Direct Potable Reuse Monitoring:

Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards

Volume 2 of 2

FINAL

by
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Additional funding provided by

December 2016

Appendix A

Data Report

Data Report for

Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards

FINAL

by

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December 2016

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Texas Water Development Board
Contract # 1348321632

Direct Potable Reuse Monitoring: Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards

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STATE OF TEXAS
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by
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December 2016

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Explanatory Comments

This Data Report is provided as a separate deliverable to the Texas Water Development Board in accordance with the contract scope. Per the original project schedule, this Data Report was due to be delivered well in advance of the Final Report for the project. However, due to project delays, this Data Report is being submitted concurrently with the Final report.

This Data Report contains only raw data tables, figures, and associated laboratory reports. All interpretation thereof is provided in the Final Report, to which this Data Report functions as an Appendix. In accordance this function, Tables are therefore numbered as A-1 through A-18, and Figures are numbered A.1 through A.31.

Table A.1

Analytical Results for Grab Samples Collected in July 2014 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		7/8/2014	7/7/2014	7/7/2014	7/7/2014	7/7/2014	7/7/2014	7/7/2014
Location		Moss Creek Lake	RWPF Influent	RO Feed	RO Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Acetaminophen	ng/L	< 5	< 5	< 5	< 100	< 5	< 5	< 5
Atenolol	ng/L	< 1	40	58	220	< 1	< 1	< 1
Caffeine	ng/L	< 5	< 100	< 5	< 100	< 5	< 5	< 5
Carbamazepine	ng/L	< 2.5	< 10	< 0.5	< 10	< 0.5	< 0.5	< 0.5
DEET	ng/L	11	22	49	250	< 1	1.0	< 1
Fluoxetine	ng/L	< 2.5	7.2	7.0	23	< 0.5	< 0.5	< 0.5
Gemfibrozil	ng/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Ibuprofen	ng/L	< 1	< 25	< 25	< 25	< 1	< 1	< 1
Meprobamate	ng/L	< 1.3	200	180	720	0.79	< 0.25	< 0.25
Naproxen	ng/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Primidone	ng/L	< 0.5	140	120	550	< 0.5	< 0.5	< 0.5
Sucralose	ng/L	380	24000	30000	130000	100	45	< 25
Sulfamethoxazole	ng/L	1.5	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
TCEP	ng/L	13	220	230	1200	< 10	< 10	< 10
Triclocarban	ng/L	< 2	33	42	140	11	< 2	< 2
Triclosan	ng/L	< 1	1.8	< 1	< 1	< 1	< 1	< 1
Trimethoprim	ng/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
PFBA	ng/L	< 5	9.4	8.8	25	< 5	< 5	6.2
PFDA	ng/L	< 1	2.7	2.3	9.3	< 1	< 1	< 1
PFDoA	ng/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
PFHpA	ng/L	1.1	3.2	3.4	15	< 0.5	< 0.5	< 0.5
PFHxA	ng/L	2	16	17	69	< 1	< 1	< 1
PFHxS	ng/L	4.7	6.2	5.8	22	< 1	< 1	< 1
PFNA	ng/L	< 1	5.4	5.4	22	< 1	< 1	< 1
PFOA	ng/L	< 5	12	12	< 5	< 5	< 5	< 5
PFOS	ng/L	1.1	5.4	5.2	22	< 1	< 1	< 1
PFPnA	ng/L	< 2	27	28	120	< 2	< 2	< 2
PFUdA	ng/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Table A.1

Analytical Results for Grab Samples Collected in July 2014 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		7/8/2014	7/7/2014	7/7/2014	7/7/2014	7/7/2014	7/7/2014	7/7/2014
Location		Moss Creek Lake	RWPF Influent	RO Feed	RO Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Nitrosodimethylamine	ng/L	**3.4**	**7.6**	**5.7**	**12**	**4.9**	**3.3**	< 2.5
Nitrosodibutylamine	ng/L	< 10	< 20	< 11	< 20	< 11	< 10	< 10
Nitrosodiethylamine	ng/L	< 5	< 10	< 5.5	< 10	< 5.3	< 5	< 5
Nitrosodiphenylamine	ng/L	< 10	< 20	< 11	< 20	< 11	< 10	< 10
Nitrosodipropylamine	ng/L	< 10	< 20	< 11	< 20	< 11	< 10	< 10
Nitrosomethylethylamine	ng/L	< 2.5	< 5	< 2.7	< 5.0	< 2.6	< 2.5	< 2.5
Nitrosomorpholine	ng/L	< 5	< 10	**5.9**	**16**	< 5.3	< 5	< 5
Nitrosopiperidine	ng/L	< 20	< 40	< 22	< 40	< 21	< 20	< 20
Nitrosopyrrolidine	ng/L	< 20	< 40	< 22	< 40	< 21	< 20	< 20
Total Nitrosamines	ng/L	< 50	< 50	< 50		< 50	< 50	< 50
Estradiol	ng/L	< 0.5	< 1	< 0.5	< 1.0	< 0.5	< 0.5	< 0.5
Estrone	ng/L	**0.26**	< 0.4	< 0.2	< 0.40	< 0.2	< 0.2	< 0.2
Ethynylestradiol	ng/L	< 1	< 2	< 1	< 2.0	< 1	< 1	< 1
Progesterone	ng/L	< 0.5	< 1	< 0.5	< 1.0	< 0.5	< 0.5	< 0.5
Testosterone	ng/L	< 0.5	< 1	< 0.5	< 1.0	< 0.5	< 0.5	< 0.5
Total Regulated HAAs	mg/L	< 0.001	**0.073**	**0.10**	NA	< 0.001	< 0.001	NS
Bromoacetic acid	mg/L	< 0.001	**0.0093**	**0.014**	NA	< 0.001	< 0.001	NS
Chloroacetic acid	mg/L	< 0.002	**0.0023**	**0.0027**	NA	< 0.002	< 0.002	NS
Dibromoacetic acid	mg/L	< 0.001	**0.039**	**0.063**	NA	< 0.001	< 0.001	NS
Dichloroacetic acid	mg/L	< 0.001	**0.012**	**0.013**	NA	< 0.001	< 0.001	NS
Trichloroacetic acid	mg/L	< 0.001	**0.01**	**0.0092**	NA	< 0.001	< 0.001	NS
Total Trihalomethanes	mg/L	< 0.0005	**0.23**	**0.31**	NA	**0.17**	**0.037**	NS
Bromodichloromethane	mg/L	< 0.0005	**0.023**	**0.035**	NA	**0.021**	**0.015**	NS
Bromoform	mg/L	< 0.0005	**0.13**	**0.16**	NA	**0.082**	**0.0039**	NS
Chlorodibromomethane	mg/L	< 0.0005	**0.079**	**0.10**	NA	**0.062**	**0.014**	NS
Chloroform	mg/L	< 0.0005	**0.0054**	**0.0074**	NA	**0.0039**	**0.0037**	NS

