

STAFF REPORT

VALLEY WATER MANAGEMENT COMPANY MCKITTRICK 1 & 1-3 FACILITY KERN COUNTY

INTRODUCTION

Valley Water Management Company (Valley Water) owns and operates oil field produced wastewater disposal pond systems named the McKittrick 1 ponds and McKittrick 1-3 ponds. The systems are interconnected, regulated as one facility, and collectively referred to as the McKittrick 1 & 1-3 Facility or Facility. The Facility is approximately 8.7 miles west of the community of Buttonwillow, as shown on Attachment A.

Oil field produced wastewater from various operators has been discharged to the Facility's approximately 149 acres of ponds for disposal by percolation and evaporation since the late 1950s. Produced wastewater comes from the South Belridge, Cymric, and McKittrick oil fields and is high in salinity and boron. The Facility is not within an established oil field (Attachment B).

Discharges to the ponds are regulated under Resolution No. 69-199 (Resolution), adopted by the Central Valley Water Board (Board) on 14 February 1969. The Resolution covers Valley Water Management discharges in the Belgian Anticline, Cymric, and McKittrick Oil Fields. The Resolution prohibits the discharges from creating pollution and nuisance, but does not require monitoring of the discharges to the ponds or to groundwater.

In June 2010, at the request of Board staff, Valley Water began voluntarily monitoring its discharge and groundwater down structure of the Facility. As discussed in detail below, the groundwater monitoring performed to date indicates that saline produced wastewater has migrated to the east beyond the Valley Water groundwater monitoring well network and has polluted or threatens to pollute groundwater that is being used or could potentially be used for beneficial uses. Therefore, additional characterization of discharges to the ponds and expansion of the existing groundwater monitoring network is necessary.

On 26 June 2017, the Assistant Executive Officer signed, on behalf of the Executive Officer, a Monitoring and Reporting Program (MRP) to Valley Water after considering Valley Water's comments on a previously circulated administrative draft MRP. The issued MRP was designed to require the complete characterization of the discharges to the ponds and expansion of Valley Water's groundwater monitoring network to delineate the plume of produced wastewater emanating from beneath the ponds. The MRP was very similar to the MRPs associated with *Waste Discharge Requirements General Order for Oil Field Discharges to Land* (General Order), *General Order Number One* and *General Order Number Two* adopted by the Central Valley Water Board (Board) at its 6 April 2017 meeting. Valley Water subsequently requested rescission of the MRP, submitted a petition to State Board that asserted the Executive Officer does not have the authority to issue MRPs, and expressed a desire to obtain coverage for the subject discharges under General Order Number Three, which does not require groundwater monitoring.

This Staff Report describes why a Board ordered/issued MRP is necessary and why coverage under General Order Three is not appropriate. Specifically, it will describe the Facility, the

discharges to the Facility, the local geology, the results of groundwater monitoring conducted to date, and why additional monitoring is necessary and appropriate. It also provides the basis for a Resolution by the Board to give staff guidance on how to regulate this specific site going forward. In preparing this Staff Report, Board staff reviewed the Board files for the Facility, including, but not limited to, those documents listed in Attachment C

FACILITY

The Facility is constructed on alluvial fan deposits just east of the Cymric and Monument Junction oil fields as shown on Attachment D. These fan deposits are discussed in more detail below, but are generally considered to be coarse grained and highly permeable. Structurally, the fans dip from the southwest to the northeast. Similarly, topography in the area slopes at about 30-feet-per-mile from the west-southwest to the east-northeast, as shown by the surface water channels depicted on Attachment D. The Clean Harbors Buttonwillow, LLC, Class I waste facility (Clean Harbors) is about 1.5 miles to the east-northeast, as shown on Attachment D.

Table 1 below presents the range of analytical results for various constituents associated with samples of produced wastewater discharged to the ponds from 10 February 1988 through 28 June 2017. These analytical results are from samples collected by Board staff during field inspections or submitted by, or on behalf of, Valley Water.

Table 1. *Range of Select Constituents Discharged to or in McKittrick 1 & 1-3 Ponds*

Parameter (units)	Concentration range	State MCL ⁴
Electrical Conductivity (EC) @ 25°C ¹ (µS/cm ²)	15,000 - 42,000	1,600/2,200 ⁵
Total Dissolved Solids (TDS) (mg/L)	7,772 - 26,000	1,000/1,500 ⁵
Chloride (mg/L)	4,100 - 16,000	500/600 ⁵
Boron (mg/L)	42.5 - 130	
Benzene (µg/L ³)	4.9 - 400	1.0 ⁶
Toluene (µg/L)	7.2 - 1000	100 ⁶
Ethylbenzene (µg/L)	0.93 - 120	300 ⁶
Xylenes (µg/L)	4.7 - 550	1750 ⁶

1. °C = Centigrade.

2. µS/cm = microsiemens per centimeter which is equivalent to micromhos per centimeter.

3. µg/L = micrograms per liter.

4. State of California drinking water Maximum Contaminant Level (MCL)

5. Secondary MCL, upper limit/short term limit.

6. Primary MCL.

The State Drinking Water Maximum Contaminant Levels are presented for comparison purposes. Oil field produced wastewater discharged to the Facility is from the more saline marine Diatomite Formation and the relatively less saline Tulare Formation. The range in concentrations above depends on the number of wells producing and the corresponding zone of

production discharging to the ponds. The electrical conductivity (EC), chloride, and boron concentrations in the produced wastewater greatly exceed the numerical limits set for oil field discharges to land in the *Water Quality Control Plan for the Tulare Lake Basin* (Revised 2016)(Basin Plan) of 1,000 umhos/cm, 175 mg/L, and 1.0 mg/L respectively. The discharges to the ponds also greatly exceed Maximum Contaminant Levels (MCLs) limits for EC, total dissolved solids (TDS), chloride, benzene, and toluene, and greatly exceed EC, TDS, chloride, and boron objectives for agriculture.

