SJRRP Flow Bench Evaluation

May 15, 2019

Introduction

This Flow Bench Evaluation (FBE) report evaluates the groundwater conditions in advance of flood control releases. Flood control releases from Friant Dam are not subject to the Seepage Management Plan (SMP), but any Restoration Flows will be operated to the SMP.

Reclamation increased Restoration Flow releases from Friant Dam on Tuesday, May 14 from 582 cfs to 1,000 cfs at 1:00 PM. These releases will serve to evacuate the reservoir while reducing the magnitude and duration of any subsequent flood control releases. A portion of these releases will be recaptured at Mendota Pool and made available in San Luis reservoir for Friant Contractors.

As of May 15, 2019:

1. Channel conveyance: Flow rates are below known conveyance thresholds in all reaches. A low berm breach on the former MLT property recently acquired by Reclamation may constrain Reach 2B flow rates below those listed in the Channel Capacity Advisory Group report, however this berm is under contract for immediate repairs.

2. Operations Conference Call: An operations call was held on May 15, 2019. The anticipation of flood control releases was discussed on this call.

3. Seepage Hotline Calls: The seepage hotline received one call regarding elevated groundwater levels in Water Year 2019 on March 30, 2019; however, the elevated groundwater conditions were due to flood flows. Although the conditions were due to flood flows and not Restoration Flows, the SJRRP recorded this report for further investigation to inform the response at this site for higher flow rates.

4. Real-time wells: Telemetered groundwater monitoring equipment was removed from MW-09-49B due to flood flows, but other real-time equipment remains intact. Real-time equipment was recently installed at MW-17-225. All telemetered groundwater monitoring well levels were below SMP thresholds as of May 15. In lieu of telemetered equipment at MW-09-49B, manual measurements were recorded and indicated levels below well threshold but above field threshold due to irrigation (see Data and Analysis).

5. Priority wells: As indicated in the Weekly Groundwater Reports, wells throughout the Restoration Area are below SMP thresholds. Additional critical wells have been identified for targeted monitoring during recent monitoring efforts. Therefore, this FBE includes more wells than the Weekly Groundwater Report contains.

6. Projected Groundwater Level Changes: Although groundwater levels are projected to increase in anticipation of flood control operations, this early evacuation is expected to reduce the magnitude and duration of subsequent flood control releases; thereby reducing the potential groundwater table impact overall. Approximately 500 cfs will be recaptured at Mendota Pool, and 200 cfs will be released past Sack Dam. Additional capacity has been identified in Reach 4A. If the RA Recommendation utilizes this additional capacity,

then groundwater levels in Reach 3 and Reach 4A are also expected to increase; however, at a smaller increment than increases in the upper reaches. Reclamation has evaluated the increase in flows using the Groundwater Level Method as described in Appendix J of the SMP.

7. Levees: LSJLD has not expressed concerns about this flow change.

8. Water Districts: The SJRECWA has not identified any operational concerns.

Data

The following Data section considers the most recent monitoring measurements collected prior to the May 14th flow change from Friant Dam. These values are referred to as "pre-condition" to inform any further flow changes that may need to occur based on ongoing monitoring. The "projected" values indicate the modeled results from this FBE model-based analysis under the condition of releases from Friant Dam as of May 14. These values are discussed in the Analysis section.

Table 2 shows groundwater depths in four active real-time wells and 11 manual measurements from field staff. Measurements are reported from the field between April 30, 2019 and May 14, 2019. Values for priority wells are published by Reclamation in the Weekly Groundwater Report on the SJRRP website HERE, and are taken with manual measurements via electronic well sounder. To calculate field depths, Reclamation adds ground surface buffers and lateral gradient buffers to measured groundwater depths in the well (Equation 1, Figure 1). Some soil borings have also been measured to verify groundwater levels directly in fields.

$$Field\ Depth_{Current} = D_{well} - GS_{Buffer} + LG_{Buffer} \quad (1)$$

Where:

$Field\ Depth_{Current}$	Current groundwater level depth in the field
D_{Well}	Current groundwater level depth as measured in the monitoring well
GS_{Buffer}	Ground surface buffer, or the difference in elevation between the well and the field
LG_{Buffer}	Lateral gradient buffer, to account for losing reaches where the groundwater table slopes away from the river (if any)

