APPENDIX H

Corrosivity Assessment

[PAGE LEFT INTENTIONALLY BLANK]

February 26, 2019

Paige Russell P.E.
Brown and Caldwell
9665 Chesapeake Drive, Suite 201
San Diego, CA 92123

SUBJECT: EMWD EUCALYPTUS BOOSTER PUMP STATION SITE CORROSIVITY ASSESSMENT

RFYeager Engineering Project No.: 16073

Dear Ms. Russell:

RFYeager Engineering has conducted a site corrosivity assessment for the Eastern Municipal Water District's (District) Eucalyptus Booster Pump Station Project (Project) located in Moreno Valley, California. Brown and Caldwell contracted RFYeager Engineering to conduct a corrosivity assessment at the proposed booster pump station (BPS) Project site to determine the relative corrosivity of the soils and to assess the potential for premature corrosion on buried metallic yard piping. It is our understanding that the preliminary materials of construction for the buried metallic yard piping associated with the Project is cement mortar lined and coated (CML&C) steel pipe. Accordingly, the corrosion control findings and recommendations made in this corrosivity assessment letter report consider pipe material, coating options, and available corrosion control methods. These methods include electrical isolation from other utilities, pipeline continuity, and the installation of corrosion monitoring test stations.

Project Description

The new Eucalyptus BPS will be located on the south side of Eucalyptus Avenue approximately 1,300 feet west of Moreno Beach Drive in Moreno Valley. It is our understanding that the Project design includes the construction of a new reinforced concrete block booster pump station building that will contain four (4) vertical turbine pumps, emergency power generator and associated yard piping. The yard piping consists of a proposed 20-inch discharge header, 30-inch suction header and 14-inch

1016 Broadway, Suite 1016 El Cajon California 92020 Ph:760.715.2358 Fx:619.561.0031 RGeving@RFYeager.com

bypass. The proposed material for all of the new piping is cement mortar lined and coated (CML&C) steel pipe.

Scope

RFYeager Engineering conducted a corrosivity assessment of the proposed Project site and yard piping alignment to determine the aggressiveness of the soil and to assess the affect it may have on the associated underground metallic structures. The corrosivity assessment included: a visual inspection of the project site topography; field resistivity testing; a review of the Project geotechnical report including soil sample chemical analysis data; an assessment of the potential for stray current interference; and recommendations for corrosion control. The soil sample was tested for minimum soil resistivity, pH, water soluble chloride concentration, and water soluble sulfate concentration.

Conclusions, Observations, and Recommendations

The following are significant conclusions, observations, and recommendations resulting from this evaluation:

Conclusions and Observations

1. The in-situ field resistivity test data indicate that soils at the Project site should be considered as relatively non-aggressive to buried ferrous pipe (see Table 1). The readings indicate conditions ranging from “moderately corrosive” to “slightly corrosive”. All of the in-situ test readings are above 5,000 ohm-cm.

2. Geotechnical soil borings found that the Project site consists primarily of undocumented fill, underlain by alluvium. The subsurface excavation had a maximum depth of 41.5 feet. Granitic bedrock was encountered beneath the alluvial soils at 23 to 31 feet below the ground level surface. Groundwater was not encountered during the geotechnical investigation. These site conditions are not considered to be aggressive.

3. One soil sample was collected from the project site and subjected to laboratory tests. The water soluble chloride and sulfate concentrations for the soil sample are considered to be relatively low and representative of non-corrosive soil. Additionally, the pH reading of the soil sample indicates a slightly alkaline soils condition.

4. RFYeager Engineering’s contacted pipeline operators in the area including Southern

California Gas Company (SoCal Gas) and Questar Gas. One cathodic protection rectifier was identified within one mile of the project site. Based upon the proximity of this rectifier, there is a possibility that the impressed current cathodic protection system will cause a stray current interference condition on the new Project yard piping.

5. Since the soil conditions are relatively non-aggressive, dielectric coatings and cathodic protection is not recommended for the Project buried yard piping. However, standard corrosion control measures are warranted for long-term, corrosion-free service and to preserve future corrosion control options.