The discharge flows to the McKittrick 1 & 1-3 ponds were not metered until recently. Reported flows and their sources are shown in Attachment E and have ranged from 5000 barrels (bbls) per day (~ 210,000 gallons per day 'gpd') to 115,000 bbls per day (4.83 million gpd). The average of the reported flows is approximately 67,000 bbls per day or 2.8 million gpd. Based on the average flows, the volume of produced water discharged to the ponds from 1960 to 2018 is about 1.4 billion barrels (60 billion gallons).

GENERAL HYDROGEOLOGY AND GROUNDWATER MONITORING RESULTS

Several general studies of the hydrogeology in the area that encompasses the Valley Water facilities that serve the Cymric and Monument Junction Oil Fields have been conducted. At Board staff's request, Valley Water has also conducted hydrogeology studies in the area of the McKittrick 1 & 1-3 ponds and installed a groundwater monitoring network. Similarly, Clean Harbors, has conducted local hydrogeology studies and installed a groundwater monitoring network for its facility. The following describes salient information in those reports and studies. As previously mentioned, the reports and studies consulted are listed in Attachment C.

Stratigraphy

The following describes the general stratigraphy underlying the McKittrick 1 & 1-3 Facility and the Clean Harbors facility. The nomenclature is generally consistent with that provided in Valley Water technical reports and self-monitoring reports. Attachment F.1 and F.2 provide general cross sections.

Alluvium

The first layer underlying the McKittrick 1 & 1-3 Facility is comprised of Holocene age alluvial fans consisting of sediments transported eastward from the Coast Ranges. These sediments are in interbedded layers of poorly sorted relatively coarse-grained, subangular to angular sands with silts and clays. Angular to subangular gravelly sands occasionally occur in the interbedded sequence.

Geomega's report on the initial hydrogeologic investigation, dated 17 October 2003, said "Silty clay layers within the shallower alluvial fan sequence act to perch groundwater in the Cymric area. Multi-perched water zones in the alluvial fan sequence encountered in borehole/monitoring wells CYM-17N1 and CYM-19H1 are apparent from air rotary drilling and geophysical log interpretation." The alluvium is saturated to the east and serves as an aquifer

for water supply wells.

Regional bed referred to as the "Corcoran Clay Equivalent", or CCE, or basal alluvial clay

Under the alluvium is a silty-clay to clay bed probably deposited in an alluvial plain to lacustrine environment transition. This bed separates the alluvium from the Tulare Formation. As described in the studies and reports provided by Valley Water, this bed does not act as a significant aquitard; i.e. it does not act as a significant barrier to the downward migration of produced wastewater discharged from the McKittrick 1 & 1-3 Facility ponds.

Upper Tulare

Below the CCE is what is called the upper Tulare or upper Tulare sand. It consists of Pleistocene age deposits that vary greatly from lacustrine delta deposits to braided stream, and point bar deposits, probably as a result of a Tulare Lake regressional sequence. The deposits are comprised of fine-grained sands with interbedded silt and clay layers and gravel lenses. The upper Tulare sand serves as an aquifer to the east that supplies water supply wells.

Regionally extensive clay layer

The upper Tulare sand is separated from what is called the deeper Tulare or deeper Tulare sand by a dense, stiff clay bed approximately 70 feet thick. This is sometimes called the upper Tulare clay.

Deeper Tulare

The deeper Tulare or deeper Tulare sand is composed primarily of fine-grained to medium-grained well-sorted sands. Valley Water documents indicate the deeper Tulare contains the "regional aquifer." The deeper Tulare serves as an aquifer for water supply wells to the east.

Depositional Environment

Within the Cymric area, the Quaternary stratigraphic depositional environment generally consists of uplifted arid alluvial fan systems underlain by lacustrine (lake deposits) silts, sands, and clays. Alluvial fan systems are formed from the release of water-borne sediments from mountainous catchments into an adjacent valley or basin. Sediments are deposited to the fan by sheet flow and an incised channel that is an extension of the catchment feeder channel. The incised channel will usually end short of the distal portion of the fan. At the end of the channel, flows expand laterally onto the fan surface. Headward-eroding gullies are common on the distal fan either as single channels or as a downward-converging network. These gullies may eventually intersect the incised channel which could result in changing the active portion of the fan to another direction. Alluvial fan systems can transition to an alluvial plain and then on to a lacustrine environment. Alluvial plain deposits are typically well sorted, fine to medium-grained sands. Lacustrine deposits are formed by sedimentation in a lake. These deposits are characterized by well-sorted, fine-grained sediments, such as clays and silts, which formed in a low-energy environment. The edges of lacustrine deposits may have alluvial delta or fluvial

deposits.

Potentially significant consequences of the above described depositional environment include:

1. What appear to be homogenous (uniform) and isotropic (similar in all directions) deposits in cross-section may actually be heterogeneous (varied) in nature due to the channel cutting and deposition of higher energy (larger) sediments laid down during higher energy storm events.
2. What appear to be continuous confining layers in cross section such as the CCE and the clay layer that separates the upper Tulare from the deeper Tulare may be riddled with more permeable channel deposits that compromise the layers' integrity, preventing them from serving as effective aquitard.
3. Intersecting the more permeable channel deposits with monitoring wells is difficult without detailed subsurface information. Groundwater typically flows preferentially much faster through channel deposits.

Groundwater Monitoring Networks and Results

The locations of the Valley Water McKittrick 1 & 1-3 Facility groundwater monitoring wells and select Clean Harbors facility groundwater monitoring wells are shown in Attachment G. The monitoring well network does not have any upgradient or up-structure wells

As part of the initial hydrogeologic investigation in 2002, Valley Water installed monitoring wells CYM-19H1 and CYM-17N1 in the upper Tulare and monitoring well CYM-21D1 in the deeper Tulare. The borings for the monitoring wells were drilled using air rotary drilling until groundwater was encountered. At that point, the drilling method was switched to mud rotary.

Analysis of groundwater samples obtained in 2002 contained elevated concentrations of EC, TDS, chloride, and boron. Valley Water's consultant Geomega, Inc., concluded in its September 2003 report titled *Hydrogeologic Characterization Report Valley Waste Disposal Company, Cymric Field Study (Phase I Study)* that produced wastewater from the ponds had infiltrated the upper Tulare at least as far as 0.75 miles from the Facility. The Phase I Study also concluded that groundwater samples from well CYM-21D1 indicated that produced wastewater had not reached groundwater in the deeper Tulare at that point at that time.

