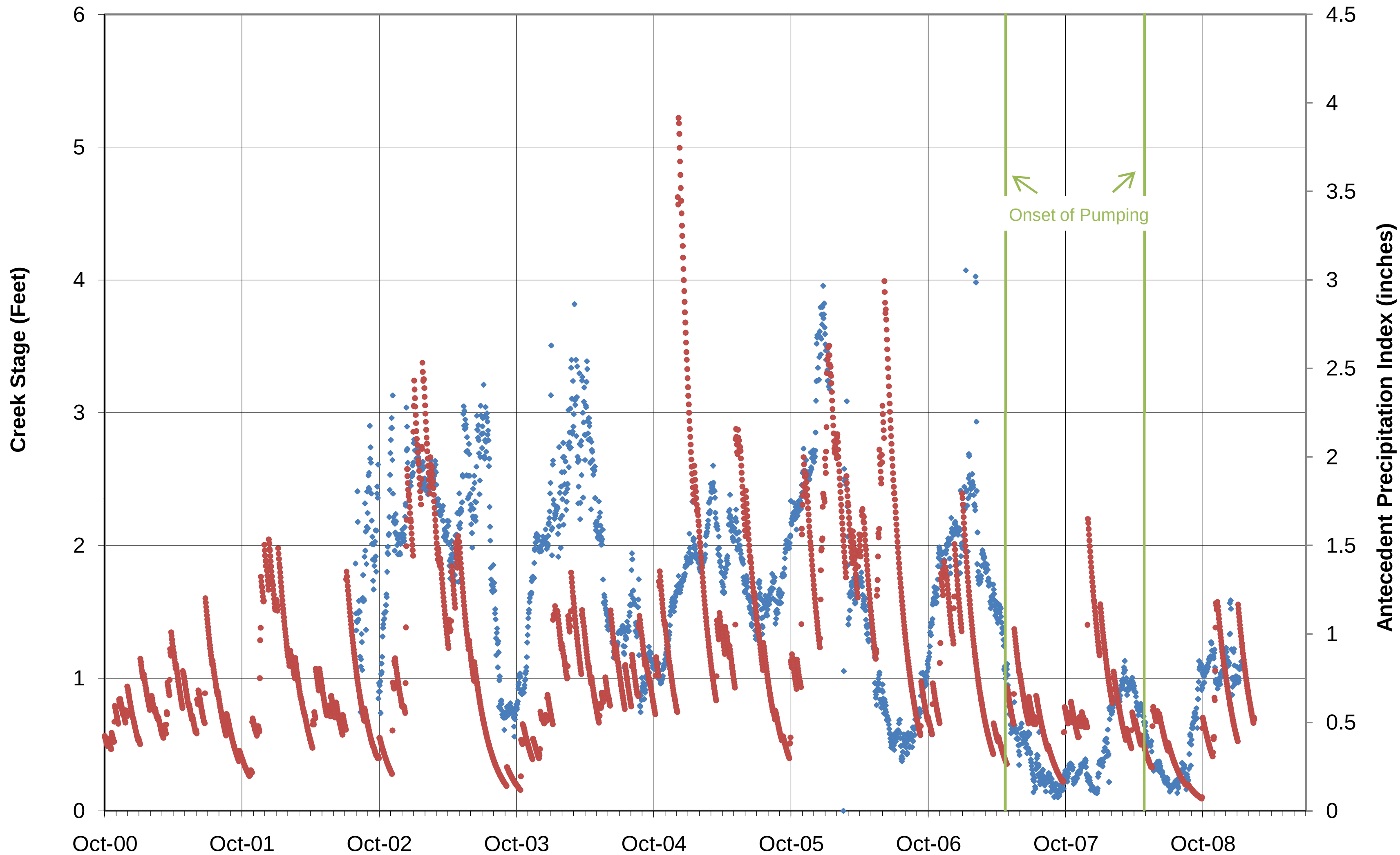

Figure 8
McCartney Creek Hydrograph and API