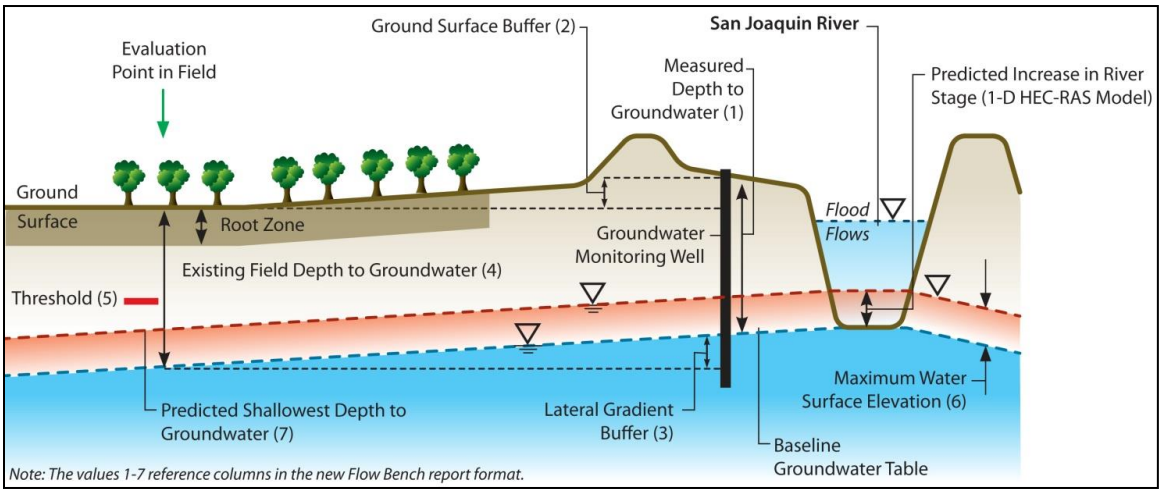

Figure 1. Conceptual Model for Observed Groundwater Level Method

Pre-Condition

The pre-condition well data in Table 2 shows all groundwater levels below threshold prior to May 14, with the exception of MW-09-49B. This well has elevated groundwater levels due to recent irrigation in the field. External influences such as irrigation do not call for a decrease in a flow recommendation (further discussion in Analysis section). From Table 2, note that field thresholds for MW-18-80B and MW-17-225 are assumed in lieu of QAQC survey data. The groundwater monitoring network was re-surveyed in Spring 2019 and the data is currently being reviewed. Soil boring measurements were taken in field for MW-18-80B and MW-17-225; however, they were drilled to dry depths rather than continued drilling to groundwater. The field conditions were therefore calculated for MW-17-225 and approximated for MW-18-80B. Soil boring measurements were also taken at MW-09-49B and applied directly as the field groundwater depth in Table 2.

For MW-18-80B, the soil boring was drilled to a total depth of 6.8 ft_bgs and observed to be dry (at least 0.1 ft below assumed threshold). Therefore, groundwater levels in field are only known to be deeper than 6.8 ft_bgs. For MW-17-225, the soil boring was drilled to a total depth of 6.63 ft_bgs and observed to be dry (at least 0.13 ft below assumed threshold). Therefore, groundwater levels in field are only known to be deeper than 6.63 ft_bgs. The approximate ground surface buffer value for MW-17-225 from Spring 2019 surveys applied to the most recent well measurement provides an approximate calculated field groundwater depth of 6.8 ft_bgs. This same approach was not informative when applied to MW-18-80B as it resulted in a calculated field groundwater depth of 5.9 ft_bgs, while soil borings measured in field confirm dry conditions to at least 6.8 ft_bgs. This suggests a lateral gradient buffer applies to MW-18-80B but requires further analysis to be quantified. In lieu of a lateral gradient buffer, the water surface elevation change allowed at MW-18-80B should be no greater than the water surface elevation change predicted for MW-17-225 to be conservative and acceptable.