In 2006, Valley Water completed monitoring wells CYM-17K1, CYM-17M1, CYM-17Q1, and CYM-19H1 in an unsaturated portion of the upper Tulare down-structure from the wells installed in 2002. The well locations are also shown in Attachment G. These wells were positioned as "sentinel wells" that would indicate whether and when the plume of produced water reached those points in the upper Tulare downgradient from the ponds. Geomega, Inc., submitted an April 2007 report titled *Phase II Hydrogeologic Characterization Report Valley Waste Disposal Company, Cymric Field Study (Phase II Report)* including results from samples obtained in 2006. The Phase II report concluded that produced wastewater was present in the upper

Tulare, but the sentinel wells were dry. Well CYM-21D1, in the deeper Tulare, did not show any indication of a produced wastewater impact at the time of sampling.

Borehole/Monitoring well details are presented in Table 2.

Table 2. *Valley Water McKittrick 1 & 1-3 Groundwater Monitoring Well Information.*

Well	Distance to VWMC ¹ ponds	Well total depth (ft bgs ²)	Surface Elevation (ft AMSL ³)	Screen interval (ft AMSL ³)	Screen interval (ft bgs)	6/27/2017 Water elevation (ft AMSL ³)
CYM-19H1	1,500 feet (0.28 miles)	245	469.2	354-314	115-155	349.5
CYM-17N1	3,300 feet (0.62 miles)	240	451.5	347-287	105-165	326.1
CYM-17M1	4,300 feet (0.81 miles)	197	446.5	292-262	155-185	279.0
CYM-17Q1	5,438 feet (1.03 miles)	208	437.6	278-238	160-200	240.8
CYM-17K1	5,861 feet (1.11 miles)	210	427.9	278-228	150-200	273.2
CYM-21D1	6,700 feet (1.27 miles)	300	427.1	274-294	274-294	149.1

¹ VWMC = Valley Water Management Company

² ft bgs = feet below ground surface

³ AMSL = feet above mean sea level

In September 2010, Valley Water submitted a self-monitoring report titled *Valley Water Waste Disposal Company, 2010 Semi-Annual Sampling and Analysis Report, McKittrick 1 and 1-3 Ponds Cymric Area* prepared on its behalf by Schlumberger Water Services. The report indicates that sentinel wells CYM-17K1, CYM-17M1, CYM-17Q1 contained a significant amount of water, but Valley Water did not sample the wells. Subsequent reports state that sentinel well soundings are provided in field notes, but the reports do not contain field notes.

In February 2015, Valley Water submitted a self-monitoring report titled *Valley Water Management Company, 2014 Second Semi-Annual Sampling and Analysis Report, McKittrick 1 and 1-3 Ponds Cymric Area* prepared by J Schlumberger Water Services and summarizing data collected in November 2014. The report indicates that CYM-17M1 had 26.56 feet of water, CYM-17K1 had 48.99 feet of water, CYM-17Q1 had 6.93 feet of water at the time of sampling demonstrating that produced wastewater was present in the sentinel wells (CYM-17K1, CYM-17M1, CYM-17Q1), and that these wells were hydraulically downgradient from the wells installed in 2002. The report also concluded that there were no indications of a produced water impact on the groundwater monitored by well CYM-21D1 in the deeper Tulare, even though chemical constituent concentrations associated with produced wastewater (e.g., EC, TDS, and chloride) had been increasing in well CYM-21D1 since about 2002, and more significantly since 2010, as shown in Attachment H.

In October 2017, Valley Water submitted a technical report entitled *Valley Water Management Company, Cymric Area Sampling and Analysis Report, First Semi-Annual 2017* (October 2017 Report). The report was prepared by WSP USA on behalf of Valley Water and includes data from Valley Water’s June 2017 monitoring event including sampling results from the Facility ponds and groundwater monitoring wells. Samples from each of the Valley Water wells in the upper Tulare were chemically similar to the produced wastewater in the ponds. Monitoring well CYM-21D1 in the deeper Tulare showed indications of produced water impacts. The report states, “The overall trend of increasing concentrations of chloride, magnesium, sodium, and boron at VWMC Deeper Tulare Sand well CYM-21D1 continued with the June 2017 sampling event with concentrations of chloride of 2,400 mg/L and TDS of 8,500 mg/L. The boron concentration in June 2017 was 22 mg/L. These concentrations are the highest recorded and indicate influence from produced water mixing with native groundwater.” The data submitted in self-monitoring reports by Valley Water also indicate that from 2002 to 2017 the TDS concentrations in CYM-21D1 have increased from about 1,200 mg/L to 8,500 mg/L, and the chloride concentrations have increased from 334 mg/L to 2,400 mg/L. Table 3 summarizes the Valley Water data. As previously mentioned, the TDS and chloride trends are presented in Attachment H. This information along with the increasing water levels in the Valley Water Facility groundwater monitoring wells indicates the mound of produced water emanating from the Facility ponds is continuing to expand. Attachments I.1 and I.2 present the water level trends. The direction of groundwater flow is predominantly to the northeast.

Table 3. *Valley Water McKittrick 1 & 1-3 Facility Groundwater Monitoring Well Water Quality.*

Well ID	Distance from ponds (ft ¹)	No. of results & (date range)	EC (umhos/cm ²)	TDS (mg/L ³)	Boron (mg/L ³)	Chloride (mg/L ³)
CYM-19H1	1,500	15 (2002 – 2017)	15,600 – 19,060	10,500 – 14,000	30 – 41	4,120 – 5,400
CYM-17N1	3,500	15 (2002 – 2017)	10,900 – 24,870	7,450 – 18,000	20 – 76	2,700 – 7,900
CYM-17M1	4,400	5 (2014 – 2017)	24,080 24,430	12,000 – 15,000	41 – 55	5,100 – 5,700
CYM-17Q1	5,300	5 (2014 – 2017)	24,440 – 24,900	13,000 – 16,000	45 - 60	4,900 – 5,900
CYM-17K1	5,900	5 (2014 – 2017)	24,250 – 24,390	16,000 – 18,000	55 - 68	4,200 – 7,200
CYM-21D1	6,850	15 (2002 – 2017)	1,970 – 5,430	1,200 – 8,500	2.5 - 22	334 - 2,400

¹ ft = feet.

