Technical Memorandum

TO: Oxnard-Hueneme (O-H) Pipeline Customers

FROM: Robert Richardson, UWCD

SUBJECT: Cost Benefit Analysis of Low-Flow Bypassing of Proposed Iron and Manganese Treatment Plant

DATE: August 24, 2016

CC: Tony Emmert, Deputy General Manager
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Purpose and Background:

At an O-H Pipeline User Meeting held on August 16, 2016, a question was raised regarding a bypass operation strategy for the proposed iron and manganese treatment plant that would balance an acceptable plant effluent water quality with operation costs. In particular, the question centered around partial treatment and partial bypassing of Lower Aquifer System (LAS) well water that is blended with Upper Aquifer System (UAS) well water. This Technical Memorandum (TM) provides an evaluation of this approach which shall supplement the Feasibility Assessment TM of Iron and Manganese Removal Facilities that was issued to all O-H Pipeline Users on August 11, 2016.

Discussion:

In order to evaluate this bypass operation strategy, a new blending scenario must be defined. In the previous Feasibility Assessment TM, a total of eight (8) different blending scenarios were evaluated to establish the design criteria for iron and manganese treatment. After evaluation of all eight blending scenarios, it was determined that operating one LAS well through iron and manganese treatment provided the most benefit in terms of plant effluent water quality at a lower capital and operating cost than treatment for two LAS wells. Three (3) new blending scenarios have been added for the purposes of this evaluation (see attached **Table 1**). The following two (2) blending scenarios will be used as a baseline for comparison purposes:

- "Scenario 3" – Operation of one LAS well using a variable frequency drive (VFD) at 75% speed, 24 hours per day, 365 days per year. In this scenario, the VFD is capable of limiting the LAS well's flow feeding the iron and manganese treatment system to 75% of the total well capacity. The remaining 25% of the total well capacity is not used. If more iron and manganese treatment is needed, VFD speed can be increased. If less iron and manganese treatment is needed, VFD speed can be decreased.
- "Scenario 10" – Operation of one LAS well using a soft start drive at 100% speed, 24 hours per day, 365 days per year. In this scenario, a control valve is used to bifurcate 75% of the flow to iron and manganese treatment and 25% of the flow for direct blending. If more iron and manganese

treatment is needed, bypass flows can be reduced. If less iron and manganese treatment is needed, bypass flows can be increased.

In both Scenarios 3 and 10, it is assumed that the total demand for the O-H Pipeline water is 14,086 ac-ft per year. Also in both scenarios, an identical flow of 1,875 gpm goes through iron and manganese treatment. The primary difference is that in Scenario 3, all of the flow from the LAS well goes through iron and manganese treatment. In Scenario 10, an extra 625 gpm is produced by the LAS well which bypasses iron and manganese treatment and is blended directly with UAS well water.

Two parameters were used to compare the operational costs of both scenarios: electrical and chemical. The electrical costs were estimated based on the number of wells running to meet demand, average motor horsepower of the wells and average Southern California Edison (SCE) Time of Use (TOU) charge. The chemical costs were estimated based on the typical chlorine demand for disinfection, chlorine demand for the full oxidation of iron and manganese, and the current cost for gaseous chlorine.

Conclusion and Recommendation:

The bypass operation (Scenario 10) did slightly improve water quality in terms of nitrates over the VFD operation (Scenario 3). However, the iron and manganese concentrations were significantly higher for the bypass operation as compared to the VFD operation. The electrical cost was approximately 14% higher ($96,000 annually) for the bypass operation as compared to the VFD option. The chemical cost was approximately the same for both options.

It is recommended that VFDs are installed at the three (3) LAS wells as this is the most energy efficient operation and provides the best reduction in iron and manganese concentrations. As a future consideration, it might be desirable to control the VFDs using an online nitrate analyzer at the blended plant effluent that can increase LAS well production in the event of increasing nitrates, and lower LAS well production with decreasing nitrate concentrations.

