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TECHNICAL MEMORANDUM

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TO: Larry Parlin

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SUBJECT: Nitrate and Manganese Groundwater Quality Impacts Associated with Wastewater Releases from the Effluent Storage Ponds at the City of Lodi White Slough Water Pollution Control Facility

This technical memorandum presents an evaluation of the potential nitrate and manganese groundwater quality impacts associated waste releases from the Effluent Storage Ponds at the City of Lodi (City) White Slough Water Pollution Control Facility (WPCF). This document is organized as follows:

- Background Information
- Nitrate Evaluation
- Manganese Evaluation
- Summary of Conclusions

BACKGROUND INFORMATION

The Central Valley Regional Water Quality Control Board's (Regional Board) Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan) includes narrative and numeric objectives that apply to groundwater. However, if it is demonstrated that naturally occurring background concentrations exceed the otherwise applicable objectives, then the naturally occurring background concentrations of the constituent becomes the de facto objective. A Background Groundwater Quality Characterization Report (Background Groundwater Report)[1] has been submitted to the Regional Board that provides: 1) a characterization of the background groundwater conditions; and 2) a comparison of groundwater concentrations measured onsite to the applicable Basin Plan objective and to the background groundwater

[1] Prepared by West Yost Associates on behalf of the City in January 2011.

concentrations. Evidence in the Background Groundwater Report supports the following conclusions:

- For most constituents of concern measured in the onsite wells (including nitrate, manganese, total dissolved solids, sodium, chloride), the background concentrations exceed the Basin Plan water quality objectives.
- The ***only*** constituent in the onsite wells that exceed background groundwater quality *and the observed background concentration is less than an applicable water quality objective* is boron[2]. Nevertheless, boron concentrations in all of the onsite wells and waste releases from all WPCF facilities are also well below the boron agricultural goal of 700 µg/L.
- Both nitrate and manganese exceed background groundwater quality and applicable water quality objectives in select onsite wells. Because the Basin Plan does not allow exceedances of background groundwater quality where degradation has already occurred, the City must implement additional controls with respect to nitrate and manganese.

The City has three discharges that could be ***potential*** sources of groundwater degradation for nitrate and manganese: land application of wastewater, land application of dewatered biosolids, and percolation from the Effluent Storage Ponds. The Background Groundwater Report also includes an evaluation of each of these three potential sources to determine the likely sources of impacts, and this evaluation showed that the Effluent Storage Ponds are not a likely source of the exceedances of nitrate and manganese.

The purpose of this TM is to provide additional details regarding the potential for the Effluent Storage Ponds to be the cause of exceedances of the background groundwater quality for nitrate and manganese. The analysis builds off of the conclusions from the Background Groundwater Report, including a summary of data collected since the Background Groundwater Report was developed.

[2] Both potassium and phosphorus exceed the observed background concentrations. However, there are not any applicable water quality objectives for these compounds.

NITRATE EVALUATION

The Background Groundwater Report documented statistical exceedances[3] of the nitrate levels in the combined data sets from the two background wells (WSM-17 and WSM-18) for the following onsite wells:

- WSM-2
- WSM-5[4]
- WSM-16

A vicinity map of the WCPF site monitoring wells and the groundwater elevation contours from May 8, 2013[5] is presented on Figure 1. The following conclusions can be drawn based on a review of this figure:

- WSM-16 is located along a recharge mound that is upgradient of the Effluent Storage Ponds. Therefore, movement of groundwater from the Effluent Storage Ponds to its location is not possible.
- WSM-2 is located just south of the Effluent Storage Ponds and cross-gradient. Therefore, there may be the potential for some movement of nitrate (via dispersion actions) from the ponds to this well.
- WSM-5 is located further south of the ponds than WSM-2, but is slightly downgradient. Therefore, there may be the potential for some movement of nitrate (via dispersion actions) from the ponds to this well. It should be noted, however, that the City has documented in the Quarterly Groundwater Monitoring and Reports submitted since the first Quarter 2012 that WSM-5 no longer demonstrates nitrate concentrations that are statistically greater than the concentrations in background well WSM-18.

Given the information above, additional consideration of whether the ponds are the likely source of elevated nitrate levels in WSM-2 and WSM-5 is warranted.