² umhos/cm = micromhos per centimeter.

³ mg/L = milligram per liter.

Central Valley Water Board staff have reviewed the self-monitoring reports for the Clean Harbors Class I landfill facility. As described previously, the Clean Harbors facility is about 1.5 miles to the east-northeast, as shown on Attachment B. The Clean Harbors facility is also down structure and down gradient of the McKittrick 1 & 1-3 Facility ponds. In its hydrogeological investigations, Clean Harbors has differentiated three zones that contain groundwater: 1. Perched zone, 2. Intermediate zone, and 3. Lower zone. These zones generally correspond to the Alluvium, upper Tulare, and deeper Tulare.

Valley Water obtained split samples during the June 2017 sampling of the Clean Harbors groundwater monitoring wells. In part, the samples were analyzed for general minerals and stable isotopes of oxygen and hydrogen. Generally, the native groundwater in the Cymric area is enriched in sodium, calcium, and sulfate, likely due to the abundance of gypsum present throughout the sediments of the Tulare formation. In contrast, the produced wastewater discharged to Valley Water's ponds are marine waters from deeper zones that occur with petroleum and, as such, are enriched with sodium and chloride.

Clean Harbors' groundwater monitoring wells MW-148I and MW-102RL are on the upgradient side of the Class I facility (i.e., the side closest to the McKittrick 1 & 1-3 Facility) (Attachment G). MW-48I is screened in the upper Tulare sand and MW-102RL is screened in the deeper Tulare. Groundwater sample analyses from monitoring well MW-148I and MW-102RL indicate that TDS and chloride concentrations in these wells has been increasing from as early as 2007, as shown on Attachments J.1 and J.2. From 2011 to 2017, the TDS in MW-148I has increased from about 2,340 mg/L to 5,400 mg/L, and from 2009 to 2017 the chloride concentration has increased from about 246 mg/L to 1,200 mg/L. From 2013 to 2017, the TDS in MW-102RL has increased from about 3,040 mg/L to 3,900 mg/L, and from 2007 to 2017 the chloride concentration has increased from about 450 mg/L to 740 mg/L. Concentrations of sulfate have been stable. The data suggest that groundwater at the Clean Harbors location has been adversely impacted by produced wastewater and polluted with respect to TDS and chloride.

Stable isotopes of oxygen and hydrogen can be used to differentiate between wastewaters discharged to ponds and native groundwaters, or a combination thereof. The ratios of H^2 to H^1 and O^{18} to O^{16} are measured in each sample and are expressed as parts-per-thousand differences from that of Vienna Standard Mean Ocean Water. They are then plotted with δ^2H on the y-axis and $\delta^{18}O$ on the x-axis, as shown on Attachment K.1 and K.2. The plotted points are compared to the Global Meteoric Water Line or a Local Meteoric Water Line. Native groundwater that has not been significantly evaporated plots below, but near the LMWL, as shown on Attachment K.1 and K.2. Wastewater that has been subject to significant evaporation in ponds plots farther to the right side of the graph, and farther from the LMWL. Mixtures plot in between the two, with those containing more pond water plotting farther to the right than those containing less pond water.

Attachment K.1 and K.2 show results from Clean Harbors MW-170L and Kern County Water Well 23. These wells are below and slightly to the right of the LMWL, and probably do not represent groundwater that has been mixed with any significant volume of produced wastewater from ponds. There are only single sample results for Clean Harbors MW-102RL and MW-149I,

but these wells plot farther from the LMWL indicating possible mixing with produced wastewater from the McKittrick 1 & 1-3 ponds. MW-148I plots still farther to the right of the LMWL. From 2006 to 2017, data for CYM-21D1 shows consistent movement away from the LMWL and towards the data associated with the Valley Water McKittrick 1 & 1-3 Upper Tulare Formation wells CYM-19H1, CYM-17N1, CYM-17K1, CYM-17M1, CYM-17Q1, and CYM-19H1. The quality of groundwater in these wells reflects primarily the quality of produced wastewater discharged to the McKittrick 1 & 1-3 Facility ponds. Isotope data for the produced wastewater from the McKittrick 1 & 1-3 Facility ponds is included in Attachment K.2 for reference. As expected, it is generally farther to the right and away from the LMWL. The isotope results of the groundwater samples CYM-21D1 and from Clean Harbors' wells MW-102RL, MW-148I, and MW-149I show that produced wastewater is mixing with groundwater in the upper and deeper Tulare sands, at least as far down gradient as Clean Harbors. .

The ionic composition of the minerals dissolved in a water (wastewater, unaffected groundwater, or a combination of both) can be used to classify the water based on the dominant dissolved anions (negatively charged) and cations (positively charged). The ionic composition of the water is expressed in milliequivalents per liter (meq/L). A milliequivalent is a measurement of the molar concentration of the ion, normalized by the ionic charge of the ion. The dominant dissolved ion must be greater than 50 percent of the total. For example, water classified as a sodium-bicarbonate-type water contains more than 50 percent of the total cation milliequivalents as sodium and more than 50 percent of the total anion milliequivalents as bicarbonate. If no cation or anion is dominant (greater than 50 percent), the water is classified as mixed and the two most common cations or anions in decreasing order of abundance are used to describe the water type. For example, a water containing 45 percent sodium, 35 percent calcium, and 20 percent magnesium, and 55 percent bicarbonate, 30 percent sulfate, and 15 percent chloride would be classified as a sodium-calcium-bicarbonate-type water. Stiff and Piper diagrams can be used to illustrate the ionic composition of water samples (e.g., wastewater, unaffected groundwater, or a combination of both.) and, with sufficient data, how the composition changes over time.