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

2. Abbreviations: DEET = N,N -Diethylmetatoluamide, HAAs = haloacetic acids, mg/L = milligrams per liter,ng/L = nanograms per liter, NS = not sampled, PFBA = perfluorobutanoic acid, PFDA = perfluorodecanoic acid, PFDoA = perfluorododecanoic acid, PFHxS = perfluorohexane sulfonate, PFHxA = perfluorohexanoic acid, PFNA = perfluorononanoic acid, PFOS = perfluorooctane sulfonate, PFOA = perfluorooctanoic acid, PFPnA = perfluoropentanoic acid, PFHpA = perfluororheptanoic acid, PFUdA = perfluoroundecanoic acid, TCEP = *Tris* (2-carboxyethyl)phosphine.

Table A.2

Analytical Results for Grab Samples Collected in February 2015 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		2/10/2015	2/10/2015	2/9/2015	Not Sampled	2/9/2015	2/9/2015	2/9/2015
Location		**Moss Creek Lake**	**RWPF Influent**	**RO Feed**	**Concentrate**	**AOP Feed**	**Finished water**	**Field blank**
Parameter	**Units**							
Acetaminophen	**ng/L**	< 5	< 100	< 100	NS	< 5	NS	< 5
Atenolol	**ng/L**	< 1	**330**	**330**	NS	< 1	NS	< 1
Caffeine	**ng/L**	< 100	< 100	< 100	NS	< 5	NS	< 5
Carbamazepine	**ng/L**	**0.84**	< 10	< 10	NS	< 0.5	NS	< 0.5
DEET	**ng/L**	**65**	**3.1**	**4.5**	NS	< 1	NS	< 1
Fluoxetine	**ng/L**	< 0.5	**190**	**220**	NS	< 0.5	NS	< 0.5
Gemfibrozil	**ng/L**	< 0.25	< 0.25	< 0.25	NS	< 0.25	NS	< 0.25
Ibuprofen	**ng/L**	< 1	< 20	< 20	NS	< 1	NS	< 1
Meprobamate	**ng/L**	< 0.25	**230**	**220**	NS	**0.33**	NS	< 0.25
Naproxen	**ng/L**	< 0.5	< 0.5	< 0.5	NS	< 0.5	NS	< 0.5
Primidone	**ng/L**	< 10	**190**	**220**	NS	< 0.5	NS	< 0.5
Sucralose	**ng/L**	**230**	**41000**	**38000**	NS	**67**	NS	< 25
Sulfamethoxazole	**ng/L**	< 0.25	< 5	< 0.25	NS	< 0.25	NS	< 0.25
TCEP	**ng/L**	< 10	**2100**	**370**	NS	< 10	NS	< 10
Triclocarban	**ng/L**	< 2	**160**	**190**	NS	**16**	NS	< 2
Triclosan	**ng/L**	< 1	< 1	< 1	NS	< 1	NS	< 1
Trimethoprim	**ng/L**	< 0.25	< 0.25	< 0.25	NS	< 0.25	NS	< 0.25
PFBA	**ng/L**	< 5	< 5	< 5	NS	< 5	NS	< 5
PFDA	**ng/L**	< 1	< 1	**1.2**	NS	< 1	NS	< 1
PFDoA	**ng/L**	< 1	< 1	< 1	NS	< 1	NS	< 1
PFHpA	**ng/L**	**0.72**	**2.0**	**2.0**	NS	< 0.5	NS	< 0.5
PFHxA	**ng/L**	**1.9**	**11**	**11**	NS	< 1	NS	< 1
PFHxS	**ng/L**	**3.2**	**4.7**	**4.7**	NS	< 1	NS	< 1
PFNA	**ng/L**	< 1	< 1	**1.6**	NS	< 1	NS	< 1
PFOA	**ng/L**	< 5	**6.6**	**7.9**	NS	< 5	NS	< 5
PFOS	**ng/L**	< 1	< 1	**1.5**	NS	< 1	NS	< 1
PFPnA	**ng/L**	< 2	**10**	**11**	NS	< 2	NS	< 2
PFUdA	**ng/L**	< 1	< 1	< 1	NS	< 1	NS	< 1