Table 2. Pre-Condition Well Data (Conditions Prior to May 14 Flow Change)

Well	Reach	1 - Measured Groundwater Depth in Well (feet bgs)	Date Measured	2 - Ground Surface Buffer (feet)	3 - Lateral Gradient Buffer (feet)	4 – Calculated Field GW Depth (feet bgs)	5 - Field Threshold (feet bgs)	Comparison of Calculated Field GW and Field Threshold
FA-9	2A	9.2	5/8/2019	2.0	2.5	**9.7**	**6.0**	**Acceptable**
MW-09-47	2A	8.4	5/8/2019	2.5	3.3	**9.2**	**6.5**	**Acceptable**
MA-4	2A	11.5	5/8/2019	6.1	4.6	**10.0**	**7.0**	**Acceptable**
MW-09-49B	2A	5.6	5/14/2019	1.7	2.4	**4.9**[2]	**5.5**	**Acceptable**[4]
MW-09-54B	2B	15.2	5/6/2019	7.9	5.5	**12.8**	**7.0**	**Acceptable**
MW-09-55B	2B	8.5	5/6/2019	3.7	3.0	**7.9**	**5.5**	**Acceptable**
PZ-09-R3-5	3	10.3	5/6/2019	1.2	0.0	**9.2**	-	**Acceptable**[3]
MW-12-191	3	11.8	5/6/2019	1.0	0.0	**10.8**	**6.5**	**Acceptable**
PZ-09-R3-7	3	7.9	5/14/2019	0.7	0.0	**7.1**	**6.5**	**Acceptable**
MW-10-75	3	16.9	5/14/2019	0.5	0.2	**16.6**	**8.0**	**Acceptable**
MW-10-78	3	7.1	5/14/2019	3.0	-	**5.1**[2]	**3.9**	**Acceptable**
MW-10-89	4A	10.5	5/14/2019	1.0	-	**9.5**	**6.5**	**Acceptable**
MW-18-80B	4A	10.0	5/14/2019	-	-	**6.8**[2]	**6.7**[1]	**Acceptable**
MW-17-225	4A	8.9	5/14/2019	-	-	**6.8**	**6.5**[1]	**Acceptable**
MW-10-188	4A	9.5	4/30/2019	2.1	-	**7.4**	**5.5**	**Acceptable**

bgs = below ground surface; GW = groundwater; Header numbers refer to Figure 1

[1] Field thresholds are estimated in lieu of QAQC survey data.

[2] Soil boring measurements were taken in field.

[3] Most recent field notes indicate field is currently fallow and therefore no threshold is assigned.

[4] Groundwater levels elevated due to recent irrigation. External influences such as irrigation do not call for a decrease in a flow recommendation.

Analysis

All sites are expected to increase in groundwater elevation, with the greatest change occurring in reaches between Friant Dam and Mendota Pool. With the majority of water being used for recapture at Mendota Pool, only an additional 15 cfs from the previous FBE (235 cfs to 250 cfs) is recommended to pass Sack Dam into Reach 4A with the limitations of MW-18-80B and MW-17-225.

Under the evaluated releases, all wells except MW-09-49B are projected to be below threshold given the conceptual model for the Observed Groundwater Level Method (Figure 1 and depicted further in Figure 2). This well has elevated groundwater levels due to recent irrigation in field. External influences such as irrigation do not call for a decrease in a flow recommendation. Furthermore, the impact of Restoration Flows on MW-09-49B was evaluated in February 2019 while irrigation was not occurring (Figure 3). This informed that the direct relationship of flows in the channel with the groundwater elevation in the well was not a potential impact until flows in excess of 820 cfs at the Gravelly Ford (GRF) gauge. Historical flow conditions were not considered in this report, but other historical demands while Restoration Flows were not in the system have been known to exceed 1,200 cfs. As a 1,000 cfs Restoration Flow release from Friant attenuates downstream, Reach 1 holding contract demands are met, and additional losses applied, the flow passing GRF is estimated to be 815 cfs or less. This location will be monitored closely to verify flows and depth to water measurements.

Monitoring will continue throughout the network with current releases to record changes in groundwater elevation. Subsequent FBEs may be completed to inform any potential flow changes necessary.