Stiff diagrams provide a graphical representation of geochemical data and are often used when qualitative comparison of many analyses is needed. A polygonal shape is created by plotting major cation and anion concentrations in milliequivalents on parallel horizontal lines with anions plotted to the right of a vertical zero line and cations plotted to the left.

Stiff diagrams presented on Attachments L.1 – L.4 show recent water quality of the Facility produced wastewater, water quality of wells that appear to be unaffected by the produced wastewater (which is date dependent), and water quality in Valley Water and Clean Harbors groundwater monitoring wells that have been impacted by produced wastewater. The Stiff diagrams indicate that the Valley Water monitoring wells between the Facility ponds and the Clean Harbors groundwater monitoring wells have been affected by produced wastewater when compared to the unaffected water quality. Well CYM-21D1 (Attachment L.4) has shown a steady increase in some cations and anions and primarily sodium and chloride, indicative of increasing impacts over time from produced wastewater. Significant impacts are also appearing in some of the Clean Harbors facility monitoring wells down gradient of the Valley Water groundwater monitoring well network. The primary source of produced wastewater is

discharges from the Facility ponds.

For the attached Piper diagrams, cation and anion concentrations for each of the produced wastewater and groundwater samples have been converted to total meq/L and plotted as percentages of their respective totals in two triangles (Attachments M.1-M.4). The cation and anion relative percentages in each triangle are then projected into a quadrilateral polygon that describes the water type. The attached Piper diagrams provide graphical representations of the major cations and anions for Valley Water's produced wastewater ponds, waters that appear to be unaffected by infiltrated produced wastewater, and waters that have been impacted by produced wastewater over time appear to show a progressive mixing over time between the two types (CYM-21D1).

These diagrams show that the Valley Water produced wastewater is dominated by sodium and chloride (Attachment M.1). Better quality water that appears to be largely unaffected by the produced wastewater is more sulfate-rich, consistent with groundwater typical of the west side of the San Joaquin Valley, and here represented by wells MW-170L, MW-149I, Belridge 16, and CYM-21D [in 2006] on Attachment M.2). Piper diagrams for several wells show mixing of produced wastewater with better quality water (Attachment M.3), or in the case of well CYM-21D1, increasing impacts over time from produced wastewater (Attachment M.4), which clearly shows a shift from a sulfate type water to a chloride type water with time.

Notwithstanding the above, the October 2017 Report concludes that Valley Water's discharges from its McKittrick 1 & 1-3 Facility ponds have not impacted groundwater in Clean Harbors' upgradient monitoring wells and proffers the following arguments:

- Groundwater levels in the Clean Harbors' wells have been decreasing while levels in the Valley Water wells are increasing. The report states, therefore, the wells are not hydraulically connected.
- Boron concentrations have been increasing in the Valley Water monitoring wells and show no trends in Clean Harbors' wells.
- The calculated groundwater flow velocity shows that the produced water constituents could not have reached the Clean Harbors' wells at this time.
- The pH of the water from the Valley Water monitoring well CYM-21D1 is more acidic (6.6 to 6.8) than the groundwater from the nearest Clean Harbors groundwater monitoring wells, which are more alkaline (7.5 to 8.1). The report states, therefore, the wells are not hydraulically connected.

The arguments posited by WSP USA on Valley Water's behalf are not persuasive. Valley Water has provided no evidence of a geologic structure that would impede or isolate the produced wastewater discharged into and from the McKittrick 1 & 1-3 Facility ponds from the Clean Harbors' facility monitoring wells. Further, the Clean Harbors' facility is down structure from and much closer to large areas of irrigated agriculture than the McKittrick 1 & 1-3 Facility ponds. The decrease in the Clean Harbors' groundwater monitoring well water levels is likely due to

increased pumping of groundwater for irrigation during the recent current drought conditions. The increases in the groundwater levels in the Valley Water monitoring wells are probably due to the large volume of percolated produced wastewater that is moving through the formations tapped by the groundwater monitoring wells.

That boron concentrations in samples from the Clean Harbors' groundwater monitoring wells are not increasing is not unexpected. Boron tends to be mobile in sands and gravels, but readily adsorbs to finer grained soils such as silts and clays. Therefore, the boron front of a plume typically moves slower through the subsurface than more conservative constituents, such as chloride. As mentioned, chloride concentrations have been increasing in samples from Clean Harbors' groundwater monitoring wells.

Lastly, the groundwater flow velocity calculation presented in the October 2017 Report assumes a consistent flow gradient, employs a hydraulic conductivity value derived from the analysis of one soil sample, and uses an assumed effective porosity. The report gives no consideration to the heterogeneous nature of the local hydrogeology. For example, produced wastewater that finds its way into a subterranean channel comprised of coarse sand or gravel will travel much faster than calculated.

The pH in CYM-21D1 has ranged from 7.73 to 10.7 pH units. The pH in the Clean Harbors wells historically ranged from 7.5 to 8.1 pH units. The pH range for CYM-21D1 overlaps the pH range reported for the Clean Harbors wells, which contradicts the assertion made in the October 2017 Report.

Downgradient Groundwater Quality and Beneficial Uses

The beneficial uses of groundwater in the Cymric area designated by the Basin Plan are: Municipal and Domestic Supply (MUN), Agricultural Supply (AGR), and Industrial Service Supply (IND). In many instances, the quality of groundwater to the east of the McKittrick 1 & 1-3 Facility ponds is of sufficient quality to meet water quality objectives for MUN, AGR, and IND.

Attachment N shows the locations of select Clean Harbors monitoring wells and existing water supply wells, mostly agricultural wells, downgradient of the McKittrick 1 & 1-3 ponds. As described above, TDS and chloride concentrations in MW-148I and MW-102RL have increased over time. The historical quality in MW-148I was suitable for MUN and AGR. It now appears to be unsuitable for both.