Table A.2

Analytical Results for Grab Samples Collected in February 2015 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		2/10/2015	2/10/2015	2/9/2015	Not Sampled	2/9/2015	2/9/2015	2/9/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Nitrosodimethylamine	ng/L	< 2.5	**5.8**	**7.9**	NS	**5.8**	< 2.5	< 2.5
Nitrosodibutylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosodiethylamine	ng/L	< 5	< 5	< 5	NS	< 5	< 5	< 5
Nitrosodiphenylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosodipropylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosomethylethylamine	ng/L	< 2.5	< 2.5	< 2.5	NS	< 2.5	< 2.5	< 2.5
Nitrosomorpholine	ng/L	< 5	**7.5**	**7.6**	NS	< 5	< 5	< 5
Nitrosopiperidine	ng/L	< 20	< 20	< 20	NS	< 20	< 20	< 20
Nitrosopyrrolidine	ng/L	< 20	< 20	< 20	NS	< 20	< 20	< 20
Total Nitrosamines	ng/L	< 50	**66**	**83**	NS	< 50	< 50	< 50
Estradiol	ng/L	< 1	< 1	< 1	NS	< 0.5	NS	< 0.5
Estrone	ng/L	**1.2**	< 0.2	< 0.2	NS	< 0.2	NS	< 0.2
Ethynylestradiol	ng/L	< 1	< 1	< 1	NS	< 1	NS	< 1
Progesterone	ng/L	**0.65**	< 0.5	< 1	NS	< 0.5	NS	< 0.5
Testosterone	ng/L	< 0.5	< 0.5	< 1	NS	< 0.5	NS	< 0.5
Total Regulated HAAs	mg/L	< 0.001	**0.0750**	**0.0770**	NS	< 0.001	< 0.001	NS
Bromoacetic acid	mg/L	< 0.001	**0.0078**	**0.0074**	NS	< 0.001	< 0.001	NS
Chloroacetic acid	mg/L	< 0.002	< 0.002	< 0.002	NS	< 0.002	< 0.002	NS
Dibromoacetic acid	mg/L	< 0.001	**0.0380**	**0.0400**	NS	< 0.001	< 0.001	NS
Dichloroacetic acid	mg/L	< 0.001	**0.0170**	**0.0180**	NS	< 0.001	< 0.001	NS
Trichloroacetic acid	mg/L	< 0.001	**0.0120**	**0.0120**	NS	< 0.001	< 0.001	NS
Total Trihalomethanes	mg/L	< 0.0005	**0.1400**	**0.1600**	NS	**0.0480**	**0.0130**	NS
Bromodichloromethane	mg/L	< 0.0005	**0.0190**	**0.0230**	NS	**0.0078**	**0.0063**	NS
Bromoform	mg/L	< 0.0005	**0.0590**	**0.0660**	NS	**0.0190**	**0.0006**	NS
Chlorodibromomethane	mg/L	< 0.0005	**0.0510**	**0.0600**	NS	**0.0190**	**0.0037**	NS
Chloroform	mg/L	< 0.0005	**0.0077**	**0.0075**	NS	**0.0020**	**0.0022**	NS

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".
2. Abbreviations: DEET = N,N -Diethylmetatoluamide, HAAs = haloacetic acids, mg/L = milligrams per liter,ng/L = nanograms per liter, NS = not sampled, PFBA = perfluorobutanoic acid, PFDA = perfluorodecanoic acid, PFDoA = perfluorododecanoic acid, PFHxS = perfluorohexane sulfonate, PFHxA = perfluorohexanoic acid, PFNA = perfluorononanoic acid, PFOS = perfluorooctane sulfonate, PFOA = perfluorooctanoic acid, PFPnA = perfluoropentanoic acid, PFHpA = perfluororheptanoic acid, PFUdA = perfluoroundecanoic acid, TCEP = *Tris* (2-carboxyethyl)phosphine.

Table A.3

Analytical Results for Grab Samples Collected in June 2015 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		6/2/2015	6/1/2015	6/1/2015	Not Sampled	6/1/2015	6/1/2015	6/1/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Acetaminophen	ng/L	< 5	< 5	< 100	NS	< 5	< 5	< 5
Atenolol	ng/L	< 1	**140**	**170**	NS	1.3	< 1	< 1
Caffeine	ng/L	< 5	< 5	**27**	NS	< 5	< 5	< 5
Carbamazepine	ng/L	< 0.5	< 10	**15**	NS	< 0.5	< 0.5	< 0.5
DEET	ng/L	**55**	**190**	**500**	NS	**2.1**	< 1	< 1
Fluoxetine	ng/L	< 0.5	**8**	**8.1**	NS	< 0.5	< 0.5	< 0.5
Gemfibrozil	ng/L	< 0.25	< 0.25	**34**	NS	**0.33**	**0.45**	< 0.25
Ibuprofen	ng/L	< 1	**3.4**	**23**	NS	< 1	< 1	< 1
Meprobamate	ng/L	< 0.25	**110**	**130**	NS	< 0.25	< 0.25	< 0.25
Naproxen	ng/L	< 10	< 10	**41**	NS	< 0.5	< 0.5	< 0.5
Primidone	ng/L	< 10	**86**	**110**	NS	< 0.5	< 0.5	< 0.5
Sucralose	ng/L	**300**	**24000**	**24000**	NS	**48**	**43**	< 25
Sulfamethoxazole	ng/L	**1.3**	< 0.25	**24**	NS	< 0.25	< 0.25	< 0.25
TCEP	ng/L	< 10	**280**	**300**	NS	< 10	< 10	< 10
Triclocarban	ng/L	< 2	**88**	**170**	NS	**53**	**17**	**11**
Triclosan	ng/L	< 1	< 1	< 1	NS	< 1	**2**	< 1
Trimethoprim	ng/L	< 0.25	< 0.25	**4.9**	NS	< 0.25	< 0.25	< 0.25
PFBA	ng/L	< 25	< 25	< 25	NS	< 25	< 5	< 5
PFDA	ng/L	< 1	< 1	**1.8**	NS	< 1	< 1	< 1
PFDoA	ng/L	< 1	< 1	< 1	NS	< 1	< 1	< 1
PFHpA	ng/L	**0.95**	**1.4**	**1.4**	NS	< 0.5	< 0.5	< 0.5
PFHxA	ng/L	**2**	**6.9**	**7.8**	NS	< 1	< 1	< 1
PFHxS	ng/L	**3.8**	**6.3**	**5.8**	NS	< 1	< 1	< 1
PFNA	ng/L	< 1	**1.2**	**1.9**	NS	< 1	< 1	< 1
PFOA	ng/L	< 5	< 5	**5.6**	NS	< 5	< 5	< 5
PFOS	ng/L	< 1	**2.6**	**3.4**	NS	< 1	< 1	< 1
PFPnA	ng/L	< 10	< 10	< 10	NS	< 2	< 2	< 2
PFUdA	ng/L	< 1	< 1	< 1	NS	< 1	< 1	< 1