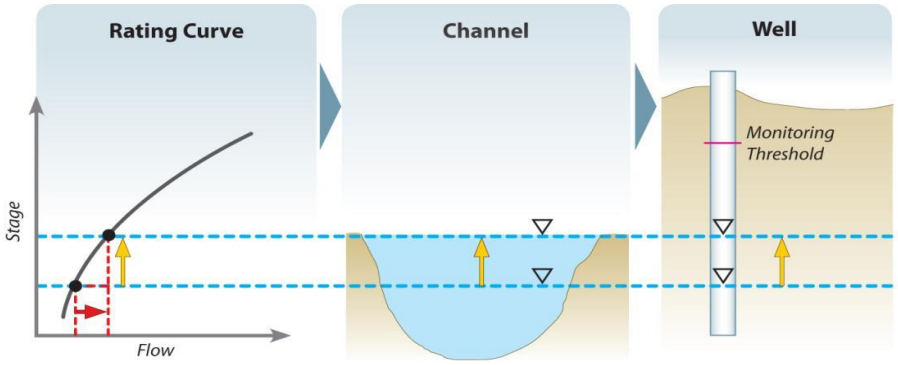

Figure 2. Conceptual Relationship between River Stage and Groundwater Levels

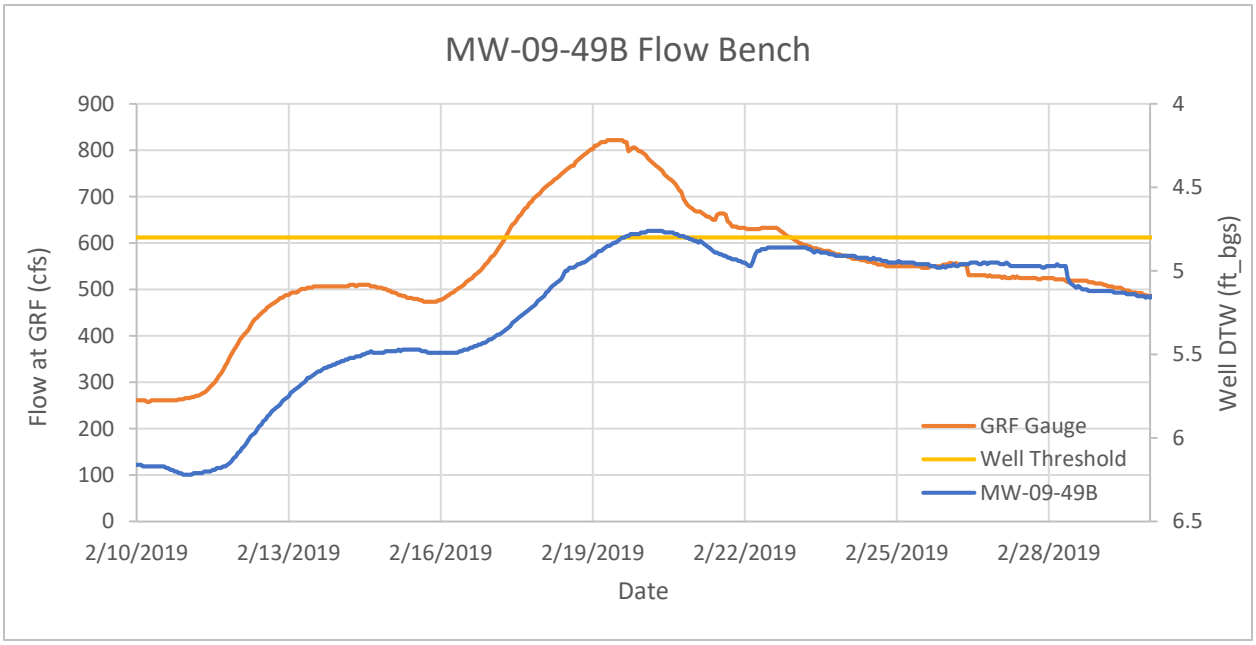

Figure 3. Relationship of Flows and Well Response at MW-09-49B without Irrigation

Projected Conditions

Table 3 shows the projected flow rates based on current Friant Dam releases used to evaluate projected groundwater depths. Reclamation calculated losses based on the values assumed in Exhibit B. Henry Miller Reclamation District demands were also accounted for in Reach 3 using the San Luis & Delta-Mendota Water Authority Daily Water Operations Report sent May 15. Pre-condition flows are based on the Restoration Flows sustained prior to the flow change at Friant Dam on May 14. The comparison of pre-condition and projected flows informs the estimated result of increasing releases in advance of flood control operations. Acceptable Restoration Flows may be refined further through future FBEs following groundwater monitoring.

Table 3. Anticipated Change in Flows.