Attachment N shows several agricultural wells operated primarily by Starrh Family Farms, LP (Starrh Farms) to the north of the McKittrick 1 & 1-3 Facility and the Clean Harbors facility. Starrh Farms well Belridge 7 had a TDS of 2,700 mg/L in 2013 when it was last sampled by AMEC, Foster, Wheeler. The sampling notes indicate that at the time of sample collection the well was actively pumping, and presumably irrigating crops. Other agricultural wells in the area have TDS values ranging from 2,300 mg/L to 6,800 mg/L. The agricultural well closest to the Valley Water Facility had a TDS of 18,000 mg/L. The better quality wells contain TDS and chloride concentrations that do not require dilution prior to use on salt-tolerant crops. The wells

with higher TDS concentrations can be blended with higher quality surface water to irrigate a variety of crops. On 26 January 2018, Starrh Farms communicated to Board staff that these wells are very important to its operations when surface water allocations are short.

Attachment N also shows TDS concentrations for many agricultural wells to the east of the McKittrick 1 & 1-3 Facility and Clean Harbors. The TDS values for these wells range from 391 mg/L to 5,952 mg/L. Data for these wells is old but do demonstrate that high quality groundwater has existed, and presumably exists today, down gradient of the McKittrick 1 & 1-3 Facility.

Additional Groundwater Monitoring Well Installation Work Plan

On November 2014, Kennedy/Jenks Consultants and Schlumberger Water Services, on behalf of Valley Water submitted a report titled, *Monitoring Well Installation Work Plan for the McKittrick Ponds, Cymric Oil Field, California* (Work Plan). Kennedy/Jenks then met with Board staff on 6 January 2015 to discuss the Work Plan. On January 2015, Kennedy/Jenks submitted a proposed modification to the Work Plan. The Work Plan proposed to drill three to four borings and install at least two, and possibly four monitoring wells to further characterize the vadose zone and groundwater. The work plan proposed to drill in two phases. In the first phase, two wells would be drilled "soon" (CYM-19H2 and CYM-21D2) and two borings (CYM-17H1 and CYM-17H2) would be drilled later because they were proposed in an area of protected species habitat. CYM-19H2 would be installed as a deep groundwater monitoring well. CYM-21D2 would be installed as a shallow monitoring well or if water was not encountered, as a sentinel well. If groundwater quality changed in the CYM-21D1 well (CYM-21D1 is now impacted), then CYM-17H2 would be installed as a deep groundwater monitoring well.

On January 2015, Board staff issued a letter to Valley Water generally concurring with the Work Plan. Staff requested a second monitoring be installed above the Upper Tulare Clay, and that CYM-17H1 be installed.

As of January 2018, Valley Water has not implemented the proposed work plan.

On April 2016, Valley Water submitted a report titled *Biological Report for the Valley Water Management Cymric Water Monitoring Well Project* (Biological Report). The Biological Report concluded that well 17H1 and well 17H2 could be installed but that the other proposed wells were in endangered species habitat. It also stated that there is enough room near a Clean Harbors monitoring well location for a drilling rig. Further, the Biological Report stated, "As for the other monitoring wells that were proposed near the McKittrick pond facility, it appears that we will have to obtain a "take" in permit prior to the installation of those wells. A "take" permit currently requires at least six months and more likely one year to obtain a permit."

As of January 2018, Valley Water has not provided an update on whether it sought or acquired a "take" permit (or whether one was denied) for the installation of CYM-19H2 and CYM-21D2 monitoring wells, nor if the 17H1 and well 17H2 wells have been installed.

Groundwater Monitoring Conclusions

Several lines of evidence, including but not limited to, increasing water levels in Valley Water's groundwater wells, increasing concentrations of TDS and chloride in Valley Water's CYM-21D1 and Clean Harbors' MW-148I and MW-102RL groundwater monitoring wells, and isotope data support the conclusion produced wastewater from the Valley Water McKittrick 1 & 1-3 ponds has migrated and continues to migrate down-structure through the previously unsaturated sediments of the upper Tulare and has also impacted groundwater quality in the regional aquifer in the deeper Tulare.

Existing information indicates the waste constituents have migrated at least 2.2 miles (well MW-148I) down gradient from the Facility in the upper Tulare and 1.9 miles (well MW-102RL) down gradient in the deeper Tulare, which is generally thought to be connected to the regional aquifer. Water Board staff believe the discharge is adversely affecting, to the point of pollution groundwater, that has designated beneficial uses of MUN, AGR, and IND, and existing beneficial uses of AGR. Valley Water has only completed one monitoring well in the deeper Tulare making it difficult to adequately assess aquifer characteristics and the dynamics of the wastewater plume. The information also demonstrates that the Alluvium, upper Tulare, and deeper Tulare units are hydraulically connected. Given the nature of the local depositional environment, the existing groundwater monitoring well network is not sufficient to characterize the downgradient extent of the produced wastewater plume. The heterogeneity inherent in alluvial/fluvial systems produces preferential pathways through the sediment that are difficult to capture with a handful of sampling points spread over four or five square miles. Staff believes there is a good chance that produced wastewater traveling through channels of coarse grained materials has migrated far beyond the Clean Harbors facility, but it has not been detected due to limitations associated with the existing groundwater monitoring network.

Additional hydrogeologic investigation and expansion of the groundwater monitoring well network is needed to collect more data on groundwater movement and aquifer characteristics. Also, a regulated monitoring program is required to ensure consistency in reporting and data quality. A thorough evaluation of the aquifer systems east of the Valley Water ponds is needed to fully understand the extent and dynamics of the percolated wastewater plume.

MONITORING AND REPORTING PROGRAM (MRP) R5-2017-0806 AND PROPOSED MRP

Central Valley Water Board staff prepared a draft Monitoring and Reporting Program for the Facility and made it available, as a courtesy, to Valley Water on 3 October 2016. Valley Water submitted comments on the draft MRP on 26 October 2016 and Monitoring and Reporting Program No. R5-2017-0806 was issued 26 June 2017 under authority delegated to the Executive Officer by the Board.

The intent, in part, of the MRP was to compel Valley Water to fully characterize its discharge to the McKittrick 1 & 1-3 Facility and fully delineate the plume of wastewater migrating from beneath its ponds. Additionally, the intent was also to ensure that the Board had an enforceable

mechanism in place to ensure the timely submittal of quality self-monitoring reports. As mentioned earlier, submitted reports sometimes were missing materials referenced therein.