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[3] The nonparametric Wilcoxon Rank Sum test is used to evaluate exceedances of background groundwater quality. Details regarding the specific comparison procedures are presented in the Background Groundwater Report, with the revisions to the approach detailed in the Attachment A to the City's First Quarter 2012 Groundwater Monitoring and Reporting Program Report (submitted to the Regional Board on April 30, 2012). As documented in the latter, the statistical analysis compares the data from each onsite well to data from each background well individually. If the onsite well concentrations statistically exceed the concentrations in all of the background wells individually, the onsite well is identified as exceeding the background water quality.

[4] As documented in the City's Quarterly Groundwater Monitoring and Reports submitted since the first Quarter 2012, WSM-5 no longer demonstrates nitrate concentrations that are statistically greater than the concentrations in background well WSM-18.

[5] While the contours represented in Figure 1 represent a specific date, the City has submitted similar quarterly maps to Regional Board since early 2012, and an easterly to east-southeasterly groundwater gradient, similar to that shown in Figure 1, is consistently shown.

As indicated by the groundwater contour information in Figure 1, while there may be a potential for some movement of groundwater from the Effluent Storage Ponds to WSM-2 and WSM-5, the water quality in onsite wells WSM-4 and WSM-8 are more likely to be influenced by the Effluent Storage Ponds because they are directly downgradient of the ponds (and are located much closer to the ponds than WSM-5). The median nitrate concentrations in WSM-4 and WSM-8, based on quarterly data for February 2008 to May 2013, are 3.3 mg/L as N and 12 mg/L as N, respectively, both of which are significantly lower than the median concentration of 30 mg/L observed in background well WSM-18 (and the concentrations observed in WSM-2 and WSM-5). Because there is no reason to suspect that impacts of the ponds would be more pronounced in WSM-2 and WSM-5 than in WSM 4 or WSM-8, it can be concluded that the ponds are not the cause of nitrate exceedances in WSM-2 and WSM-5.

A second point of evidence as to whether the Effluent Storage Ponds are the cause of the onsite exceedances of the background water quality for nitrate is the water quality that is maintained in the Effluent Storage Ponds. First, the Background Groundwater Report documented that the *total inorganic nitrogen* (ammonia, nitrate, and nitrite) concentrations in the Effluent Storage Ponds were not statistically greater than the concentrations observed in any of the onsite wells. Moreover, since January 2010, the City has eliminated discharges of biosolids supernatant and WAS thickening subnatant to the Effluent Storage Ponds – thus improving the pond water quality for nitrogen compounds. The City has collected ammonia, nitrate, and nitrite data in the Effluent Storage Ponds on a monthly basis since this improvement was made. A summary of this data in comparison to the median concentrations observed in WSM-18 (the background well) is provided in Figure 2. As shown, the average total inorganic nitrogen concentrations are approximately *a third* of the median concentration in WSM-18.

Finally, Table 1 presents the results of a statistical comparison of the inorganic nitrogen concentrations in the Effluent Storage Ponds to the nitrate concentrations in the background wells and in the three onsite wells that have historically been determined to exceed water quality objectives (WSM-2, WSM-5 and WSM-16).

Table 1. WPCF Groundwater Monitoring Well Nitrate Concentrations Relative to Inorganic Nitrogen Concentrations in the Effluent Storage Ponds[a]

Parameter	Effluent Storage Ponds	Onsite Wells			Background Wells	
		WSM-2	WSM-5	WSM-16	WSM-17	WSM-18
Median Concentration[b], mg/L as N	7.1	55	23	30	5.5	30
Number of Data Points	66	22	22	22	19	19
P-Value (Well vs. Ponds)[c]		0.000	0.000	0.000	0.530	0.000
Median > 10 mg/L as N[d]?	**No**	Yes	Yes	Yes	No	Yes
Pond Median > Well Median?		**No**	**No**	**No**	Yes	**No**
Pond Data Statistically Higher?		No	No	No	**No**	No

[a] Data is for Feb. 2008-May 2013, monthly (generally) for the ponds and quarterly for the wells.
[b] Pond concentrations are for inorganic nitrogen (ammonia plus nitrate and nitrite); well concentrations are for nitrate only. Non-detect data has been set equal to the Method Detection Limit.
[c] Values shown are the two-tailed p-value from the Wilcoxon Rank Sum test. Values > 0.05 indicate statistically similar data sets. Values < 0.05 indicate statistically different data sets.
[d] Primary Maximum Contaminant Level for nitrate plus nitrite.