Recommendations

The following recommendations apply the new steel underground piping at the Project site.

1. Provide all steel underground piping with a high quality mortar coating per AWWA C-205 standards. Cathodic protection is not recommended for these new structures.

2. Electrically isolate the new buried yard piping from other pipelines at the tie-in points. This will require the use of flange isolation kits if the new piping is to tie into existing metallic pipelines. All buried flange isolation kits shall have a 4-wire test station and be wax tape coated. Note that no insulators are required at tie-in points to non-metallic piping.

3. Provide all steel air/vac and blow-off piping with the same coating system as the new buried yard piping. The steel air/vac and blow-off piping must be fully continuous along their length and fully continuous with the yard piping. Electrically isolate copper air/vac or blow-off piping from the steel yard piping with insulating bushings, insulated couplings, etc. Do not wrap copper tubing. Protect buried copper piping by fully encasing them in a clean sand backfill.

4. Provide corrosion monitoring test stations, joint bonds (for inline valves, flanges, couplings, adapters, etc.), pipe joint bonds (for non-welded pipe joints), insulators, and attendant wiring. The number and location of corrosion control facilities shall be provided during the design phase of the project.

5. Provide full time inspection for field-applied coatings at all pipe joints, for insulating flange kit installations, and for coatings on all in-line appurtenances.

6. Provide all non-coated buried valves, flanges, couplings, adapters, and bare sections of pipe with a 3-part wax tape coating system per AWWA C-217. Additionally, all buried insulating flanges shall be wax tape coated. No bare metallic surfaces shall be in direct contact with the soil.

7. Electrically isolate any electrical grounding systems such as motorized valves, electrical flow meters, and telemetry units from buried steel piping.

8. The initial potential survey should include testing to determine the level of DC interference (if any) on the new yard piping due to the nearby foreign rectifiers.

9. The corrosion monitoring system should be inspected and tested by a qualified Corrosion Engineer. The testing should include native pipe-to-soil potentials, test lead resistance measurements, insulating flange inspections, and pipeline continuity testing through all mechanical joints, valves, couplings, adapters, flanges, and non-welded pipe joints. All test data should be provided to the owner before the project is considered complete.

Discussion

Corrosive Soil Criteria

External corrosion of buried ferrous structures is dependent upon many factors. Some of these factors include temperature, pH, soil resistivity, soluble ion concentrations, moisture content, and the amount of free oxygen in the soil to allow for the oxidation (corrosion) reaction to occur. The combination of these factors can lead to extreme variations in corrosion attack. However, some general rules can be assumed. Soils with high moisture content, high electrical conductivity (inversely low resistivity), high acidity (low pH), and high levels of soluble ions (dissolved salts) typically will be the most corrosive to buried ferrous metals.

Chlorides are the most aggressive of common soil salts. Soils with chloride concentrations above 300 ppm (0.030%) are considered corrosive to buried or concrete embedded steel. Additionally, soils with low pH (below 5.5) and high sulfate concentrations (above 1000 ppm or 0.10%) may be considered detrimental to mortar or concrete in contact with the soil.

Soil Resistivity

Soil resistivity is one common indicator in which to determine soil corrosivity. Corrosion is an electrochemical process that deteriorates a substance, or its properties, due to a reaction with its environment. In corrosive soils, the reaction of the metal to its environment is high, and metal loss occurs. Soil resistivity is not the only measure of soil corrosivity, nor is it completely sufficient, but it is a strong indicator and should be given the most weight when assessing site corrosivity. A low soil resistivity indicates the potential for high local currents between anodic and cathodic areas on the metal surface, whereas high resistivity soils would reduce the potential for current flow between anodic and cathodic sites.