Table A.3

Analytical Results for Grab Samples Collected in June 2015 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		6/2/2015	6/1/2015	6/1/2015	Not Sampled	6/1/2015	6/1/2015	6/1/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Nitrosodimethylamine	ng/L	< 2.5	**3.5**	**5.3**	NS	**3.1**	< 2.5	< 2.5
Nitrosodibutylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosodiethylamine	ng/L	**8.1**	**6.5**	< 5	NS	< 5	< 5	< 5
Nitrosodiphenylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosodipropylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosomethylethylamine	ng/L	< 2.5	< 2.5	< 2.5	NS	< 2.5	< 2.5	< 2.5
Nitrosomorpholine	ng/L	< 5	**5.7**	**6**	NS	< 5	< 5	< 5
Nitrosopiperidine	ng/L	< 20	< 20	< 20	NS	< 20	< 20	< 20
Nitrosopyrrolidine	ng/L	< 20	< 20	< 20	NS	< 20	< 20	< 20
Total Nitrosamines	ng/L	NS	NS	NS	NS	NS	NS	NS
Estradiol	ng/L	< 0.5	< 0.5	< 0.5	NS	< 0.5	< 0.5	< 0.5
Estrone	ng/L	**0.26**	< 0.2	< 0.2	NS	< 0.2	< 0.2	< 0.2
Ethynylestradiol	ng/L	< 1	< 1	< 1	NS	< 1	< 1	< 1
Progesterone	ng/L	< 0.5	**0.8**	< 0.5	NS	< 0.5	< 0.5	< 0.5
Testosterone	ng/L	< 0.5	< 0.5	< 0.5	NS	< 0.5	< 0.5	< 0.5
Total Regulated HAAs	mg/L	< 0.001	**0.0240**	**0.0420**	NS	< 0.001	**0.001**	< 0.001
Bromoacetic acid	mg/L	< 0.001	< 0.001	**0.0027**	NS	< 0.001	< 0.001	< 0.001
Chloroacetic acid	mg/L	< 0.002	< 0.002	< 0.002	NS	< 0.002	< 0.002	< 0.002
Dibromoacetic acid	mg/L	< 0.001	**0.0071**	**0.0170**	NS	< 0.001	< 0.001	< 0.001
Dichloroacetic acid	mg/L	< 0.001	**0.0073**	**0.0091**	NS	< 0.001	**0.0012**	< 0.001
Trichloroacetic acid	mg/L	< 0.001	**0.0093**	**0.0130**	NS	< 0.001	< 0.001	< 0.001
Total Trihalomethanes	mg/L	< 0.0005	**0.1800**	**0.1700**	NS	**0.0840**	**0.0310**	< 0.0005
Bromodichloromethane	mg/L	< 0.0005	**0.0300**	**0.0380**	NS	**0.0220**	**0.0160**	< 0.0005
Bromoform	mg/L	< 0.0005	**0.0670**	**0.0530**	NS	**0.0220**	**0.0007**	< 0.0005
Chlorodibromomethane	mg/L	< 0.0005	**0.0700**	**0.0620**	NS	**0.0340**	**0.0070**	< 0.0005
Chloroform	mg/L	< 0.0005	**0.0091**	**0.0140**	NS	**0.0070**	**0.0073**	< 0.0005

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

2. Abbreviations: DEET = N,N -Diethylmetatoluamide, HAAs = haloacetic acids, mg/L = milligrams per liter,ng/L = nanograms per liter, NS = not sampled, PFBA = perfluorobutanoic acid, PFDA = perfluorodecanoic acid, PFDoA = perfluorododecanoic acid, PFHxS = perfluorohexane sulfonate, PFHxA = perfluorohexanoic acid, PFNA = perfluorononanoic acid, PFOS = perfluorooctane sulfonate, PFOA = perfluorooctanoic acid, PFPnA = perfluoropentanoic acid, PFHpA = perfluororheptanoic acid, PFUdA = perfluoroundecanoic acid, TCEP = *Tris* (2-carboxyethyl)phosphine.

Table A.4

Analytical Results for Grab Samples Collected in September 2015 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		9/16/2015	9/15/2015	9/15/2015	9/15/2015	9/15/2015	9/15/2015	9/16/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Acetaminophen	ng/L	< 5	< 5	< 5	NS	< 5	< 5	< 5
Atenolol	ng/L	< 1	**57**	**42**	NS	< 1	< 1	< 1
Caffeine	ng/L	< 5	< 5	< 5	NS	< 5	< 5	< 5
Carbamazepine	ng/L	< 0.5	< 0.5	< 0.5	NS	< 0.5	< 0.5	< 0.5
DEET	ng/L	**210**	< 1	**1.6**	NS	< 1	< 1	< 1
Fluoxetine	ng/L	< 0.5	**18**	**22**	NS	< 0.5	< 0.5	< 0.5
Gemfibrozil	ng/L	< 0.25	< 0.25	**0.88**	NS	< 0.25	< 0.25	< 0.25
Ibuprofen	ng/L	< 1	< 20	**2.2**	NS	< 1	< 1	< 1
Meprobamate	ng/L	< 0.25	**230**	**260**	NS	0.4	0.45	< 0.25
Naproxen	ng/L	**0.73**	< 0.5	**0.52**	NS	< 0.5	< 0.5	< 0.5
Primidone	ng/L	< 0.5	**190**	**140**	NS	< 0.5	< 0.5	< 0.5
Sucralose	ng/L	**360**	**39000**	**42000**	NS	45	150	< 25
Sulfamethoxazole	ng/L	**1.6**	< 0.25	< 0.25	NS	< 0.25	< 0.25	< 0.25
TCEP	ng/L	**12**	**240**	**250**	NS	< 10	< 10	< 10
Triclocarban	ng/L	< 2	**51**	**75**	NS	**34**	< 2	< 2
Triclosan	ng/L	< 1	< 1	< 1	NS	< 1	< 1	< 1
Trimethoprim	ng/L	< 0.25	< 0.25	< 0.25	NS	< 0.25	< 0.25	< 0.25
PFBA	ng/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5
PFDA	ng/L	< 1	**1.1**	**1.7**	**6.2**	< 1	< 1	< 1
PFDoA	ng/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
PFHpA	ng/L	**0.65**	**1.8**	**2.1**	**8.8**	< 0.5	< 0.5	< 0.5
PFHxA	ng/L	**1.8**	**11**	**12**	**45**	< 1	< 1	< 1
PFHxS	ng/L	**2.7**	**4**	**4.9**	**19**	< 1	< 1	< 1
PFNA	ng/L	< 1	< 1	**1.1**	**5.7**	< 1	< 1	< 1
PFOA	ng/L	< 5	**9.5**	**12**	**51**	< 5	< 5	< 5
PFOS	ng/L	< 1	**1.7**	**3.5**	**13**	< 1	< 1	< 1
PFPnA	ng/L	< 2	**24**	**27**	**93**	< 2	< 2	< 2
PFUdA	ng/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Table A.4

