



April 29, 2011

Eastern Municipal Water District
Attn: Jayne Joy
Director, Environmental and Regulatory Compliance
2270 Trumble Road
Perris, CA 92572-8300

Subject: Results of the Soil Characterization Study at the San Jacinto Wildlife Area in Support of the Use of Recycled Water in the San Jacinto Lower Pressure Management Zone

Dear Ms. Joy:

Pursuant to Regional Board Order R8-2008-0008, *Waste Discharge and Producer/User Reclamation Requirements for Eastern Municipal Water District Regional Water Reclamation Facilities Discharge to Groundwater Management Zones within San Jacinto River Basin*, the Eastern Municipal Water District (EMWD) is required to develop a regulatory compliance strategy for the continued use of recycled water in the San Jacinto Lower Pressure (SJLP) Management Zone. The EMWD hired Wildermuth Environmental, Inc. (WEI) to assist in the development of that strategy. Together, EMWD and WEI developed a work plan¹ to perform a soil characterization study to demonstrate, or not, that the impact of the EMWD's recycled water use in the SJLP Management Zone is *de minimis* and that a salt offset plan may not be necessary as part of the regulatory compliance strategy. The EMWD submitted the work plan to the Regional Board on May 26, 2010, and it was accepted by the Regional Board in June 2010.² WEI is pleased to submit this letter report, containing summary results of the soil characterization study and our recommendations for an alternative regulatory compliance strategy.

BACKGROUND

The EMWD delivers about 3,000 acre-feet per year of tertiary-treated recycled water to the San Jacinto Wildlife Area (SJWA) and several privately owned duck clubs (DCs) for use in maintaining their wetland habitats. The SJWA, owned and operated by the California Department of Fish and Game (DFG), is located in the southwestern portion of the SJLP Management Zone (see Figures 1 and 2). The SJWA consists of about 9,000 acres of wildlife habitat and is a cornerstone reserve in the Riverside County Multi-Species Habitat

¹ Eastern Municipal Water District and Wildermuth Environmental, Inc. 2010. *Work Plan to Characterize the Impact of the Use of Recycled Water at the San Jacinto Wildlife Area on the Salinity of the San Jacinto Lower Pressure Management Zone*. Submitted to the Regional Board on May 26, 2010.

² Email correspondence from Ken Theisen to Jayne Joy, dated June 10, 2010.

Conservation Plan. The DCs are located adjacent to the SJWA. Combined, the SJWA and private DCs manage about 2,400 acres of restored wetlands, collectively referred to in this report as the Study Area, as shown of Figure 3.

Although the Study Area wetlands have been in operation since the late 1980s, the operators have only recently relied upon recycled water year-round to maintain the wetlands habitat. Prior to 2005, the DFG and the DCs pumped groundwater from the SJLP Management Zone to support the wetland habitats during winter months. The high concentrations of total dissolved solids (TDS) in the underlying groundwater were considered detrimental to certain wetland species; thus, when recycled water was made available year round, the wetlands operators discontinued the use of groundwater as a water supply. The SJWA is the first state wildlife area to utilize recycled water to supply a wetlands habitat. Figure 2 delineates the wetlands ponds that receive recycled water.

While the use of recycled water in the Study Area provides many environmental and recreational benefits, the Regional Board has regulatory concerns about the potential infiltration of recycled water to the SJLP Management Zone. Per the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan), the TDS groundwater objective in the SJLP Management Zone is 520 milligrams per liter (mg/L). The 2006 ambient TDS concentration is 810 mg/L.³ Therefore, the SJLP Management Zone lacks assimilative capacity for TDS.

The TDS concentrations of the recycled water delivered to recycled water users in the SJLP Management Zone vary depending on the blend of effluent source(s). Recycled water delivered to the Study Area can be a combination of effluent from the following EMWD regional water reclamation facilities (RWRF):

- San Jacinto Valley RWRF (12-month average TDS = 557 mg/L)
- Perris Valley RWRF (12-month average TDS = 661 mg/L)
- Moreno Valley RWRF (12-month average TDS = 472 mg/L)

The average percent contributions of waters delivered to the Study Area in 2010 from the San Jacinto Valley, Perris Valley, and Moreno Valley RWRFs was 37%, 36%, and 27%, respectively. The blended TDS concentrations ranged from 516 mg/L to 620 mg/L and averaged 572 mg/L. Since the TDS concentration of the recycled water delivered to the Study Area typically exceeds the TDS objective of the SJLP Management Zone, the Regional Board has required, through order R8-2008-0008, that the EMWD develop a salt offset plan to mitigate TDS loading to the SJLP Management Zone in excess of the objective or discontinue deliveries of recycled water to the DFG and the DCs. However, available data and anecdotal observations from wetland operators indicate that the shallow soils underlying Mystic Lake and the Study Area are clay-rich and that water applied to the wetlands infiltrates in only *de minimus* amounts.