One method to determine in-situ soil resistivities is by using the Wenner 4-Pin Method. The Wenner 4-pin Method provides an average resistivity of a hemisphere of soil (essentially) whose diameter is approximately equal to the pin spacing. For example, the resistivity value obtained with the pins spaced at 5 feet apart is the average resistivity of a hemisphere of soil from the surface to a depth of 5 feet. By taking readings at different pin spacings (or depths), average soil resistivity conditions can be obtained within areas at, above, and below trench zones.

Soil resistivity measurements were taken at four separate test locations at the Project site (see Figure 1 at end of report). The Soil Resistivity test data and the Frequency Distribution of the test data for the site are found in Table 1 and Table 2.

Table 1

EMWD – Eucalyptus Booster Pump Station Soil Resistivity Data Prepared by: RFYeager Engineering Test Date: 02.20.2019						
Test Site[1]		**Soil Resistivity (Ohm-cm)** **Ave. Soil Depth (feet)**				
Test No.	**Location**	**20**	**15**	**10**	**5**	**2.5**
1	Location 1	14631	12495	10475	7813	6434
2	Location 2	11413	9623	9096	7066	5697
3	Location 3	14516	12696	10150	7124	6664
4	Location 4	18537	16775	13903	8053	5343

1 – See Figure 1

EMWD – Eucalyptus Booster Pump Station **Frequency Distribution of Soil Resistivity Data** Prepared by: RFYeager Engineering Test Date: 02.20.2019				
Resistivity Range (ohm-cm)	Corrosivity Classification	No. of readings within range	% of Total	Cumulative % of Total
0 - 1000	Very Corrosive	0	0.0	0.0
1001 - 2000	Corrosive	0	0.0	0.0
2001 - 5000	Fairly Corrosive	0	0.0	0.0
5001 - 12000	Moderately Corrosive	13	65.0	65.0
12001 - 30000	Slightly Corrosive	7	35.0	100.0
Above 30000	Negligible	0	0.0	100.0
	Total No. of Readings	20		

It can be seen from Tables 1 and 2 above that all of the soil resistivity readings are above 5,000 ohm-cm and that the majority of the readings are in the Moderately Corrosive Soil Classification.

Barnes Layer Analysis of Soil Resistivity

The field soil resistivity test data can be analyzed further by using the Barnes method for soil resistivity layer analysis. With this method, the average soil resistance for a given layer of soil can be found using the equation $R_{Layer} = \{1/ [1/R_n - 1/R_{n-1}]\}$. For example, the average resistance of a layer of soil between 5 feet and 10 feet would be {1/ [1/ (the resistance of soil between zero and 10 feet) – 1/ (the resistance of soil between zero and 5 feet)]. The Barnes Layer Analysis of the Project Soil resistivity test data are found in Table 3 on the next page. The frequency distribution of the Barnes Layer resistivities is listed by layer in Table 4.

1016 Broadway, Suite 1016 El Cajon California 92020 Ph:760.715.2358 Fx:619.561.0031 RGeving@RFYeager.com

Table 3

EMWD – Eucalyptus Booster Pump Station Soil Resistivity Data - Barnes Layer Analysis Prepared by: RFYeager Engineering Test Date: 02.20.2019						
	Test Site	**Soil Resistivity (Ohm-cm) Soil Layer (feet)**				
Test No.	**Location[1]**	**20 - 15**	**15 - 10**	**10 - 5**	**5 - 2.5**	**2.5 - 0**
1	Location 1	30020	20342	15888	9944	6434
2	Location 2	25834	10883	12762	9302	5697
3	Location 3	25460	25489	17643	7651	6664
4	Location 4	27064	28589	50836	16339	5343

1 – See Figure 1

Table 4

EMWD – Eucalyptus Booster Pump Station Frequency Distribution of Barnes Layer Resistivity Data Prepared by: RFYeager Engineering Test Date: 02.20.2019				
Resistivity Range (ohm-cm)	Corrosivity Classification	No. of readings within range	% of Total	Cumulative % of Total
0 - 1000	Very Corrosive	0	0.0	0.0
1001 - 2000	Corrosive	0	0.0	0.0
2001 - 5000	Fairly Corrosive	0	0.0	0.0
5001 - 12000	Moderately Corrosive	8	40.0	40.0
12001 - 30000	Slightly Corrosive	10	50.0	90.0
Above 30000	Negligible	2	10.0	100.0
	Total No. of Readings	20		

The Barnes Layer Soil Resistivity Data found in Tables 3 and 4 above indicate that the corrosivity of the various layers is relatively consistent with the general resistivity data.