Analytical Results for Grab Samples Collected in September 2015 (provided by Southern Nevada Water Authority Laboratory)

Date Collected		9/16/2015	9/15/2015	9/15/2015	9/15/2015	9/15/2015	9/15/2015	9/16/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	Concentrate	AOP Feed	Finished water	Field blank
Parameter	Units							
Nitrosodimethylamine	ng/L	**3.8**	**5**	**5.5**	NS	**4.6**	< 2.5	< 2.5
Nitrosodibutylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosodiethylamine	ng/L	< 5	< 5	< 5	NS	< 5	< 5	< 5
Nitrosodiphenylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosodipropylamine	ng/L	< 10	< 10	< 10	NS	< 10	< 10	< 10
Nitrosomethylethylamine	ng/L	< 2.5	< 2.5	< 2.5	NS	< 2.5	< 2.5	< 2.5
Nitrosomorpholine	ng/L	< 5	**8.5**	**9.2**	NS	< 5	< 5	< 5
Nitrosopiperidine	ng/L	< 20	< 20	< 20	NS	< 20	< 20	< 20
Nitrosopyrrolidine	ng/L	< 20	< 20	< 20	NS	< 20	< 20	< 20
Total Nitrosamines	ng/L	< 50	< 50	< 50	NS	< 50	NS	NS
Estradiol	ng/L	NS	NS	NS	NS	NS	NS	NS
Estrone	ng/L	NS	NS	NS	NS	NS	NS	NS
Ethynylestradiol	ng/L	NS	NS	NS	NS	NS	NS	NS
Progesterone	ng/L	NS	NS	NS	NS	NS	NS	NS
Testosterone	ng/L	NS	NS	NS	NS	NS	NS	NS
Total Regulated HAAs	mg/L	< 0.001	**0.0480**	**0.0360**	NS	< 0.001	< 0.001	< 0.001
Bromoacetic acid	mg/L	< 0.001	**0.005**	**0.0035**	NS	< 0.001	< 0.001	< 0.001
Chloroacetic acid	mg/L	< 0.002	< 0.002	< 0.002	NS	< 0.002	< 0.002	< 0.002
Dibromoacetic acid	mg/L	< 0.001	**0.0320**	**0.0210**	NS	< 0.001	< 0.001	< 0.001
Dichloroacetic acid	mg/L	< 0.001	**0.0076**	**0.0062**	NS	< 0.001	< 0.001	< 0.001
Trichloroacetic acid	mg/L	< 0.001	**0.0039**	**0.0053**	NS	< 0.001	< 0.001	< 0.001
Total Trihalomethanes	mg/L	< 0.0005	**0.1600**	**0.1800**	NS	**0.1200**	**0.0310**	**0.0010**
Bromodichloromethane	mg/L	< 0.0005	**0.0160**	**0.0270**	NS	**0.0180**	**0.0140**	< 0.0005
Bromoform	mg/L	< 0.0005	**0.0810**	**0.0800**	NS	**0.0470**	**0.0021**	< 0.0005
Chlorodibromomethane	mg/L	< 0.0005	**0.0540**	**0.0700**	NS	**0.0480**	**0.0110**	< 0.0005
Chloroform	mg/L	< 0.0005	**0.0037**	**0.0069**	NS	**0.0042**	**0.0042**	**0.0006**

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

2. Abbreviations: DEET = N,N -Diethylmetatoluamide, HAAs = haloacetic acids, mg/L = milligrams per liter,ng/L = nanograms per liter, NS = not sampled, PFBA = perfluorobutanoic acid, PFDA = perfluorodecanoic acid, PFDoA = perfluorododecanoic acid, PFHxS = perfluorohexane sulfonate, PFHxA = perfluorohexanoic acid, PFNA = perfluorononanoic acid, PFOS = perfluorooctane sulfonate, PFOA = perfluorooctanoic acid, PFPnA = perfluoropentanoic acid, PFHpA = perflurorheptanoic acid, PFUdA = perfluoroundecanoic acid, TCEP = *Tris* (2-carboxyethyl)phosphine.