On 5 July 2017, Valley Water submitted a request to rescind the MRP (Attachment O). The rescission request made the following points:

1. Since MRPs are intended to be a part of WDRs, it should be subjected to public notice and comment periods for WDRs described under Water Code section 13167.(a)(1);
2. Since the MRPs are intended to be a part of WDRs, issuance of MRPs cannot be delegated to the Executive Officer; and
3. Staff had not provided an explanation with respect to Water Code section 13267(b)(1) which states in part "The burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the reports."

The rescission request also Valley Water's interest to discuss potential regulatory coverage for the Facility by one of the General Orders for Oil field Discharges to Land. On 1 September 2017, the Executive Officer rescinded MRP R5-2017-0806 and notified Valley Water that a revised MRP would be prepared for Board consideration.

Water Code section 13267 authorizes the Central Valley Water Board to require monitoring and technical reports as necessary to investigate the impact of a waste discharge on waters of the State. This authority is independent of Water Code section 13263, which provides the Board the authority to issue WDRs. Water Code section 13167.5(a)(1) specifically cites the types of orders to which a 30-day public notice and comment period are required and monitoring and reporting programs issued pursuant to Water Code section 13267 is not cited.

The proposed MRP Order includes Facility inspections, maintenance requirements, effluent monitoring, and groundwater monitoring. The MRP would require Valley Water to report on the quantity and quality of produced wastewater before it is discharged to the ponds, the quality of produced wastewater while it resides in the ponds, and the quality of monitoring well water.

The MRP would require Valley Water to install additional monitoring wells to delineate the vertical and lateral extent of the produced wastewater plume to help to ensure the protection of designated beneficial uses of groundwater.

The MRP requires wastes (solids, liquid, and semi-solids) and groundwater to be analyzed for a wide range of constituents that are defined in MRP Table 1. Monitoring reports would be required to include full laboratory reports.

Some of the more important MRP requirements are outlined below:

- The submittal of information regarding the use of all chemicals used during well drilling, installation, operation, and maintenance activities associated with each well generating waste materials (liquids and solids) that are discharged to the McKittrick 1 & 1-3 Facility ponds.

- The submittal of a Monitoring Well Installation and Sampling Plan (MWISP) within 60 days of MRP issuance. The MWISP would provide for the installation of an appropriate number of upgradient/up-structure dip groundwater monitoring wells to identify background water quality and an appropriate number of downgradient/down-structure and cross gradient/cross-structure dip wells to delineate the plume of produced wastewater emanating from the Facility ponds in both the shallow and deep groundwater zones.
- The submittal of a Monitoring Well Installation Completion Report (MWICR) within 90 days of installation of a groundwater monitoring well(s).
- The submittal of Quarterly monitoring reports whether or not there is a discharge.

The MRP issued on 26 June 2017, and the MRP now proposed, are very similar to those in General Order Number One and General Order Number Two. With respect to Water Code section 13267(b)(1) requirements, Valley Water owns and operates the Facility. Facility discharges have migrated and continue to migrate to the east and are adversely affecting groundwater in the regional aquifer, which is designated for MUN, AGR, and IND, and is used nearby for AGR. The monitoring requirements contained in the MRP are necessary to fully characterize the discharge and the lateral and vertical extent of the groundwater plume emanating from the Facility and inform an effective strategy to protect water quality. The related costs are similar to those carried by other dischargers under General Order Number One and General Order Number Two and are reasonable considering the magnitude of known and potentially ongoing impacts to water quality.

PROPOSED RESOLUTION

In addition to the proposed MRP, staff has prepared a resolution seeking guidance from the Central Valley Water Board on how to regulate the Facility given Valley Water's request to have the McKittrick 1 & 1-3 Facility discharges covered under General Order Number Three. General Order Number Three does not require groundwater monitoring, and as shown, the Facility is responsible for an undefined plume of produced wastewater that is migrating northeast polluting groundwater with both designated and existing beneficial uses.

The following options are apparent:

1. Enroll the Facility under one of the General Orders for oil field discharges to land,
2. Prepare a order to compel Valley Water to bring discharges from its McKittrick 1 & 1-3 Facility into compliance with Resolution No. 69-199 or to cease discharge,
3. Require Valley Water to submit a report of waste discharge to receive an updated set of individual waste discharge requirements (This option would probably also require a schedule to come into compliance or cease discharge.).

Option 1

Valley Water has asked in meetings to have the discharges from the McKittrick 1 & 1-3 Facility covered under General Order Three, which does not require groundwater monitoring. The primary reason expressed is that implementing the MRP for General Order Number Three is less expensive because it does not require groundwater monitoring.

Board staff does not believe coverage under any of the General Orders is appropriate for the following reasons:

1. General Order Number One requires discharges to comply with the Basin Plan effluent limits for EC, chloride, and boron. As described earlier, Valley Water's discharges greatly exceed these limits and, therefore, cannot comply with them.
2. General Order Number Two requires discharges to comply with the State Anti-degradation Policy. As Valley Water's discharge comingles with better quality groundwater down gradient, given its high salinity, it will caused degradation, and likely pollution. Therefore, the discharge cannot comply with General Order Number Two.
3. General Order Three requires dischargers to either demonstrate that there is no groundwater beneath the discharge areas and that produced wastewater and constituents associated with other approved wastes discharged will not migrate into areas that there is groundwater with designated beneficial uses, or if there is first encountered groundwater underlying the discharge location, demonstrate that the current Basin Plan groundwater beneficial uses are eligible for de-designation. There is first encountered groundwater underlying the Facility and within the influence of the Facility discharges; however, in Board staff's opinion the beneficial uses likely are not eligible for de-designation because locally the quality of this groundwater is suitable for its designated beneficial uses and groundwater is beneficially used within a short distance from the Facility. Valley Water's monitoring reports indicate that its discharges are likely polluting groundwater in the regional aquifer (CYM-21D1 and MW-148I), which has an active beneficial use of AGR. Additionally, the produced wastewater has migrated to the east and beyond the Facility groundwater monitoring well network. To date, the extent of plume migration has not been fully characterized, but given the local hydrogeology, it is expected to remain uncontained and continue to migrate eastward. Therefore, the discharge likely cannot comply with General Order Number Three.