In general, the Wenner 4-pin results indicate relatively non-aggressive soil conditions. Typically, a ferrous pipeline is not considered to be at a significant risk of premature corrosion failure until the majority of the soil resistivity readings are less than 2000 ohm-cm. Based upon these test results, cathodic protection measures are not justified.

Soil Chemical Analysis

One soil sample was taken from excavations at the Project site. The soil sample was tested for chloride concentration, sulfate concentration, pH, and soil box resistivity in the saturated condition (minimum soil box resistivity). The soil chemical analysis data for the tests conducted on each sample are shown in Table 5 below:

Table 5

EMWD – Eucalyptus Booster Pump Station Soil Chemical Analysis Data[1] Prepared by: RFYeager Engineering				
Test Pit No. (Depth)	**Min. Soil Box Resistivity - CalTest 643 (ohm-cm)**	**Chloride Concentration - CalTest 422 (ppm)**	**Sulfate Concentration - CalTest 417 (ppm)**	**pH CalTest 643**
B-4 @ 0-1.5 ft	3886	36	45	7.7

1 – Provided by Kleinfelder (see report submitted December 2017)

Overall, the soil data are indicative of relatively non-aggressive soils. The soluble salt concentrations are relatively low and the pH readings indicate neutral conditions. The minimum soil box resistivity was measured within the “Fairly Corrosive” classification.

Stray Current Interference

Stray current interference may also cause premature corrosion to occur on metallic structures. Metallic structures, which are exposed to DC potential earth gradients, can pick up a significant magnitude of interference current. Cathodic protection rectifiers are one of the most common sources of DC earth gradients and stray current interference. Other sources of stray current interference include high-voltage overhead power lines, transit systems, welding shops, and other industrial and manufacturing areas.

RFYeager Engineering contacted local pipeline operators including SoCal Gas and Questar Gas. One (1) cathodic protection rectifier, operated by Questar, was found within one mile of the project site on Moreno Beach Dr. The output of the rectifier is shown below in Table 5. Given the moderate current output level of the Questar rectifier, there is a slight risk that this foreign CP system will produce a stray current interference condition on the project yard piping. For this reason, it is recommended that the initial potential survey of the new yard piping include interference testing to determine the extent of influence from this rectifier.

Table 5

Rectifiers Within One Mile of Eucalyptus Booster Pump Station Project Prepared by: RFYeager Engineering				
Owner/Operator	Rectifier ID	Voltage	Current	Location
Questar Gas	90-25	70	13.28	Moreno Beach Blvd.

Buried Piping Corrosion Control Considerations

The proposed materials of construction for the Eucalyptus BPS yard piping is CML&C. This material is an appropriate choice based on the Project site corrosivity conditions. Long-term, corrosion-free performance of steel piping is often achieved in low to moderately corrosive soils with the use of a high quality mortar coating and without the application of cathodic protection. The highly alkaline environment that the mortar provides at the steel surface passivates the steel such that little or no corrosion occurs.

In order to ensure that the protective levels on the buried piping are maintained, it is important that a monitoring program be implemented shortly after the Project is complete. Only through routine monitoring and assessment of the data, can any changes in the site corrosivity be identified. Pipe-to-soil potentials should be monitored just after initial installation, after six months of operation and then at one year intervals. Potential survey results should be evaluated by a qualified corrosion engineer.

Thank you for this opportunity to provide these corrosion engineering services. Please call if you have any questions.