	Pre-condition Flows (cfs)	Projected Flows from Evaluation (cfs)
Reach 1	580	1000
Reach 2A	343	815
Reach 2B	263	690
Reach 3	473	570[1]
Reach 4A	235	250

[1] Assumes 320 cfs demand for Arroyo Canal

Table 4 shows the change in groundwater based on estimated changes in river stage and the conceptual models shown in Figures 1 – 2. Field depths are calculated by taking the most recent measurements from Table 2, adding the ground surface and the lateral gradient buffers, and subtracting the maximum predicted stage increase (Equation 2).

$$Field\ Depth_{Predicted} = Field\ Depth_{Current} - WSEL_{Max\ Increase} \quad (2)$$

Table 4. Predicted Groundwater Levels for Priority Wells with Projected Flows

Well	Reach	1 - Measured GW Depth in Well (feet bgs)	Date Measured	2-Ground Surface Buffer (feet)	3 - Lateral Gradient Buffer (feet)	4 - Field GW Depth (feet bgs)	6 - Predicted WSEL Change (feet)	7 - Predicted Shallowest GW Depth (ft bgs_field)	5 - Field Threshold (feet bgs)	Comparison of Predicted Field GW and Field Threshold
FA-9	2A	9.2	5/8/2019	2.0	2.5	9.7	1.0	**8.7**	**6.0**	**Acceptable**
MW-09-47	2A	8.4	5/8/2019	2.5	3.3	9.2	1.0	**8.2**	**6.5**	**Acceptable**
MA-4	2A	11.5	5/8/2019	6.1	4.6	10.0	1.0	**9.1**	**7.0**	**Acceptable**
MW-09-49B	2A	5.6	5/14/2019	1.7	2.4	4.9[2]	1.0	**3.9**	**5.5**	**Acceptable[4]**
MW-09-54B	2B	15.2	5/6/2019	7.9	5.5	12.8	1.2	**11.5**	**7.0**	**Acceptable**
MW-09-55B	2B	8.5	5/6/2019	3.7	3.0	7.9	1.2	**6.6**	**5.5**	**Acceptable**
PZ-09-R3-5	3	10.3	5/6/2019	1.2	0.0	9.2	0.4	**8.8**	**-**	**Acceptable[3]**
MW-12-191	3	11.8	5/6/2019	1.0	0.0	10.8	0.4	**10.4**	**6.5**	**Acceptable**
PZ-09-R3-7	3	7.9	5/14/2019	0.7	0.0	7.1	0.4	**6.7**	**6.5**	**Acceptable**
MW-10-75	3	16.9	5/14/2019	0.5	0.2	16.6	0.3	**16.3**	**8.0**	**Acceptable**
MW-10-78	3	7.1	5/14/2019	3.0	-	5.1[2]	0.3	**4.8**	**3.9**	**Acceptable**
MW-10-89	4A	10.5	5/14/2019	1.0	-	9.5	0.7	**8.7**	**6.5**	**Acceptable**
MW-18-80B	4A	10.0	5/14/2019	-	-	6.8[2]	0.3	**-**	**6.7[1]**	**Acceptable[5]**
MW-17-225	4A	8.9	5/14/2019	-	-	6.8	0.3	**6.5**	**6.5[1]**	**Acceptable**
MW-10-188	4A	9.5	4/30/2019	2.1	-	7.4	0.5	**6.9**	**6.5**	**Acceptable**

bgs = below ground surface; GW = groundwater; WSEL = water surface elevation; Header numbers refer to Figure 1

[1] Field thresholds are estimated in lieu of QAQC survey data.

[2] Soil boring measurements were taken in field.

[3] Most recent field notes indicate field is currently fallow and therefore no threshold is assigned.

[4] Groundwater levels elevated due to recent irrigation. External influences such as irrigation do not call for a decrease in a flow recommendation.

[5] Current field groundwater depth is known to be deeper than 6.8 ft_bgs, but specific value is unknown in lieu of lateral gradient analysis. Therefore, the water surface elevation change allowed at MW-18-80B should be no greater than the water surface elevation change predicted for MW-17-225 to be conservative and acceptable.