The following observations can be made from the results shown in Table 1:

1. The median inorganic nitrogen concentration in the Effluent Storage Ponds between February 2008 and May 2013 is less than the 10 mg/L as N nitrate water quality objective.
2. The median nitrate concentrations in WSM-2, WSM-5, WSM-16, and WSM-18 (a background well) are all well above the water quality objective.
3. The median concentration of inorganic nitrogen in the Effluent Storage Ponds is well below the median nitrate concentrations in all of the onsite wells.
4. The median concentration of inorganic nitrogen in the Effluent Storage Ponds is well below the median nitrate concentrations in the background well WSM-17.
5. The p-value for WSM-17 compared to the ponds is greater than 0.05, so the WSM-17 data set is statistically similar to the data set for the ponds (*i.e.*, the inorganic nitrogen concentrations in Effluent Storage Ponds is not statistically greater than the nitrate concentrations in WSM-17).

Based on the information presented in this section, it is concluded that total inorganic nitrogen concentrations in the Effluent Storage Ponds are not statistically greater than the nitrate concentrations observed in any of the onsite wells of concern or the background wells. In addition, although WSM-2 and WSM-16 continue to show exceedances of the background groundwater quality (*i.e.*, the de facto objective for nitrate), the waste discharges from ponds are not the source of onsite groundwater degradation for nitrate.

MANGANESE EVALUATION

The Background Groundwater Report documented statistical exceedances of the dissolved manganese levels in the combined data set from three background wells (WSM-16, WSM-17 and WSM-18) for the following onsite wells:

- WSM-2
- WSM-3[6]
- WSM-4
- WSM-8
- WSM-14
- WSM-15

A contour map of the median manganese concentrations measured to date is presented as Figure 3. A comparison of this information to the groundwater contour information presented in Figure 1 demonstrates that the highest manganese concentrations (observed in WSM-15) occur upgradient of the Effluent Storage Ponds. However, WSM-2, WSM-4, WSM-8 and WSM-14 are either cross-gradient or downgradient to the Effluent Storage Ponds and, therefore, may be

[6] WSM-3 was decommissioned in late 2010, so evaluation of this well is not provided in the current discussion.

influenced by discharges from this facility. Additional consideration of whether the Effluent Storage Ponds are the likely source of elevated dissolved manganese levels in these four wells is warranted.

One key observation in this regard is the fact that manganese concentrations in the groundwater decrease by *four orders of magnitude* from upgradient of the Effluent Storage Ponds (WSM-15) to downgradient of the Effluent Storage Ponds (WSM-8). This data would therefore suggest that the Effluent Storage Ponds are reducing manganese levels in the groundwater. In fact, dissolved manganese levels decrease by *five orders of magnitude* from the northwestern boundary of the City's property (WSM-15) to the southeastern boundary of the City's property (WSM-12), and the available data would suggest that exceedances of the dissolved manganese objectives observed on the City's properties are not apparent on the wells located downgradient of the City's property.

Another key observation is that manganese concentrations for WSM-8 (the well likely to be under the greatest influence of the Effluent Storage Ponds) have dropped by two orders of magnitude since the Background Groundwater Report was prepared. Specifically, the median concentration between 2008 and 2010 was 45 µg/L, but the median concentration for 2011 through 2013 is 0.24 µg/L (assuming non-detect (ND) data are equal to the Method Detection Limit (MDL)). In fact, all of the WSM-8 manganese data since September 2010 has been either ND or detected not quantified (DNQ) data (*i.e.*, detected at levels between the MDL, which has varied between 0.030 and 0.35 µg/L, and the Reporting Level, which has varied between 0.50 and 10 µg/L). Therefore, WSM-8 no longer demonstrates manganese concentration higher than either the background groundwater concentrations *or* applicable water quality objectives. (Elimination of biosolids supernatant and WAS thickening subnatant to the Effluent Storage Ponds could be a contributing factor to this decrease.)

Another point of evidence as to whether the Effluent Storage Ponds are the cause of the onsite exceedances of the background water quality for manganese is the water quality that is maintained in the Effluent Storage Ponds. Effluent Storage Pond manganese data were not available during development of the Background Groundwater Report, so that report does not include an evaluation of manganese concentrations relative to groundwater concentrations. However, recent pond manganese data is now available to evaluate the potential for the ponds to influence the groundwater. A summary of the pond manganese data in comparison to the median concentrations observed in WSM-19[7] (the background well) is provided in Figure 4. As shown, the average manganese concentrations are approximately <u>*two orders of magnitude lower*</u> than the