The SJLP is in the San Jacinto Groundwater Basin (SJGB). This basin is bounded by the San Jacinto Mountains on the east, the San Timoteo Badlands on the northeast, the Box Mountains on the north, the Santa Rosa Hills and Bell Mountain on the south, and unnamed

³ Wildermuth Environmental, Inc. 2008. *Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1987 to 2006 Technical Memorandum*. August 2008.

hills on the west.⁴ The SJBG contains sediments that have filled valleys and underlying canyons incised into crystalline basement rock.⁴ Sediments eroded from igneous and metamorphic rocks within the surrounding mountains and hills have filled the valleys to provide reservoirs for groundwater.⁵ The San Jacinto and Casa Loma fault zones are the major geologic features that bound and/or cross-cut the SJLP on the northeast and southwest.⁵ Underlying Mystic Lake are late Holocene mixed lacustrine and fluvial deposits of clay, silt, and fine-grained sand that are unconsolidated to slightly consolidated. Prehistorically, the San Jacinto River drained into closed depression that formed at the north end of the San Jacinto pull-apart basin, adjacent to the San Jacinto Fault.⁶ Water level data from several wells within the Study Area indicate that groundwater occurs at a depth of 85 to 230 feet below ground surface across the Study Area. The screened intervals are known for two of these wells, which are 140 to 400 feet below ground surface and 735 to 1035 feet below ground surface.

Figure 2 shows that for three previously recorded lithologic logs from boreholes located within the Study Area, at least 85% of the first 100 feet of sediments were logged as “clay” on the well driller’s log. Additionally, anecdotal observations from wetland operators suggest that far greater volumes of water would be needed to maintain the wetlands habitat if the applied water were infiltrating. Based on these data and observations, we hypothesize that the fine-grained soils underlying the Study Area impede the infiltration of recycled water to the underlying aquifer to a *de minimis* amount. To test this hypothesis, we developed and executed a soil characterization study to determine if the soils underlying the Study Area are effectively impervious. The following sections summarize the methods, results, analysis, and conclusions of the soil characterization study.

METHODS

Cone Penetrometer Tests (CPTs) were used to characterize the soils in the shallow, unsaturated zone beneath the Study Area. A CPT is a subsurface soil characterization method that involves hydraulically pushing a conical-shaped probe into a soil deposit while recording the friction and resistance of the soil to penetration by the probe. The friction and resistance data are then correlated to soil behavior types. The 2,400-acre Study Area was divided into fifty 48-acre partitions, each of which contained a CPT target location. Figure 3 shows the target CPT locations.

Between August 16 and August 20, 2010, fifty 30-foot deep CPTs were performed by Fugro Consultants, Inc. (Fugro) under the supervision of WEI. The Study Area was cleared for underground utilities by Underground Service Alert. The CPTs were completed using a 25-ton capacity CPT rig. A hand-held global positioning system (GPS) was used to field-locate each CPT location as closely as possible to the locations shown in Figure 3. Several sites

⁴ State of California, Department of Water Resources. 2006. *California’s Groundwater. Bulletin 118: Hydrologic Region South Coast, San Jacinto Groundwater Basin.*

⁵ Wildermuth Environmental, Inc. 2000. *TIN/TDS Study – Phase 2A of the Santa Ana Watershed.* Prepared for the TIN/TDS Task Force. July 2000.

⁶ Morton, Douglas, M. and Matti., J.C. 2001. *Geologic Map Of The Lakeview 7.5' Quadrangle, Riverside County, California.* U.S. Geological Survey Open File Report 01-174, Version 1.0. Geological Survey, Menlo Park, California.

were moved to prevent advancing the CPT probe directly through wetland levees or to avoid standing water. The final locations of the CPTs are shown in Figure 4. All holes left by the probe were backfilled with hydrated medium bentonite chips.