Summary

This analysis indicates acceptable conditions for the current releases from Friant Dam. These releases are expected to be beneficial to management of groundwater level conditions by reducing the magnitude and duration of subsequent flood control operations. Groundwater levels will continue to be closely monitored at MW-09-49B, which is currently elevated due to irrigation. Monitoring will also continue at other critical wells (Figure 4a and 4b) and the remainder of the network. The maximum allowable flow below Sack Dam is currently limited to 250 cfs. Arroyo Canal demands will also be monitored to determine if the capacity for Restoration Flows in Reach 3 becomes limited. Reclamation retains the right to recapture Restoration Flows in Mendota Pool to adjust for Arroyo Canal demands when constrained by seepage in Reach 3. Subsequent FBEs will be performed to inform any flow changes with the potential to impact groundwater levels.

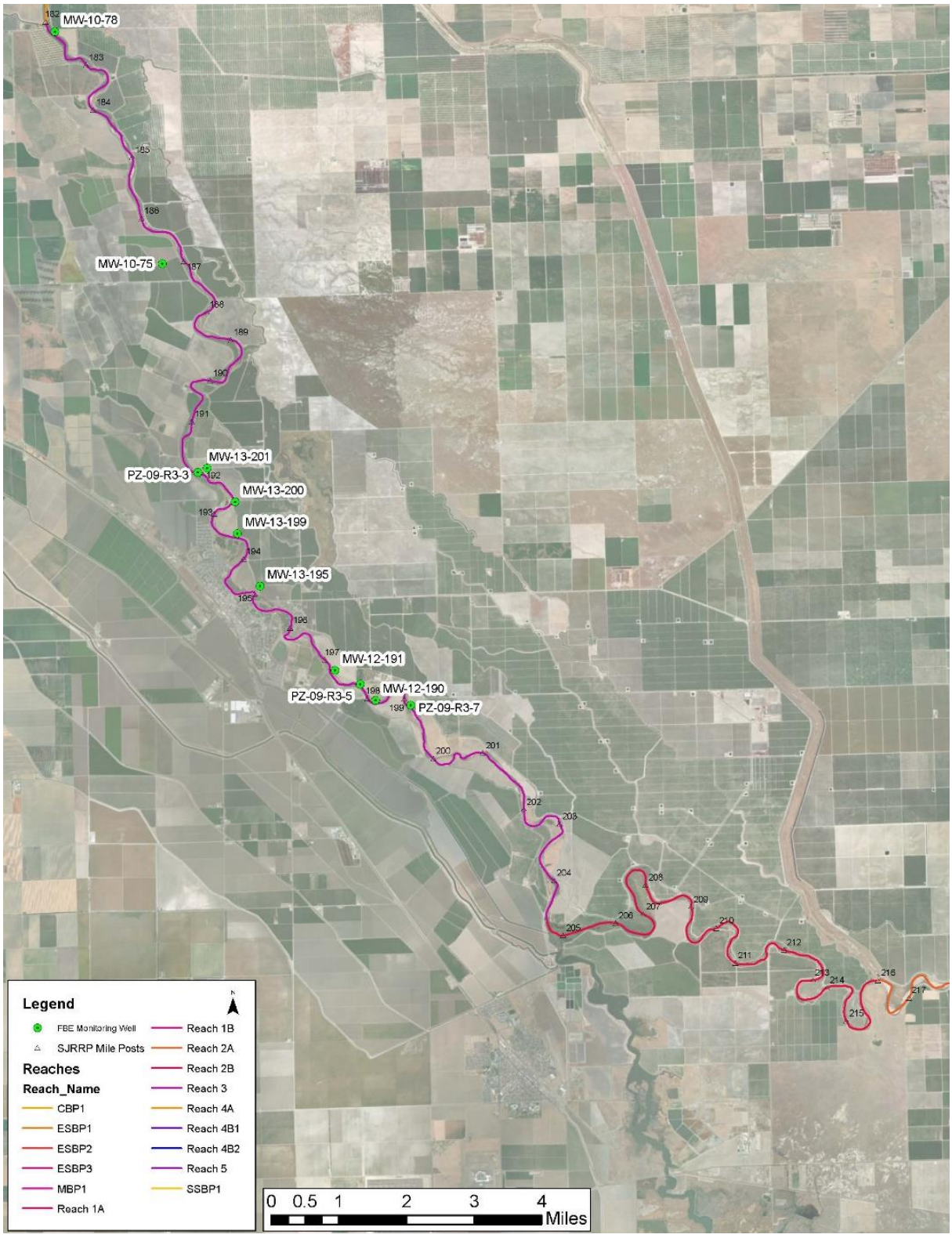

Figure 4a. Critical Monitoring Well Locations in Reach 3

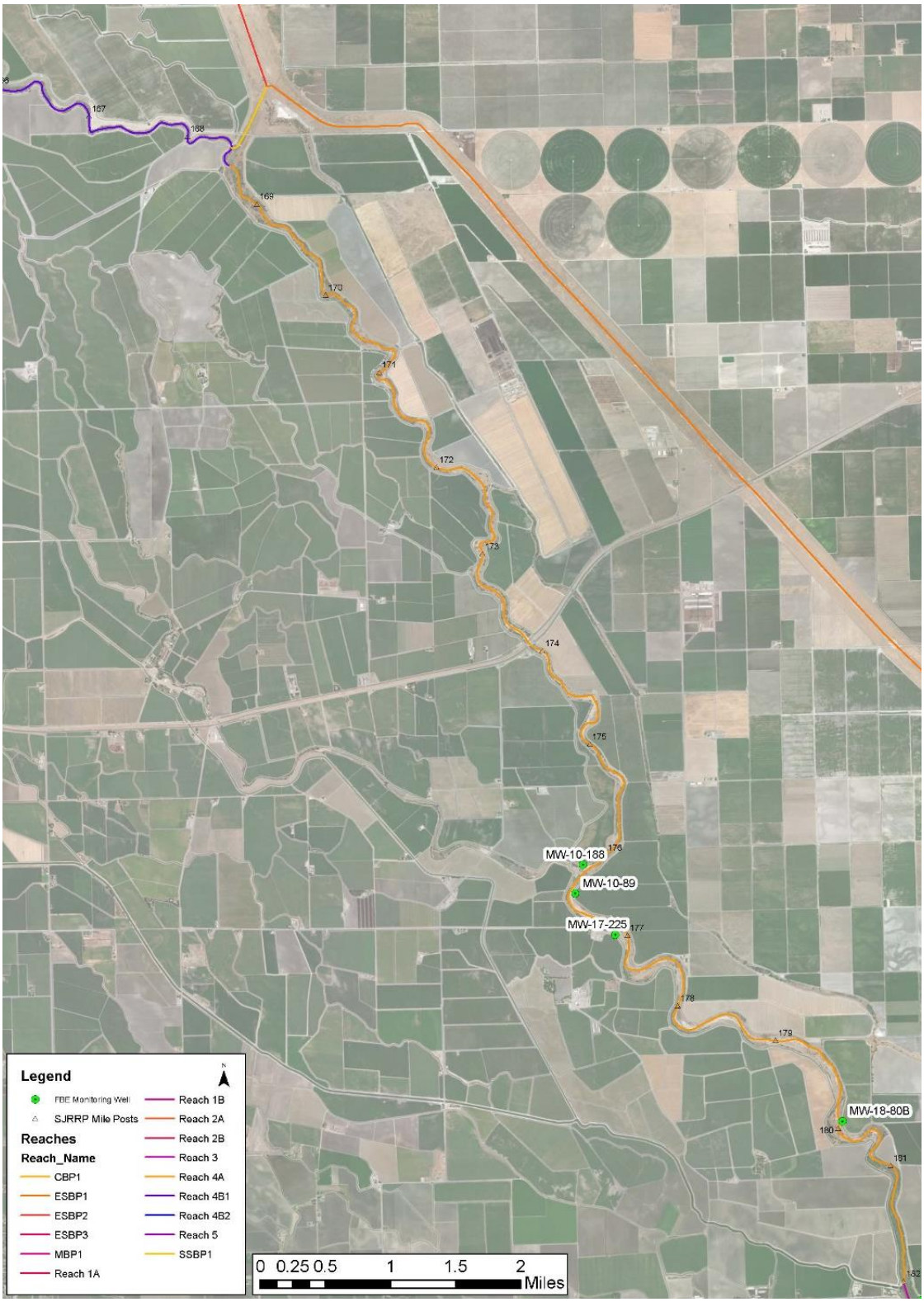

Figure 4b. Critical Monitoring Well Locations in Reach 4A