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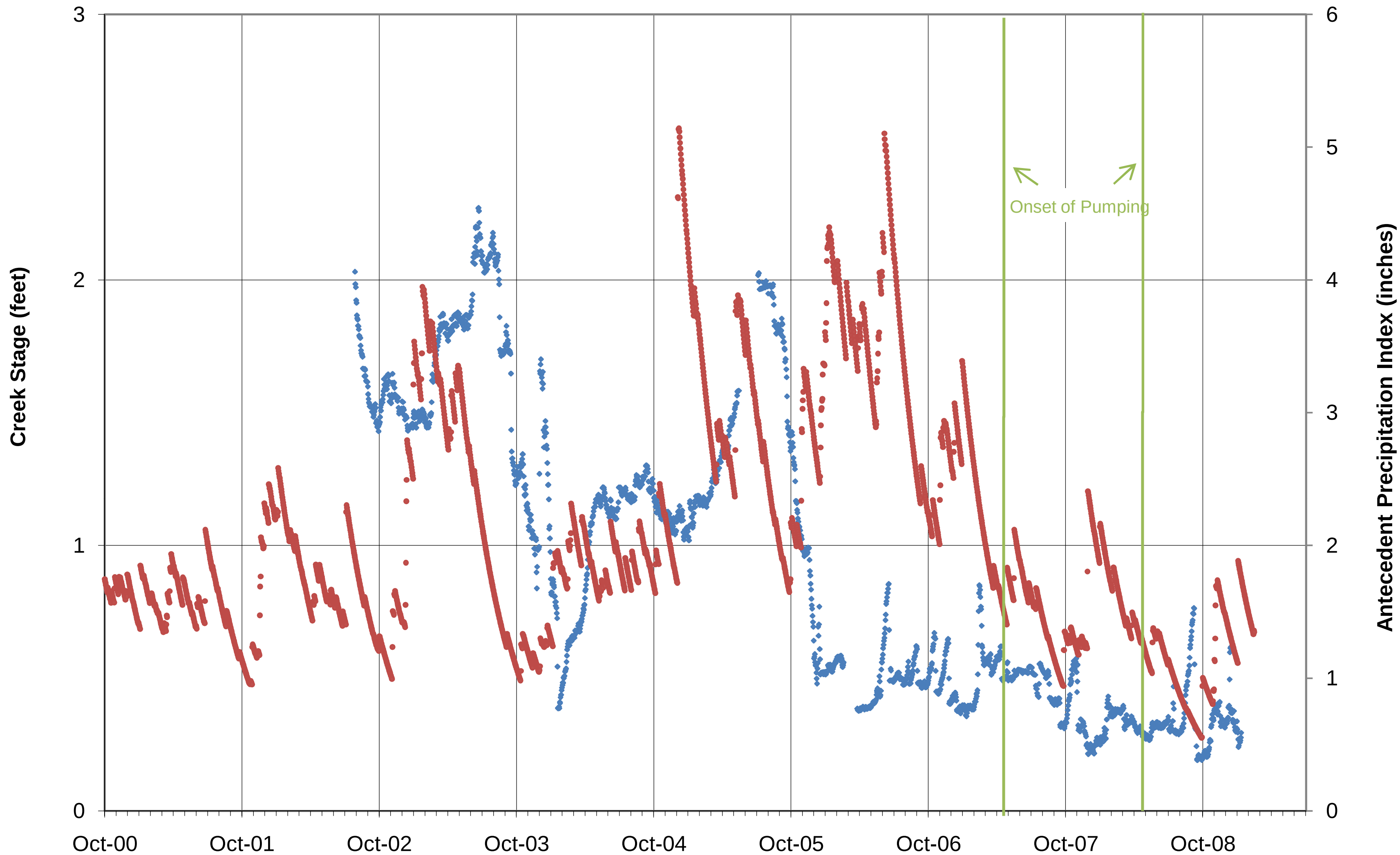
JS0901