Table 1 - Theoretical Operating (Blending) Scenarios

	Scenario (T) - Treat, (BL) Blend, (BP) Bypass	Well System	Annual Production (ac-ft/year)	Production Ratio	Nitrate (NO3) in mg/L MCL = 45 mg/L Min	Avg	Max	AEP[12]	Iron (Fe) in µg/L MCL = 300 µg/L Min	Avg	Max	AEP[12]	Manganese (Mn) µg/L MCL = 50 µg/L Min	Avg	Max	AEP[12]	Equivalent No. of Wells Running	Average Well Motor Horsepower	Est. Well Field Electrical Cost (Avg: $0.19/kWh)	Est. Chlorine Demand for Disinfection (mg/L)	Est. Chlorine Demand for Fe-Mn Treatment (mg/L)	Est. Chemical (Chlorine only) Cost ($0.31/lb)
	Theoretical Operating Scenarios and Their Respective Water Qualities																Theoretical Operating Scenarios and Their Respective Annual Operating Costs					
1	Do Nothing (2014 Blend)	UAS	8,496	78%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	1.90	100	$ 236,000	3.00	0.00	$ 21,486
		LAS	2,419	22%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.60	400	$ 298,000	3.00	1.20	$ 8,565
		Blend	**10,915**	**100%**	**0.8**	**17.0**	**71.1**	**7.8%**	**68.0**	**199.2**	**629.0**	**17.0%**	**25.9**	**43.6**	**87.9**	**21.5%**	**2.50**	**172**	**$ 534,000**	**3.00**	**0.27**	**$ 30,051**
2	Treat one LAS well @ 50%, 24/7/365	UAS	12,070	86%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.70	100	$ 335,000	3.00	0.00	$ 30,524
		LAS (T)	2,016	14%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.50	400	$ 248,000	3.00	1.20	$ 7,139
		Blend	**14,086**	**100%**	**0.9**	**18.4**	**77.4**	**8.6%**	**0.0**	**65.6**	**112.8**	**0.0%**	**0.0**	**0.7**	**1.4**	**0.0%**	**3.20**	**147**	**$ 583,000**	**3.00**	**0.17**	**$ 37,663**
3	Treat one LAS well @ 75%, 24/7/365	UAS	11,062	79%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.47	100	$ 307,000	3.00	0.00	$ 27,975
		LAS (T)	3,024	21%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.75	400	$ 372,000	3.00	1.20	$ 10,708
		Blend	**14,086**	**100%**	**0.8**	**17.1**	**71.7**	**7.9%**	**0.0**	**61.4**	**105.9**	**0.0%**	**0.0**	**1.1**	**2.1**	**0.0%**	**3.22**	**170**	**$ 679,000**	**3.00**	**0.26**	**$ 38,683**
4	Treat one LAS well @ 100%, 24/7/365	UAS	10,053	71%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.25	100	$ 279,000	3.00	0.00	$ 25,425
		LAS (T)	4,033	29%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	1.00	400	$ 496,000	3.00	1.20	$ 14,278
		Blend	**14,086**	**100%**	**0.7**	**15.9**	**66.0**	**7.1%**	**0.0**	**57.1**	**99.0**	**0.0%**	**0.0**	**1.4**	**2.9**	**0.0%**	**3.25**	**192**	**$ 775,000**	**3.00**	**0.34**	**$ 39,703**
5	Treat two LAS wells @ 100%, 24/7/365	UAS	6,021	43%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	1.35	100	$ 167,000	3.00	0.00	$ 15,227
		LAS (T)	8,065	57%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	2.00	400	$ 992,000	3.00	1.20	$ 28,555
		Blend	**14,086**	**100%**	**0.4**	**10.8**	**43.2**	**4.3%**	**0.0**	**40.2**	**71.3**	**0.0%**	**0.0**	**2.9**	**5.7**	**0.0%**	**3.35**	**279**	**$ 1,159,000**	**3.00**	**0.69**	**$ 43,782**
6	Treat one LAS well @ 50%, Blend one LAS well @ 50%, 24/7/365	UAS	10,053	71%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.25	100	$ 279,000	3.00	0.00	$ 25,425
		LAS (BL)	2,016	14%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.50	400	$ 248,000	3.00	0.00	$ 5,099
		LAS (T)	2,016	14%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.50	400	$ 248,000	3.00	1.20	$ 7,139
		Blend	**14,086**	**100%**	**0.7**	**15.9**	**66.0**	**7.1%**	**43.9**	**146.5**	**437.3**	**11.0%**	**16.7**	**28.9**	**58.2**	**13.9%**	**3.25**	**192**	**$ 775,000**	**3.00**	**0.17**	**$ 37,663**
7	Treat one LAS well @ 75%, Blend one LAS well @ 50%, 24/7/365	UAS	9,045	64%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.02	100	$ 251,000	3.00	0.00	$ 22,876
		LAS (BL)	2,016	14%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.50	400	$ 248,000	3.00	0.00	$ 5,099
		LAS (T)	3,024	21%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.75	400	$ 372,000	3.00	1.20	$ 10,708
		Blend	**14,086**	**100%**	**0.6**	**14.6**	**60.3**	**6.4%**	**43.9**	**142.2**	**430.4**	**11.0%**	**16.7**	**29.3**	**58.9**	**13.9%**	**3.27**	**215**	**$ 871,000**	**3.00**	**0.26**	**$ 38,683**
8	Treat one LAS well @ 100%, Blend one LAS well @ 50%, 24/7/365	UAS	8,037	57%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	1.80	100	$ 223,000	3.00	0.00	$ 20,326
		LAS (BL)	2,016	14%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.50	400	$ 248,000	3.00	0.00	$ 5,099
		LAS (T)	4,033	29%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	1.00	400	$ 496,000	3.00	1.20	$ 14,278
		Blend	**14,086**	**100%**	**0.6**	**13.3**	**54.6**	**5.7%**	**43.9**	**138.0**	**423.4**	**11.0%**	**16.7**	**29.6**	**59.6**	**13.9%**	**3.30**	**237**	**$ 967,000**	**3.00**	**0.34**	**$ 39,703**
9	One LAS well @ 100% speed: 50% Treated (T) 50% Bypassed (B)	UAS	10,053	71%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.25	100	$ 279,000	3.00	0.00	$ 25,425
		LAS (BP)	2,016	14%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.50	400	$ 248,000	3.00	0.00	$ 5,099
		LAS (T)	2,016	14%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.50	400	$ 248,000	3.00	1.20	$ 7,139
		Blend	**14,086**	**100%**	**0.7**	**15.9**	**66.0**	**7.1%**	**43.9**	**146.5**	**437.3**	**11.0%**	**16.7**	**28.9**	**58.2**	**13.9%**	**3.25**	**192**	**$ 775,000**	**3.00**	**0.17**	**$ 37,663**
10	One LAS well @ 100% speed: 75% Treated (T) 25% Bypassed (BP)	UAS	10,053	71%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.25	100	$ 279,000	3.00	0.00	$ 25,425
		LAS (BP)	1,008	7%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.25	400	$ 124,000	3.00	0.00	$ 2,550
		LAS (T)	3,024	21%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.75	400	$ 372,000	3.00	1.20	$ 10,708
		Blend	**14,086**	**100%**	**0.7**	**15.9**	**66.0**	**7.1%**	**21.9**	**101.8**	**268.1**	**5.5%**	**8.3**	**15.2**	**30.5**	**7.0%**	**3.25**	**192**	**$ 775,000**	**3.00**	**0.26**	**$ 38,683**
11	One LAS well @ 100% speed: 90% Treated (T) 10% Bypassed (BP)	UAS	10,053	71%	1.0	20.9	88.8	10.0%	0.0	74.0	126.7	0.0%	0.0	0.0	0.0	0.0%	2.25	100	$ 279,000	3.00	0.00	$ 25,425
		LAS (BP)	403	3%	0.0	3.3	9.1	0.0%	306.7	638.9	2393.3	76.7%	116.7	196.9	396.7	97.2%	0.10	400	$ 50,000	3.00	0.00	$ 1,020
		LAS (T)	3,629	26%	0.0	3.3	9.1	0.0%	0.0	15.0	30.0	0.0%	0.0	5.0	10.0	0.0%	0.90	400	$ 447,000	3.00	1.20	$ 12,850
		Blend	**14,086**	**100%**	**0.7**	**15.9**	**66.0**	**7.1%**	**8.8**	**75.0**	**166.7**	**2.2%**	**3.3**	**6.9**	**13.9**	**2.8%**	**3.25**	**192**	**$ 776,000**	**3.00**	**0.31**	**$ 39,295**