More than 23,000 data points were recorded from the 50 CPT locations in the Study Area with vertical intervals of 0.06 to 0.07 ft. The resistance and friction values measured by the CPT were correlated by Fugro to soil behavior types in accordance with the classification system developed by Robertson et al.⁷ This classification contains 12 soil behavior categories that range from fine-grained and organic soils to gravelly sand.

On August 25, 2010, five 30-foot soil cores were collected adjacent to CPT test sites (one core per ten CPTs). Based on preliminary CPT results, five core locations were selected (i) to obtain samples that were representative of the Study Area, (ii) to contain as many of the identified soil behavior types as possible, and (iii) to achieve spatial coverage across the Study Area. Figure 3 shows the soil core locations. The cores were collected using the Macro-core sampling system with a direct push drilling method. The 1.7-inch diameter cores were collected in rigid acetate liners. The soil cores were taken to WEI's Lake Forest office where they were photographed and visually described in accordance with the Unified Soil Classification System.⁸ The soil core photographs are included as Appendix A of this report.

Additionally, ten 6-inch long sections of the soil cores were selected and submitted to PTS laboratories in Santa Fe Springs, CA for physical soil characterization. The objective of the laboratory analysis was to determine if the measured hydraulic conductivities of the soil cores are representative of the soil behavior types described by the CPT classification system. Samples were selected based on the soil behavior types that were prevalent in the Study Area, as defined by the CPT data and the variability within soil types found during visual logging of the soil cores. For these reasons, multiple samples of CPT soil behavior types 3 (clay) and 11 (very stiff fine grained soil) were submitted for analysis. The following analyses were performed as part of the hydraulic conductivity package: moisture content, grain and bulk density, total and air-filled porosity, total pore fluid (water only) saturation, and native-state vertical permeability to water (hydraulic conductivity).

RESULTS

CPT data were compiled by Fugro into graphical reports that show resistance and friction values and the correlated soil behavior types plotted against depth. The results of the CPT tests are included in chart and text format in Appendix B of this report. Appendix B also includes the 12 Zone Soil Behavior Chart⁷ that was used by Fugro to correlate CPT data to soil behavior types. Table 1 summarizes the prevalence of each soil behavior type as a percent of total feet of soil tested by CPT. The Study Area is dominated by soil behavior type 3, defined as clay, representing 61% of all soils tested. In contrast, soil behavior type 9, defined as sand, represents only 2% of all soils tested.

⁷ Robertson, P.K, Campanella, R.G., Gillespie, D., and Greig, J. 1986. *Use of Piezometer Cone Data. In-Situ '86 Use of In-situ Testing in Geotechnical Engineering*, GSP 6. Reston, VA:ASCE, Geotechnical Engineering, Specialty Publication, pp. 1263-1280.

⁸ Geotechnical Services Branch, Research and Laboratory Services Division, Denver Office, U.S. Dept. of the Interior, Bureau of Reclamation. 1988. *Unified Soil Classification System*. Denver, CO.

Visual inspection of the core samples confirmed that soils within the Study Area are primarily fine grained. In fact, soils classified by the CPT as having a component of sand were observed in the soil cores to be fine sand with only traces of medium sand. Precise correlation of the CPT data with soil cores was difficult due to the vertical resolution of the CPT data (0.06-0.07 foot interval), the overlapping⁹ and general descriptions used for the soil behavior types, soil losses between core sections, possible soil compaction during sampling, poor recovery, and/or differences in soil structure caused by the distance between the CPT and corresponding core. However, general correlation confirmed that for the purpose of this study, the CPT data accurately represent the shallow subsurface soils of the Study Area.

The laboratory results of the core samples for hydraulic conductivity are summarized in Table 2, and the full lab report is attached as Appendix C. The results show that six of the seven soil behavior types analyzed have hydraulic conductivities less than 1.11×10^{-05} centimeters per second (cm/sec), which are typical of clay, silt, sandy silt, clayey sand, and till.¹⁰ The hydraulic conductivity of the sand sample (soil behavior type 9) is 1.04×10^{-03} cm/sec, which is typical of well-sorted sands or glacial outwash.¹⁰ The results indicate that the hydraulic conductivity of the soils tested from soil behavior types 8 and 12 are lower than the CPT soil classification descriptions suggest.