[7] As documented in the Groundwater Background Report, WSM-19 is located directly adjacent to the I-5 Peripheral Canals and is strongly under the influence of the surface water in this water body; and, because the areas surrounding the WPCF are irrigated with a groundwater supply, WSM-19 does not generally represent the type of water quality that would be exhibited on the City's property absent discharges to the City's property. Therefore, WSM-19 was not used as part of the background analysis presented in the Groundwater Background Report. However, as further detailed in Groundwater Background Report, WSM-19 is located in an area with limited depth to groundwater and has the same soil type as found in the northwestern quadrant of the City's property. Therefore, this well may be under the influence of some of the same conditions that could be causing elevated dissolved manganese levels in the City's onsite wells. Therefore, it is appropriate to consider this well in the background analysis for dissolved manganese.

median concentration in WSM-19. In fact, the average manganese concentrations in the Effluent Storage Ponds are lower than the secondary MCL of 50 µg/L.

Finally, Table 2 presents and a comparison of the Effluent Storage Pond manganese concentrations to the dissolved concentrations in background wells WSM-16, WSM-17, WSM-18, and WSM-19 and in the five existing onsite wells that have historically been determined to exceed water quality objectives (WSM-2, WSM-4, WSM-8, WSM-14 and WSM-15).

Table 2. WPCF Groundwater Monitoring Well Dissolved Manganses Concentrations Relative to Total Manganese Concentrations in the Effluent Storage Ponds[a]

Parameter	Effluent Storage Ponds	Onsite Wells					Background Wells			
		WSM -2	WSM -4	WSM -8	WSM -14	WSM-15	WSM -16	WSM -17	WSM -18	WSM - 19
Median Concentration[b], µg/L	35	740	304	0.57	210	1,440	0.75	0.37	0.16	239
Number of Data Points	16	22	22	22	22	22	22	19	19	19
P-Value (Well vs. Ponds)[c]		0.000	0.000	0.041	0.000	0.000	0.000	0.000	0.000	0.000
Median > 50 µg/L[d]?	**No**	Yes	Yes	No	Yes	Yes	No	No	No	Yes
Pond Median > Well Median?		**No**	**No**	Yes	**No**	**No**	Yes	Yes	Yes	**No**
Pond Data Statistically Higher?		No	No	Yes	No	No	Yes	Yes	Yes	No

[a] Well data was collected quarterly Feb. 2008-May 2013. Ponds data was collected monthly Apr. 2008-Jul. 2012.
[b] Pond concentrations are for inorganic nitrogen (ammonia plus nitrate and nitrite); well concentrations are for nitrate only. Non-detect data has been set equal to the Method Detection Limit.
[c] Values shown are the two-tailed p-value from the Wilcoxon Rank Sum test. Values > 0.05 indicate statistically similar data sets. Values < 0.05 indicate statistically different data sets.
[d] The secondary Maximum Contaminant Level for manganese.

The following observations can be made from the results shown in Table 2:

1. The median total manganese concentration in the Effluent Storage Ponds between April 2008 and July 2012 is less than the 50 µg/L water quality objective.
2. The median total manganese concentration in WSM-2, WSM-4, WSM-14, WSM-15 and WSM-19 (a background well) are all well above the water quality objective.
3. The median total manganese concentration in the Effluent Storage Ponds is well below the median concentrations in all of the onsite wells except WSM-8 (which is immediately downgradient of the ponds). However, the median concentrations in WSM-8 do not exceed background concentrations or the applicable water quality objective.
4. The median concentration of total manganese the Effluent Storage Ponds is well below the median dissolved manganese concentrations in the background well WSM-19.

Based on the information presented in this section, it is concluded that total manganese concentrations in the Effluent Storage Ponds are not statistically greater than the manganese concentrations observed in any of the onsite wells of concern or the background wells. Moreover, the data presented above in combination with the site information presented in the Groundwater Background Report supports a conclusion that conditions in the recharge zones located in the northwestern portion of the City's property appear to be contributing to elevated dissolved manganese levels in the onsite wells. Therefore, because there is a *four order of magnitude* decrease in groundwater dissolved manganese concentrations from upgradient to downgradient of the Effluent Storage Ponds, releases of high quality water from the Effluent Storage Ponds are likely to help mitigate impacts associated with this upgradient source. Therefore, waste discharges from ponds are not the source of onsite groundwater degradation for manganese.