Notes:
1 Scenario 1: "Do Nothing" based on 2014 production numbers (NO3, Fe and Mn concentrations from 2003-2015 statistical data)
2 Scenario 2: Operate one LAS well at 50% speed (24 hours per day, 7 days per week, 365 days per year) and provide treatment to bring Fe and Mn below detectable levels
3 Scenario 3: Operate one LAS well at 75% speed (24 hours per day, 7 days per week, 365 days per year) and provide treatment to bring Fe and Mn below detectable levels
4 Scenario 4: Operate one LAS well at 100% speed (24 hours per day, 7 days per week, 365 days per year) and provide treatment to bring Fe and Mn below detectable levels
5 Scenario 5: Operate two LAS wells at 100% speed (24 hours per day, 7 days per week, 365 days per year) and provide treatment to bring Fe and Mn below detectable levels
6 Scenario 6: Operate and provide treatment for one LAS well at 50% speed (24/7/365) and additionally operate and blend one LAS well at 50% speed w/o treatment
7 Scenario 7: Operate and provide treatment for one LAS well at 75% speed (24/7/365) and additionally operate and blend one LAS well at 50% speed w/o treatment
8 Scenario 8: Operate and provide treatment for one LAS well at 100% speed (24/7/365) and additionally operate and blend one LAS well at 50% speed w/o treatment
9 Scenario 9: Operate one LAS well at 100% speed (24/7/365) and bifurcate flow such that 50% receives Fe and Mn treatment and 50% is blended directly with UAS water
10 Scenario 10: Operate one LAS well at 100% speed (24/7/365) and bifurcate flow such that 75% receives Fe and Mn treatment and 25% is blended directly with UAS water
11 Scenario 11: Operate one LAS well at 100% speed (24/7/365) and bifurcate flow such that 90% receives Fe and Mn treatment and 10% is blended directly with UAS water
12 Because of the variability in constitutent concentrations and blending between wells, the AEP does not necessarily imply that the MCL will be exceeded