Table A.5

Results for Formation Potential Analyses Conducted by the Southern Nevada Water Authority Laboratory on Samples Collected in July 2014

Date Collected		7/17/2014	7/17/2014	7/17/2014	7/17/2014	7/17/2014
Location		Moss Creek Lake	RWPF Influent	RO Feed	AOP Feed	Finished water
Parameter	Units					
Nitrosodimethylamine	ng/L	**16**	**40**	**30**	**6.8**	< 5.0
Total Regulated HAAs	mg/L	**0.27**	**0.56**	**0.3**	**0.016**	**0.012**
Bromoacetic acid	mg/L	**0.013**	**0.02**	**0.018**	**0.0048**	**0.0047**
Chloroacetic acid	mg/L	**0.008**	**0.014**	**0.0068**	< 0.0020	< 0.0020
Dibromoacetic acid	mg/L	**0.063**	**0.14**	**0.15**	**0.0067**	**0.0023**
Dichloroacetic acid	mg/L	**0.11**	**0.23**	**0.09**	**0.0048**	**0.0034**
Trichloroacetic acid	mg/L	**0.077**	**0.16**	**0.035**	< 0.0010	**0.0017**
Total Trihalomethanes	mg/L	**0.61**	**1.1**	**0.73**	**0.16**	**0.042**
Bromodichloromethane	mg/L	**0.22**	**0.34**	**0.17**	**0.022**	**0.016**
Bromoform	mg/L	**0.059**	**0.21**	**0.24**	**0.074**	**0.0052**
Chlorodibromomethane	mg/L	**0.21**	**0.35**	**0.25**	**0.062**	**0.018**
Chloroform	mg/L	**0.12**	**0.19**	**0.066**	**0.0047**	**0.0037**

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

Table A.6

Results for Formation Potential Analyses Conducted by the Southern Nevada Water Authority Laboratory on Samples Collected in February 2015

Date Collected		2/25/2015	2/25/2015	2/25/2015	2/18/2015	2/18/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	AOP Feed	Finished water
Parameter	Units					
Nitrosodimethylamine	ng/L	**58**	**55**	**200**	**6.5**	< 5.0
Total Regulated HAAs	mg/L	**0.27**	**0.46**	**0.42**	**0.02**	**0.02**
Bromoacetic acid	mg/L	**0.037**	**0.046**	**0.041**	**0.01**	**0.01**
Chloroacetic acid	mg/L	**0.0054**	**0.0091**	**0.008**	< 0.0020	< 0.0020
Dibromoacetic acid	mg/L	**0.054**	**0.12**	**0.13**	**0.005**	**0.0011**
Dichloroacetic acid	mg/L	**0.11**	**0.19**	**0.17**	**0.0035**	**0.0038**
Trichloroacetic acid	mg/L	**0.063**	**0.10**	**0.072**	**0.0012**	**0.0012**
Total Trihalomethanes	mg/L	**0.59**	**0.71**	**0.70**	**0.050**	**0.017**
Bromodichloromethane	mg/L	**0.21**	**0.24**	**0.23**	**0.009**	**0.008**
Bromoform	mg/L	**0.058**	**0.11**	**0.12**	**0.018**	**0.0007**
Chlorodibromomethane	mg/L	**0.20**	**0.20**	**0.20**	**0.019**	**0.0046**
Chloroform	mg/L	**0.12**	**0.17**	**0.15**	**0.0032**	**0.0035**

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

Table A.7

Results for Formation Potential Analyses Conducted by the Southern Nevada Water Authority Laboratory on Samples Collected in June 2015

Date Collected		6/2/2015	6/1/2015	6/1/2015	6/1/2015	6/1/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	AOP Feed	Finished water
Parameter	Units					
Nitrosodimethylamine	ng/L	**8.6**	**99**	**170**	**8.1**	< 5.0
Total Regulated HAAs	mg/L	**0.140**	**0.240**	**0.140**	**0.015**	**0.006**
Bromoacetic acid	mg/L	**0.0110**	**0.0056**	**0.0080**	< 0.0010	< 0.0010
Chloroacetic acid	mg/L	**0.0043**	**0.0071**	**0.0053**	< 0.0020	< 0.0020
Dibromoacetic acid	mg/L	**0.0710**	**0.0630**	**0.0490**	**0.0020**	**0.0012**
Dichloroacetic acid	mg/L	**0.0300**	**0.1100**	**0.0480**	**0.0130**	**0.0048**
Trichloroacetic acid	mg/L	**0.0250**	**0.0560**	**0.0290**	< 0.0010	< 0.0010
Total Trihalomethanes	mg/L	**0.5600**	**0.5700**	**0.4300**	**0.1000**	**0.0400**
Bromodichloromethane	mg/L	**0.1400**	**0.1800**	**0.1200**	**0.0280**	**0.0200**
Bromoform	mg/L	**0.1500**	**0.0920**	**0.0810**	**0.0200**	**0.0015**
Chlorodibromomethane	mg/L	**0.2300**	**0.1800**	**0.1700**	**0.0330**	**0.0100**
Chloroform	mg/L	**0.0440**	**0.1200**	**0.0580**	**0.0200**	**0.0088**

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

Table A.8

Results for Formation Potential Analyses Conducted by the Southern Nevada Water Authority Laboratory on Samples Collected in September 2015

Date Collected		9/16/2015	9/15/2015	9/15/2015	9/15/2015	9/15/2015
Location		Moss Creek Lake	RWPF Influent	RO Feed	AOP Feed	Finished water
Parameter	Units					
Nitrosodimethylamine	ng/L	**19**	**210**	**130**	**5.2**	< 2.8
Total Regulated HAAs	mg/L	**0.240**	**0.340**	**0.260**	**0.010**	**0.008**
Bromoacetic acid	mg/L	**0.0089**	**0.0150**	**0.0110**	< 0.0010	< 0.0010
Chloroacetic acid	mg/L	**0.0069**	**0.0088**	**0.0075**	< 0.0020	< 0.0020
Dibromoacetic acid	mg/L	**0.0630**	**0.1200**	**0.1000**	**0.0048**	**0.0019**
Dichloroacetic acid	mg/L	**0.0970**	**0.1400**	**0.1000**	**0.0055**	**0.0060**
Trichloroacetic acid	mg/L	**0.0640**	**0.0640**	**0.0360**	< 0.0010	< 0.0010
Total Trihalomethanes	mg/L	**0.5700**	**0.6300**	**0.4800**	**0.1100**	**0.0400**
Bromodichloromethane	mg/L	**0.1900**	**0.1900**	**0.1500**	**0.0190**	**0.0180**
Bromoform	mg/L	**0.0500**	**0.1200**	**0.0870**	**0.0430**	**0.0023**
Chlorodibromomethane	mg/L	**0.2000**	**0.2000**	**0.1600**	**0.0440**	**0.0140**
Chloroform	mg/L	**0.1200**	**0.1200**	**0.0830**	**0.0059**	**0.0056**