With best regards,

Randy J. Geving, PE
Registered Professional Engineer – Corrosion No.1060
RGeving@RFyeager.com, 760.715.2358

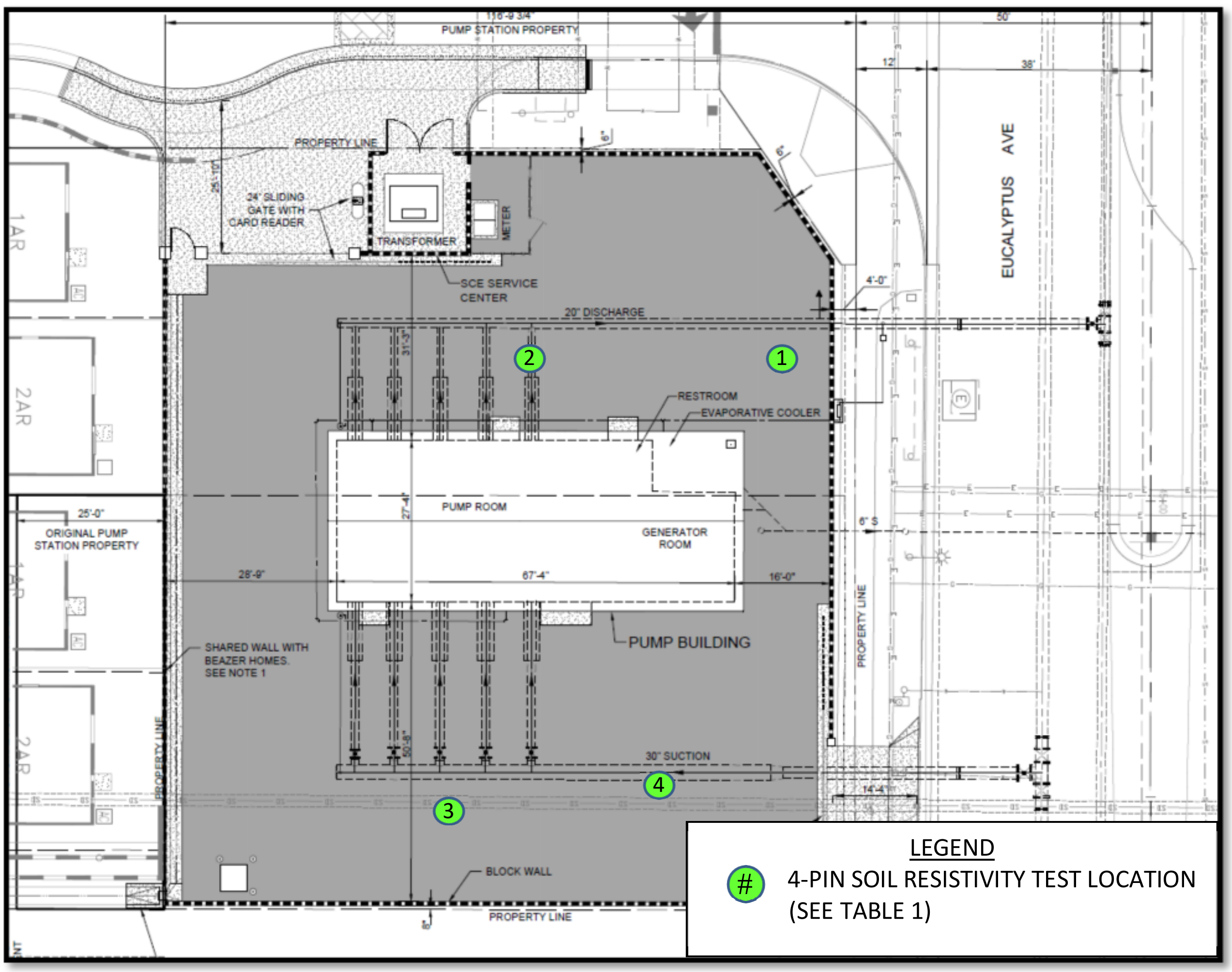

Figure 1 – BP Site Test Locations