ANALYSIS

The Study Area soils were grouped into two categories based on the CPT results for soil behavior type: (1) fine-grained soils and (2) coarse-grained soils. Table 1 summarizes this categorization. Fine-grained soils include soil behavior types that are dominated by clays, silts, and organic matter, which include CPT soil behavior types 1 through 7 and 11. Fine-grained soils comprise about 94% of the soils encountered by CPT. Coarse-grained soils include soil behavior types that are dominated by sands and gravels, which include CPT soil behavior types 8 through 10 and 12. For example, a CPT reading that correlates to soil behavior type 8 indicates a soil texture of sand to silty sand—meaning that the soil is dominated by coarse-grained materials (sand). Coarse-grained soils comprise about 5% of the soils encountered by CPT.¹¹

The soil categorization described above is a conservative approach when considering the hydraulic conductivity results. Soil behavior types 8 and 12 were classified as coarse-grained soils, but the measured hydraulic conductivity results for these types were relatively low as described previously. This approach was used because the CPT data represents the most wide-spread data set collected for this study.

The fine- and coarse-grained soil classifications were used to create hand-drawn contours of the total amount of fine-grained soils as a percentage of the total depth of soil tested by CPT, as shown on Figure 4. The percentage of all fine-grained materials ranged from 58% to

⁹ For example, soil behavior type 3, described as clay, and soil behavior type 4, described as silty clay to clay, could both indicate the presence of clay.

¹⁰ Fetter, C. W. 2001. *Applied Hydrogeology*. Upper Saddle River, New Jersey: Prentice Hall.

¹¹ 0.8% of all the soils tested by the CPT returned data values that were out of the range of the CPT tool and were not classified according to the soil behavior type classification system. For the graphical representation of fine- and coarse-grained soils, the unclassified soils were assumed to be the same as the soil behavior type adjacent to them.

100% and averaged 94%. The contours show that the fine-grained soils represent over 95% of the soils in the northern, central, and eastern portions of the Study Area. Fine grained soils represent 58% to 95% of the soil tested in the extreme western and southern portions of the Study Area. The lowest percentage of fine-grained soils are in the southwestern section of the Study Area where there are no overlying wetland ponds. CPT 47, which had the lowest percent of fine-grained soils (58%), is located outside of the SJLP Management Zone in the Lakeview/Hemet North Management Zone.

The CPT soil behavior types were used to create cross sections that show an interpretation of the subsurface occurrence of the fine- and coarse-grained soil categories plotted with overlying land uses. Land uses within the Study Area were simplified to year-round ponds, seasonal ponds, areas without ponds, levees, and roads. Figure 5 shows the cross section transects across the Study Area. The cross sections are shown in Figures 6 through 13. A brief description of each cross section is provided below.

Cross-section A-A' (Figure 6). Fine-grained soils dominate the subsurface materials. CPT-10 has a coarse-grained lens from 0.3 to 1.6 feet below ground surface. This lens overlies more than 28 feet of continuous fine-grained soils. CPTs 12, 16, and 24 contain only fine-grained soils.

Cross-section B-B' (Figure 7). Fine-grained soils dominate the subsurface materials. CPT sites 47, 36, 37, 34, and 26 contain continuous fine-grained soil layers 12 to 26 feet thick. The coarse-grained soil lenses are present on the southwestern side of the Study Area near the out-cropping hills, the thickest of which are outside of the SJLP. CPTs 21, 20, and 19 contain only fine-grained soils.

Cross-section C-C' (Figure 8). Fine-grained soils dominate the subsurface materials. Several relatively thin (<2 feet) and laterally discontinuous lenses of coarse-grained soils occur in CPT-38, which is located near the outcropping hills and over which there are no wetland ponds. The shallowest of these lenses is overlain by 10 feet of continuous fine-grained soils. CPT-33 contains more than 29 feet of continuous fine-grained soils which overlie a coarse-grained soil lens. CPT-28 contains only fine-grained soils.