PGG



- Rattlesnake Creek Stage
- Rattlesnake API

Figure 9
Rattlesnake Creek Hydrograph and API

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JS0901

PGG

APPENDIX A
UPPER MOSES COULEE AIR PHOTOS

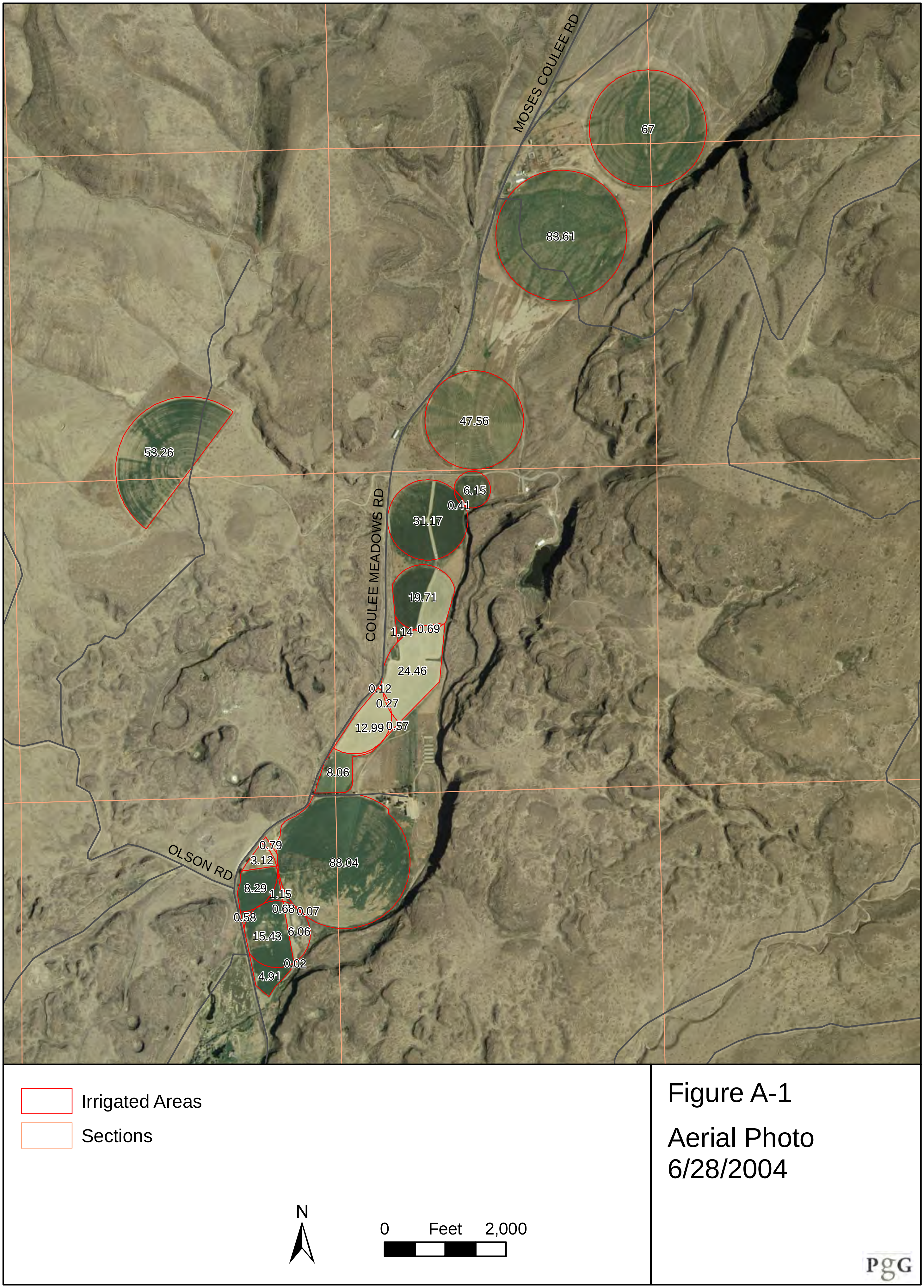