SUMMARY OF CONCLUSIONS

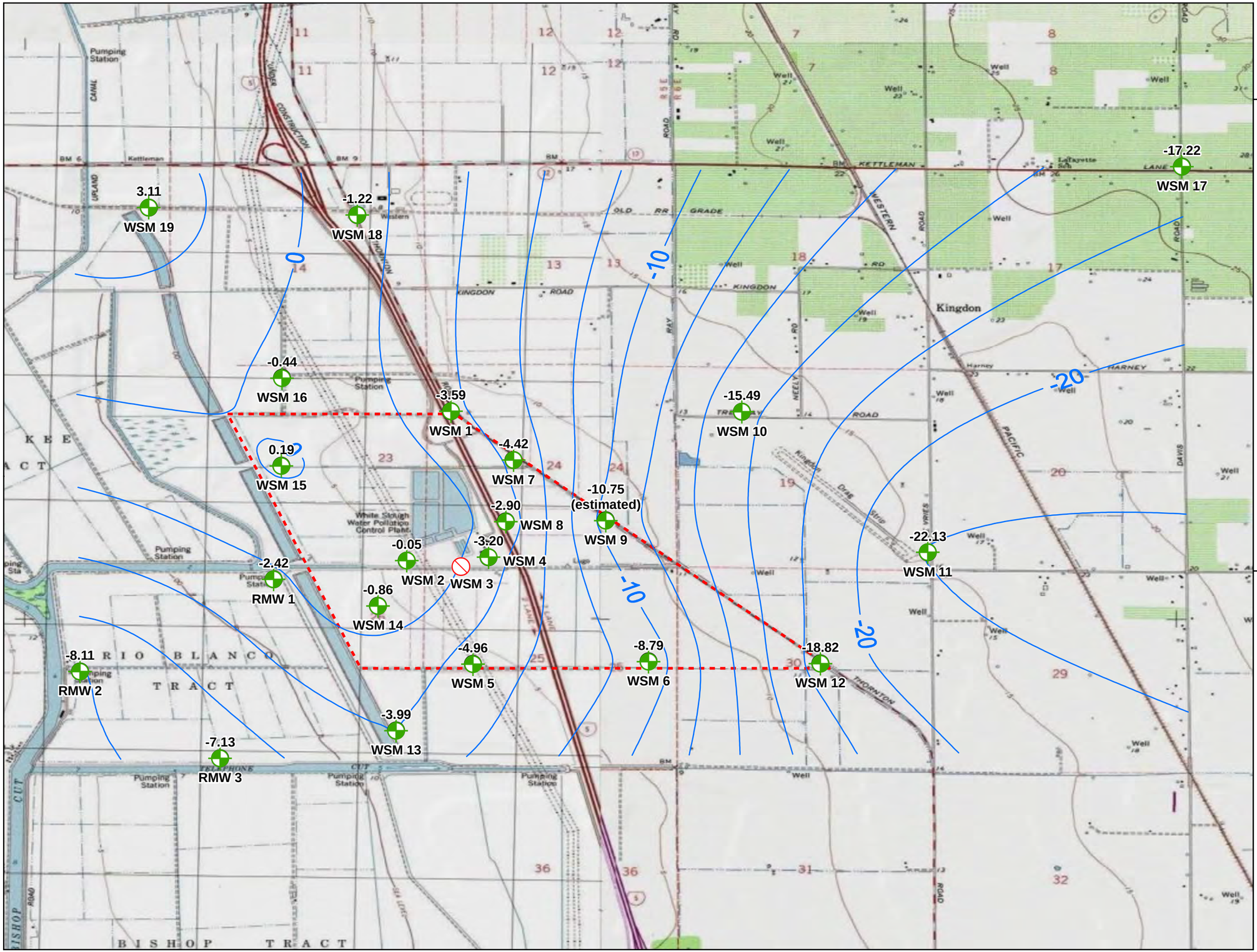
The following major conclusions are drawn from the information provided in this TM:

- Total Inorganic Nitrogen concentrations in the Effluent Storage Ponds are not statistically greater than the nitrate concentrations observed in any of the onsite wells of concern or the background wells.
- Total Manganese concentrations in the Effluent Storage Ponds are not statistically greater than the manganese concentrations observed in any of the onsite wells of concern or the background wells.
- The *four order of magnitude* decrease in groundwater dissolved manganese concentrations from upgradient to downgradient of the Effluent Storage Ponds suggests that releases of high quality water from the Effluent Storage Ponds are likely to help mitigate impacts associated with an upgradient source.
- Waste discharges from the Effluent Storage Ponds are not the source of onsite groundwater degradation for nitrate and manganese.