Notes

1. Detections are shown in bold. Non-detects are shown as the detection limit with a preceding "<".

Table A.9

Analytical Results for Field-Filtered Enteric Virus (Analyzed by BioVir)

Date	Sample Name	Volume (L)[1)]	Analyte		Result	Units
7/8/2014	Moss Creek Lake R1	106	total culturable virus	<	0.031	MPN/L
			Enterovirus		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII (PCR)		0	GC/L
7/8/2014	Moss Creek Lake R2	72	total culturable virus	<	0.046	MPN/L
			Enterovirus		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII (PCR)		0	GC/L
7/8/2014	RO Permeate R1	719	total culturable virus	<	0.0046	MPN/L
			Enterovirus		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII (PCR)		0	GC/L
7/8/2014	RO Permeate R2	708	total culturable virus	<	0.0047	MPN/L
			Enterovirus		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII (PCR)		0	GC/L
7/8/2014	RWPF Influent	167	total culturable virus	<	0.0198	MPN/L
			Enterovirus		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII (PCR)		0	GC/L
9/16/2015	MF Source Water	322	total culturable virus	<	0.01	MPN/L
			Enterovirus (PCR)		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII(PCR)		0	GC/L
9/16/2015	RO Permeate A	2180	total culturable virus	<	0.002	MPN/L
			Enterovirus (PCR)		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII(PCR)		0	GC/L
9/16/2015	RO Permeate B	2271	total culturable virus	<	0.002	MPN/L
			Enterovirus (PCR)		0	GC/L
			Norovirus GIA (PCR)		0	GC/L
			Norovirus GIB (PCR)		0	GC/L
			Norovirus GII(PCR)		0	GC/L

Notes:

1. Volume = sample volume filtered in the field. Enteric virus were not detected in any of the samples collected. The significance of the results lies in the detection limits achieved. Samples were field-filtered using a sampling manifold provided by BioVir. The sample from each filter was then divided at the laboratory into three equal portions for analysis culture, PCR for enterovirus, and PCR for norovirus. So the detection limit is calculated by inverting one third of the sample volume.

Table A.10

Analytical Results for Male-Specific Bacteriophage (Analyzed by BioVir)

Date	Sample Name	Location	Result	Units
2/10/2015	MF Source A	Plant influent	6	PFU/100mL
2/10/2015	MF Source B	Plant influent	6	PFU/100mL
2/10/2015	MF Source C	Plant influent	10	PFU/100mL
2/10/2015	RO Feed A	RO Feed	6	PFU/100mL
2/10/2015	RO Feed B	RO Feed	12	PFU/100mL
2/10/2015	RO Feed C	RO Feed	7	PFU/100mL

Table A.11

Cryptosporidium and Giardia Results from Monthly Compliance Sampling (Ongoing from November 2013)

			Influent						Product Water					
Date	**Months Sampled**	**Lab**	**Turbidity NTU**	**Vol Filtered L**	***Crypto* Count oocysts**	***Giardia* Count cysts**	***Crypto* oocysts/L**	***Giardia* cysts/L**	**Turbidity NTU**	**Vol Filtered L**	***Crypto* Count oocysts**	***Giardia* Count cysts**	***Crypto* oocysts/L**	***Giardia* cysts/L**
11/18/13	**1**	Accurate	2.986	5.14	0	**3**	<0.19	**0.58**	NR	10.00	0	0	<0.10	<0.10
12/30/13	**2**	Accurate	NR	5.86	0	**1**	<0.17	**0.17**	NR	9.75	0	0	<0.10	<0.10
Jan-14	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
2/24/14	**3**	BioVir	NR	5.5	0	**11**	<0.18	**2.0**	NR	11.00	0	0	<0.09	<0.09
3/18/14	**4**	BioVir	14.4	7.75	**40**	**302**	**5.2**	**39**	1.16	10.75	0	0	<0.09	<0.09
Apr-14	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
5/14/14	**5**	BioVir	4.04	5.5	0	**11**	<0.18	**2.0**	0.30	10.75	0	0	<0.09	<0.09
6/11/14	**6**	BioVir	1.6	10.75	0	0	<0.09	<0.09	NR	11.00	0	0	<0.09	<0.09
7/8/14	**7**	BioVir	1.0	10.75	0	0	<0.1	<0.1	NR	10.75	0	0	<0.09	<0.09
7/8/14-dup	**7**	BioVir	1.0	10.75	0	0	<0.1	<0.1	--	--	--	--	--	--
8/27/14	**8**	BioVir	0.9	10.75	**1**	0	**0.1**	<0.09	NR	10.75	0	0	<0.09	<0.09
Sep-14	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
Oct-14	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
Nov-14	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
12/16/14	**9**	BioVir	1.29	10.75	**3**	**6**	**0.28**	**0.56**	NR	10.75	0	0	<0.09	<0.09
Jan-15	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
2/9/15	**10**	BioVir	2.62	10.75	0	**6**	<0.09	**0.56**	NR	10.75	0	0	<0.09	<0.09
2/9/15 - dup	**10**	BioVir	2.62	10.75	**1**	**8**	**0.09**	**0.74**	--	--	--	--	--	--
3/10/15	**11**	BioVir	6.8	10.75	**4**	**3494**	**0.4**	**325**	NR	10.75	0	0	<0.09	<0.09
4/14/15	**12**	BioVir	2.25	10.75	0	0	<0.09	<0.09	NR	10.75	0	0	<0.09	<0.09
5/12/15	**13**	BioVir	3.22	5.4	0	**14**	<0.09	**2.6**	NR	10.75	0	0	<0.09	<0.09
6/1/15	**14**	BioVir	6.2	10.75	0	0	<0.09	<0.09	NR	10.75	0	0	<0.09	<0.09
Jul-15	*not sampled*		--	--	--	--		--	--	--	--	--	--	--
8/10/15	**15**	BioVir	1.63	10.75	**144**	0	**13**	<0.08	NR	10.75	0	0	<0.09	<0.09
9/16/15	**16**	BioVir	1.4	10.75	**20**	0	**1.9**	<0.09	NR	10.75	0	0	<0.09	<0.09
10/13/15	**17**	BioVir	2.38	10.75	**180**	**190**	**17**	**18**	NR	10.75	0	0	<0.09	<0.09
11/23/15	**18**	BioVir	1.925	10.75	**704**	**1**	**65**	**0.09**	NR	10.75	0	0	<0.09	<0.09
12/16/15	**19**	BioVir	0.306	10.75	**53**	0	**4.9**	<0.09	NR	10.75	0	0	<0.09	<0.09
1/19/16	**20**	BioVir	0.906	10.75	**24**	**56**	**2.2**	**5.2**	NR	10.75	0	0	<0.09	<0.09
2/23/16	**21**	BioVir	8.5	10.75	**460**	**198**	**43**	**18**	NR	10.75	0	0	<0.09	<0.09
3/15/16	**22**	BioVir	8.93	10.75	**6**	**9**	**0.6**	**0.8**	NR	10.75	0	0	<0.09	<0.09
4/15/16	**23**	BioVir	3.5	10.75	**13**	**500**	**1.2**	**47**	NR	10.75	0	0	<0.09	<0.09
5/3/16	**24**	BioVir	1.85	10.75	0	**3**	<0.09	**0.3**	NR	10.75	0	0	<0.09	<0.09