Option 2

Another option would be for Board staff to prepare for Board consideration an Order that provides Valley Water a time schedule to come into compliance with Waste Discharge Requirements Resolution No. 69-199 (Resolution). The Resolution issued to Valley Water states:

1. The discharge shall not cause a pollution of ground or surface waters.

Under the Explanation of Requirements section of the resolution, it states:

1. The Discharge shall not cause a pollution of ground or surface waters.

Pollution means an impairment of the quality of waters of the state by sewage or other waste to a degree which does not create an actual hazard to the public health, but which does adversely and unreasonably affect such waters for domestic, industrial, agricultural, navigational, recreational, or other beneficial use.

As described above, data indicate that the produced wastewater migrating from the McKittrick 1 & 1-3 Facility ponds is polluting or threatening to pollute downgradient groundwater.

Water Code section 13300 states:

Whenever a regional board finds that a discharge of waste is taking place or threatening to take place that violates or will violate requirements prescribed by the regional board, or the state board, or that the waste collection, treatment, or disposal facilities of a discharger are approaching capacity, the board may require the discharger to submit for approval of the board, with such modifications as it may deem necessary, a detailed time schedule of specific actions the discharger shall take in order to correct or prevent a violation of requirements.

Water Code section 13301 states:

When a regional board finds that a discharge of waste is taking place, or threatening to take place, in violation of requirements or discharge prohibitions prescribed by the regional board or the state board, the board may issue an order to cease and desist and direct that those persons not complying with the requirements or discharge prohibitions (a) comply forthwith, (b) comply in accordance with a time schedule set by the board, or (c) in the event of a threatened violation, take appropriate remedial or preventive action. In the event of an existing or threatened violation of waste discharge requirements in the operation of a community sewer system, cease and desist orders may restrict or prohibit the volume, type, or concentration of waste that might be added to that system by dischargers who did not discharge into the system prior to the issuance of the cease and desist order. Cease and desist orders may be issued directly by a board, after notice and hearing.

Given the hydrogeology of the Facility site and surrounding area, the large volume of highly saline water that has been, and continues to be, released into underlying aquifers; and the existing beneficial uses of groundwater just to the northeast of the Facility, the preparation for Board consideration of a compliance schedule under Water Code section 13300 (Time Schedule Order) or 13301 (Cease and Desist Order) could be appropriate.

Option 3

Another option would be for Board staff to require Valley Water to submit a report of waste discharge supporting an updated set of individual waste discharge requirements (WDRs) pursuant to Water Code Section 13263. Given the nature of the discharge and Facility, Valley Water's discharges at the Facility would not likely be able to comply with updated WDRs, so a compliance schedule similar to that discussed for Option 2 would likely be necessary.

Other Valley Water Facilities

Valley Water operates or has operated three other nearby facilities (McKittrick 1-1 facility, McKittrick 6, 6A, & 6B facility; and the McKittrick 7 facility), as shown on Attachment P. The McKittrick 1-1 facility is active. Central Valley Water Board records indicate a flow of about 96,000 bbls/day in 2015. The average of flow is about 22,500 bbls/day. The McKittrick 6, 6A, and 6B facility and the McKittrick 7 facility have been inactive since 2014. Prior to the cessation of discharge, average flows of 90,000 bbls/day and 29,000 bbl/day, respectively were documented for these facilities. Current and historic subsurface discharges from these facilities could potentially be adding to the plume associated with the McKittrick 1 and 1-3 Facility. The Central Valley Water Board's direction regarding the proposed MRP and the proposed Resolution will inform Board staff on how to proceed with these facilities and others like them.

CONCLUSIONS AND RECOMMENDATIONS

Valley Water's McKittrick 1 & 1-3 Facility ponds are the source of a plume of very saline produced wastewater that exceeds for several constituents water quality objectives necessary to support locally designated beneficial uses of MUN, AGR, and IND. AGR is an existing beneficial use in the area. Staff believes the plume has migrated beyond Valley Water's groundwater monitoring well network and downgradient and down-structure at least 2.2 miles (well MW-148I) in the upper Tulare sand and 1.9 miles (well MW-102RL) in the deeper Tulare sand. The plume has caused the water in MW-148I to exceed MUN and AGR water quality objectives for TDS and chloride and water in MW-102RL to exceed MUN water quality objectives for chloride. These wells are screened in aquifers that supply local agricultural wells a short distance from the Facility. The plume threatens to impair the existing beneficial uses of these local wells.

The nature of the local depositional environment indicates that it is likely that the Alluvium, the upper Tulare sand, and the deeper Tulare sand contain stringers of coarser channel deposits that allow the preferential migration of produced wastewater down gradient and down structure. The heterogeneity inherent in these alluvial/fluvial systems makes it difficult to capture these deposits with a handful of sampling points spread over four or five square miles. Staff believes there is a good chance that produced wastewater traveling through channels of coarse grained materials has migrated from the Valley Water Facility far beyond the Clean Harbors facility, but it has not been detected due to limitations associated with the existing groundwater monitoring network.

Board staff believe the proposed monitoring and reporting program is necessary to fully characterize the discharge and ensure the completion of additional hydrogeologic investigation and expansion of the groundwater monitoring well network to fully define the lateral and vertical extent of the Facility plume and recommend adoption by the Board.

Valley Water has requested coverage under General Order Number Three. Given the Facility location, geographically and geologically, relative to groundwater with an existing AGR beneficial use, the nature of the depositional environment, and the unknown expanse of the

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plume migrating to the northeast, Board staff do not believe the Facility discharge meets the requirements to be regulated under the General Orders for Oil Field Discharges to Land. Therefore, Board staff has proposed for Board consideration a Resolution soliciting Board direction on how to best bring discharges from the Facility into compliance with existing or updated waste discharge requirements.