FIGURE 1

City of Lodi
White Slough WPCF

GROUNDWATER ELEVATION CONTOUR MAP 2ND QUARTER 2013



0 1,250 2,500

Scale in Feet

Notes
1. Groundwater levels were measured on May 8, 2013.
2. Groundwater gradient from the White Slough Water Pollution Control Facility approximately -0.002 feet/foot to the east-southeast for the second quarter of 2013.
3. Well WSM 9 was dry on May 8, 2013. The groundwater elevation was estimated to be equal to or less than the well sump.
4. Well WSM 3 was destroyed in accordance with San Joaquin County Well Destruction Standards on August 17, 2010.

LEGEND

- Boundary of City-Owned Land
- -3.99 / WSM 5 — WPCF Monitoring Well with Groundwater Elevation (Feet, MSL)
- WSM 3 — Decommissioned Monitoring Well
- -5 — Groundwater Elevation Contour (Feet, MSL) Contour Interval: 2 Feet

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Figure 2. Nitrogen Concentrations in WSM-18 and Effluent Storage Ponds

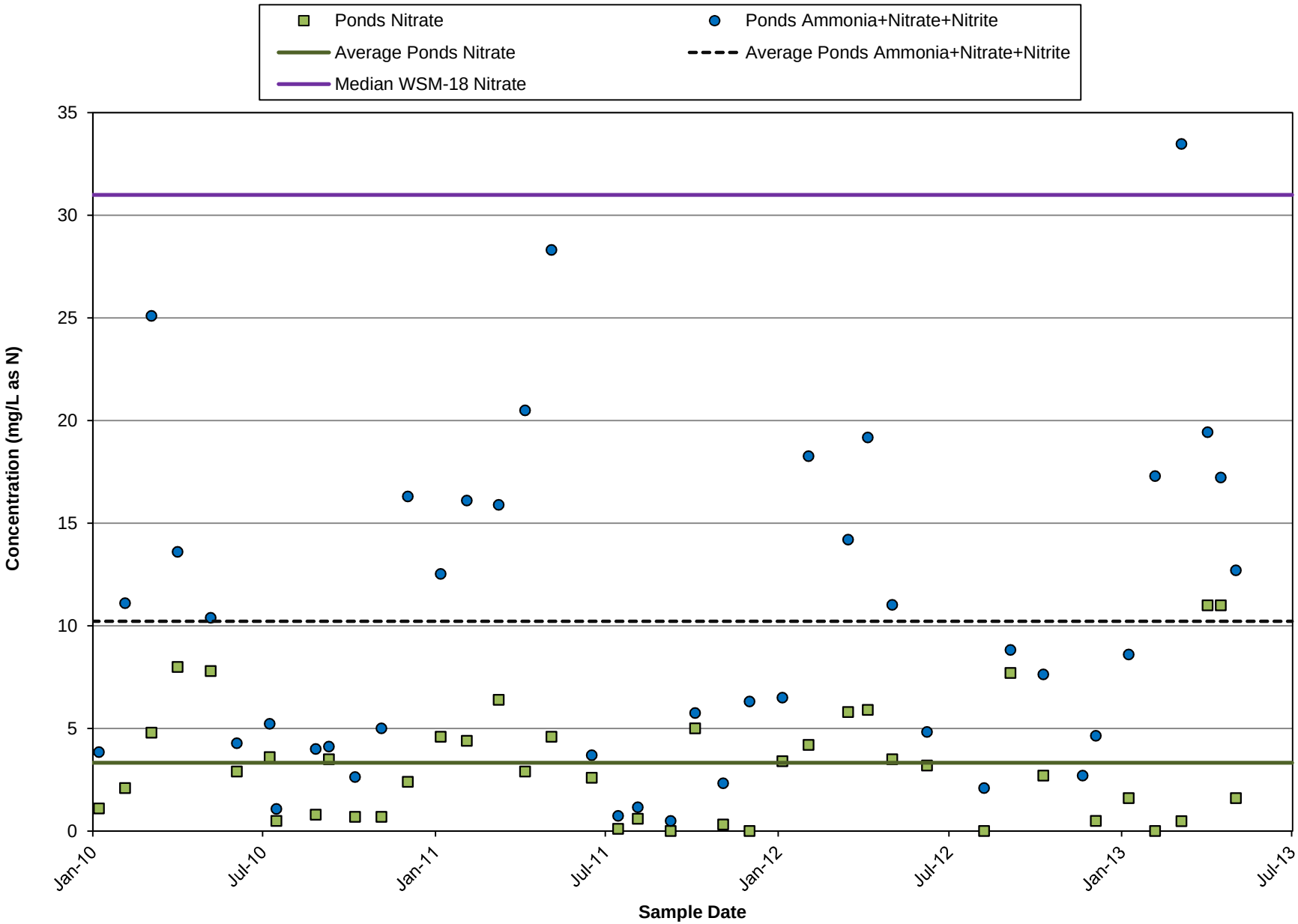

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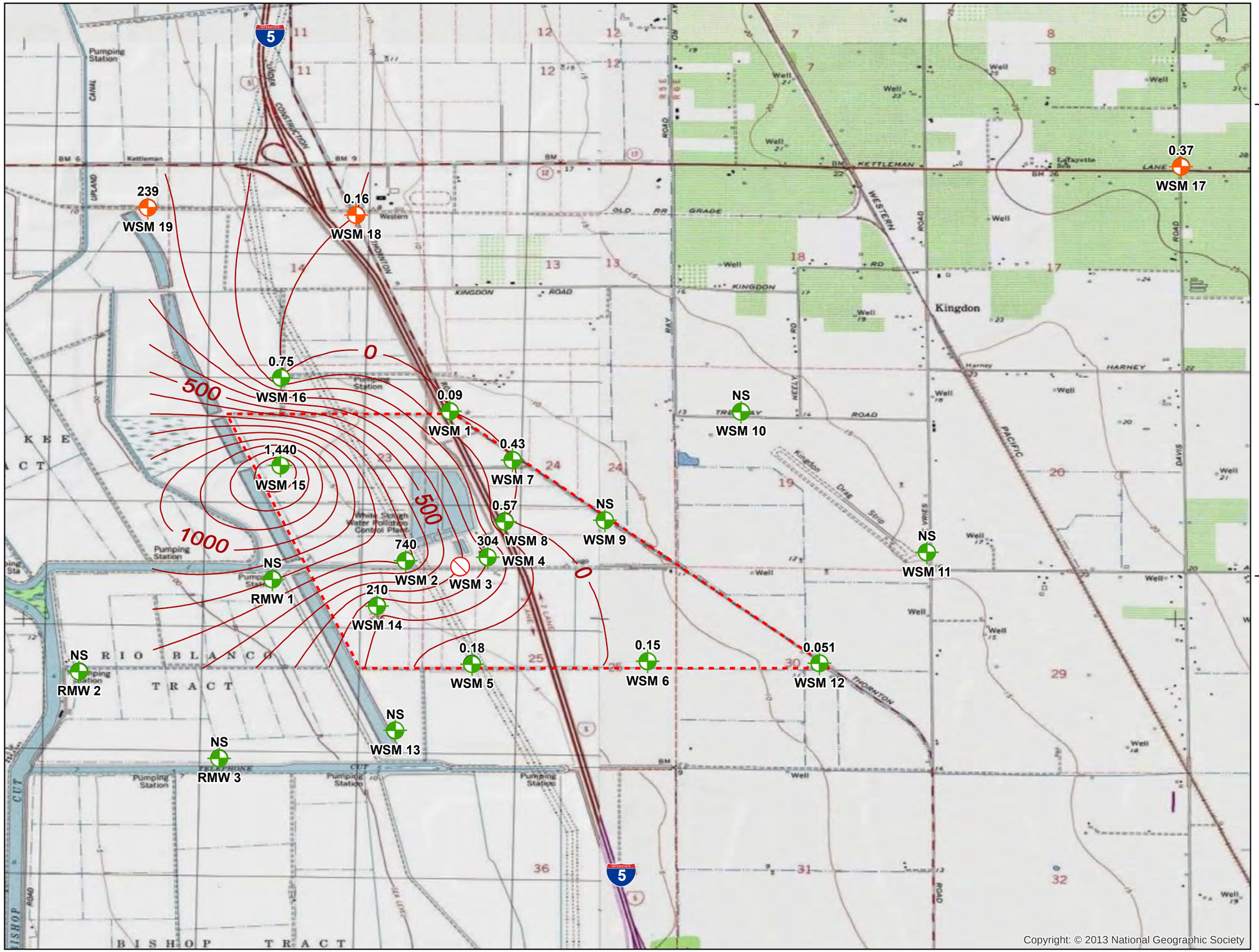
FIGURE 3

City of Lodi
White Slough WPCF

CONTOUR MAP OF MEDIAN DISSOLVED MANGANESE CONCENTRATIONS (FEB. 2008-MAY 2013)