Cross-section D-D' (Figure 9). Fine-grained soils dominate the subsurface materials. CPT-45 shows two coarse-grained lenses of less than 0.3 feet thick that are separated by over 28 feet of fine-grained soils. CPT-30 contains one lens of coarse-grained soil less than 1 foot thick underlain by 29 feet of continuous fine-grained soils. CPT 41 contains only fine-grained soils.

Cross-section E-E' (Figure 10). Fine-grained soils dominate the subsurface materials. Thin lenses of coarse-grained soils occur in CPTs 1, 7, 14, 15, 23, 25, 35, 38, and 46. These lenses range in thickness from 0.07 (CPT-14) to 3 (CPT-7) feet. All of these CPTs contain continuous fine-grained soil layers of 10 (CPT-38) to 28 (CPT-15) feet thick. CPTs 6 and 24 contain only fine-grained soils.

Cross-section F-F' (Figure 11). Fine-grained soils dominate the subsurface materials. Thin, isolated lenses of coarse-grained soils appear at various depths throughout the cross section. These lenses are 0.13 (CPT-13) to 4 feet thick (CPT-48). All of these CPTs contain continuous fine-grained soil layers of 8 (CPT-48) to 30 (CPT-33) feet thick. There are no

overlying wetland ponds at CPT 48, where the greatest amount of coarse-grained material exists.

Cross-section G-G' (Figure 12). Fine-grained soils dominate the subsurface. Very thin, isolated lenses of coarse-grained soils appear at various depths throughout the cross section. The thickest lenses occur in CPT-50, which is not overlain by wetland ponds. All of these CPTs contain continuous fine-grained soil layers of 12 (CPT-50) to 30 (CPT-2) feet thick. CPTs 12, 18, 21, 28, 32, and 41 contain only fine-grained soils.

Cross-section H-H' (Figure 13). Fine-grained soils dominate the subsurface. Isolated lenses of coarse-grained soils only occur at the near-surface in CPTs 3, 10, 30, and 42. These lenses range in thickness from 0.66 (CPT-3) to 1.38 (CPT-10) feet and overlie more than 28 feet of fine-grained soils. CPTs 4, 11, 19, 29, and 31 contain only fine-grained soils.

In summary, the data generated during the CPT indicate the soil underlying the Study Area are overwhelmingly fine-grained, with only minor amounts of coarse-grained material. The coarse-grained material occurs as relatively thin, usually less than 1 foot thick, and laterally discontinuous lenses that do not appear to provide any hydraulic connection to the underlying aquifer.

CONCLUSIONS

The following is a summary of the evidence presented in this soil characterization study:

- (i) Of the 1,500 feet of soil tested by CPT, 94% consisted of fine-grained soils, the vast majority of which is clay.
- (ii) Visual logging of the core samples confirmed that the CPT soil classifications accurately represent the shallow subsurface soils of the Study Area.
- (iii) Laboratory results for hydraulic conductivity indicate the majority of the soils analyzed have hydraulic conductivity values typical of clay, silt, sandy silt, clayey sand, and till.
- (iv) The percent of fine-grained materials at individual CPT test locations ranged from a minimum of 58% to a maximum of 100% and averaged 94%.
- (v) Analysis of the CPT data using cross sections indicate the soils underlying the Study Area are overwhelmingly fine-grained, with only minor amounts of coarse-grained material. The coarse-grained material occurs as relatively thin and laterally discontinuous lenses that do not appear to provide any hydraulic connection to the underlying aquifer.
- (vi) Though the study only classified the first 30 feet of soils beneath the Study Area, historical borehole data indicate that the fine-grained materials could extend up to 100 feet beneath the wetlands.

Based on this evidence, we believe that the extensive fine-grained soils underlying the Study Area impede the infiltration of recycled water and that all but a *de minimis* amount of water applied to the wetlands is lost to evapotranspiration. Accordingly, a salt offset plan for the SJLP Management Zone is not necessary. As an alternative regulatory strategy, we recommend that the EMWD propose to continue quarterly and annual reporting of recycled

water sales to customers in the SJLP Management Zone, as is currently done in compliance with R8-2008-0008, and to keep the Regional Board informed of any changes in recycled water use in the SJLP Management Zone.

We appreciate the opportunity to work with EMWD in developing this study to support the use of recycled water in the SJLP. Please call us at (949) 420-3030 with any questions regarding this report.

Sincerely,

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Encl. Tables 1-2; Figures 1-13; Appendices A-C