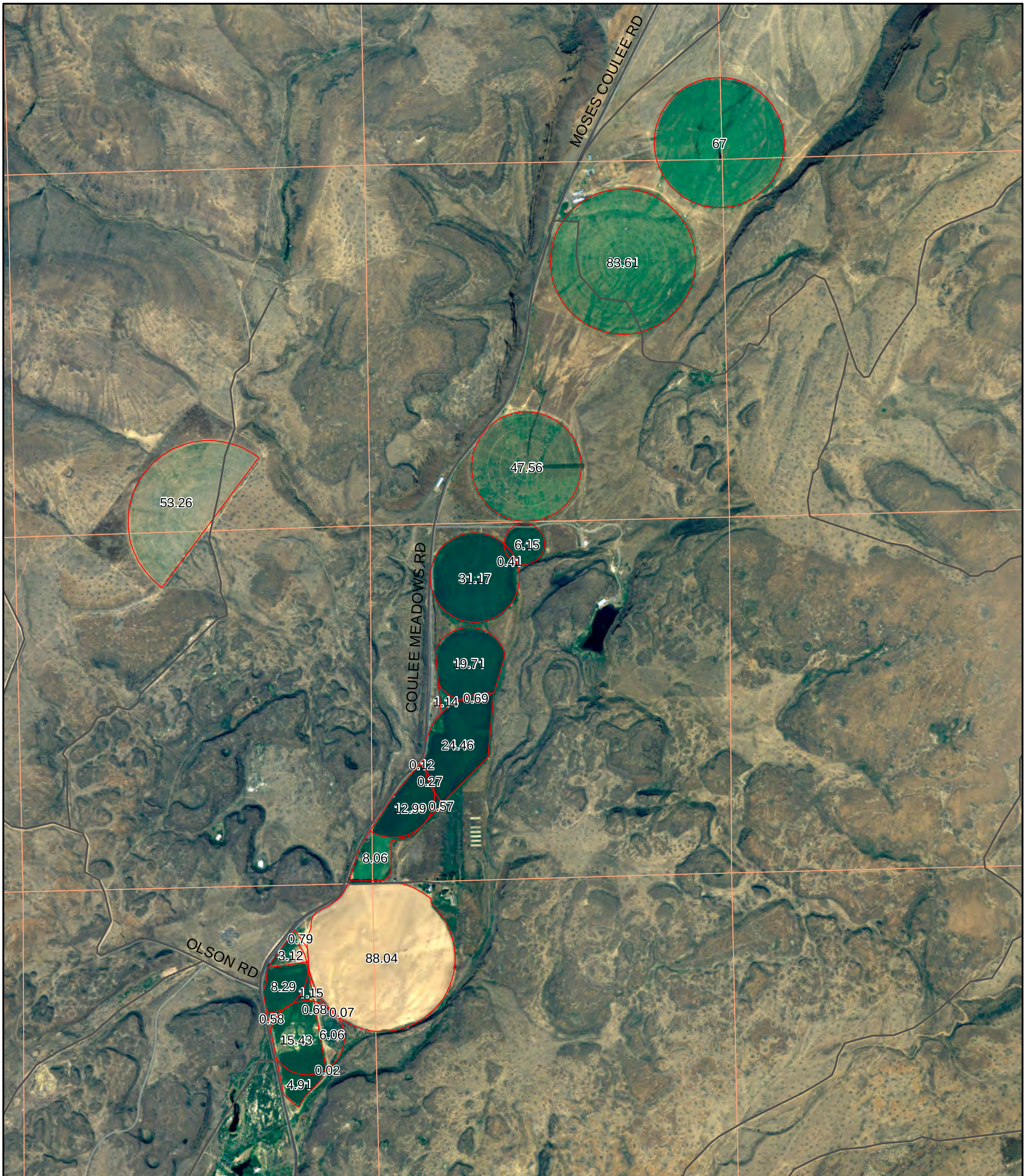


Figure A-1

Aerial Photo
6/28/2004

PGG



Irrigated Areas

Sections

N

0 Feet 2,000

Figure A-2

Aerial Photo
7/26/2005

PgG

Irrigated Areas

Sections

N

0 Feet 2,000

Figure A-3

Aerial Photo
7/1/2006

PgG