0 1,250 2,500

Scale in Feet

LEGEND

- Boundary of City-Owned Land
- -3.99 WSM 5 — Background Monitoring Well with Manganese Concentration (µg/L)
- -3.99 WSM 5 — WPCF Monitoring Well with Manganese Concentration (µg/L) ["NS" = No samples]
- WSM 3 — Decommissioned Monitoring Well
- 5 — Manganese Concentration Contour (µg/L) Contour Interval: 100 µg/L

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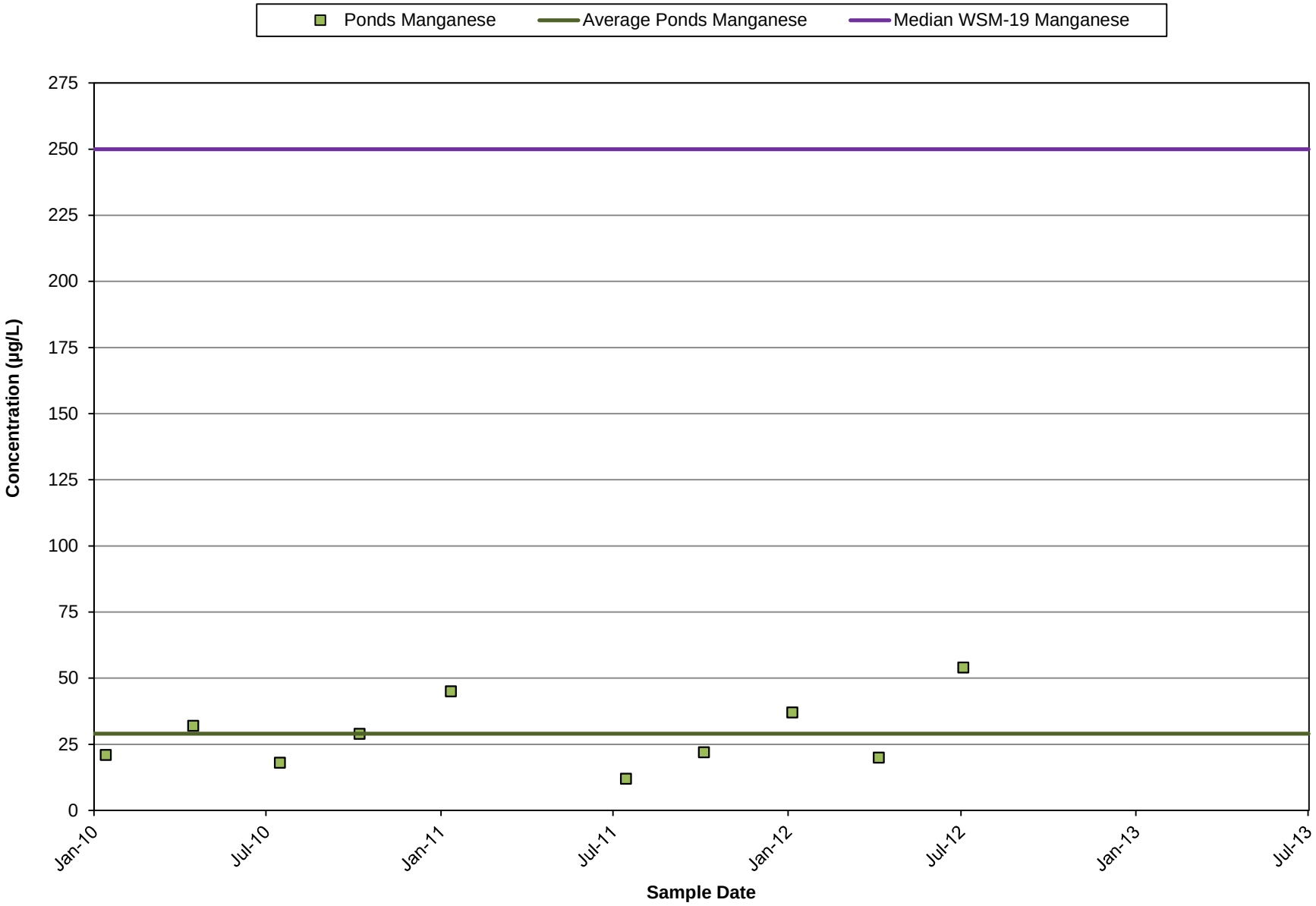
Figure 4. Manganese Concentrations in WSM-19 and Effluent Storage Ponds



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Last Revised: 08-19-13

City of Lodi
Nitrate and Manganese
Groundwater Quality Impacts TM