Notes

1) NR = not recorded

2) Cloth Filters at Big Spring WWTP were being bypassed when this sample was collected. RWPF was operating intermittently to adhere to 10 NTU shut-down condition, though the particular sample collected for analysis had higher turbidity than reflected in the online measurements. No pathogens were detected in the product water despite higher influent concentrations.

Table A.12

Analytical Results for Cryptosporidium and Giardia for Major Sample Events

Date	Sample Name	Parameter	Results		Units
7/8/2014	MF Filtrate R1	Crypto	<	0.1	oocysts/L
7/8/2014	MF Filtrate R1	Giardia	<	0.1	cysts/L
7/8/2014	MF Filtrate R2	Crypto	<	0.1	oocysts/L
7/8/2014	MF Filtrate R2	Giardia	<	0.1	cysts/L
7/8/2014	RWPF influent R1	Crypto	<	0.1	oocysts/L
7/8/2014	RWPF influent R1	Giardia	<	0.1	cysts/L
7/8/2014	RWPF influent R2	Crypto	<	0.1	oocysts/L
7/8/2014	RWPF influent R2	Giardia	<	0.1	cysts/L
7/7/2014	Product Water	Crypto	<	0.1	oocysts/L
7/7/2014	Product Water	Giardia	<	0.1	cysts/L
7/8/2014	Moss Creek Lake R1	Crypto	<	0.1	oocysts/L
7/8/2014	Moss Creek Lake R1	Giardia	<	0.1	cysts/L
7/8/2014	Moss Creek Lake R2	Crypto	<	0.1	oocysts/L
7/8/2014	Moss Creek Lake R2	Giardia	<	0.1	cysts/L
7/8/2014	RO Permeate R1	Crypto	<	0.1	oocysts/L
7/8/2014	RO Permeate R1	Giardia	<	0.1	cysts/L
7/8/2014	RO Permeate R2	Crypto	<	0.1	oocysts/L
7/8/2014	RO Permeate R2	Giardia	<	0.1	cysts/L
2/11/2015	MF Filtrate R1	Crypto	<	0.1	oocysts/L
2/11/2015	MF Filtrate R1	Giardia	<	0.1	cysts/L
2/11/2015	MF Filtrate R2	Crypto	<	0.1	oocysts/L
2/11/2015	MF Filtrate R2	Giardia	<	0.1	cysts/L
2/11/2015	MF Source Water #1	Crypto	<	0.1	oocysts/L
2/11/2015	**MF Source Water #1**	**Giardia**	**0.6**		**cysts/L**
2/11/2015	**MF Source Water #2**	**Crypto**	**0.1**		**oocysts/L**
2/11/2015	**MF Source Water #2**	**Giardia**	**0.8**		**cysts/L**
2/11/2015	Product Water	Crypto	<	0.1	oocysts/L
2/11/2015	Product Water	Giardia	<	0.1	cysts/L
2/11/2015	Moss Creek Lake R1	Crypto	<	0.1	oocysts/L
2/11/2015	Moss Creek Lake R1	Giardia	<	0.1	cysts/L
2/11/2015	Moss Creek Lake R2	Crypto	<	0.1	oocysts/L
2/11/2015	Moss Creek Lake R2	Giardia	<	0.1	cysts/L
6/2/2015	RO Feed	Crypto	<	0.1	oocysts/L
6/2/2015	RO Feed	Giardia	<	0.1	cysts/L
6/1/2015	MF Source Water	Crypto	<	0.1	oocysts/L
6/1/2015	MF Source Water	Giardia	<	0.1	cysts/L
6/1/2015	Product Water	Crypto	<	0.1	oocysts/L
6/1/2015	Product Water	Giardia	<	0.1	cysts/L
9/16/2015	Product Water	Crypto	<	0.1	oocysts/L
9/16/2015	Product Water	Giardia	<	0.1	cysts/L
9/16/2015	MF Source Water	Crypto	**1.9**		oocysts/L
9/16/2015	MF Source Water	Giardia	<	0.1	cysts/L

Notes:

Detections are shown in bold. Non-detects are shown as detection limits with a preceding "<."

Table A.13

Analytical Results for E. Coli Samples (Analyzed by City of Odessa Water Quality Lab)

Date	Sample Name	Parameter	Results	Units
7/8/2014	RO Feed A	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed B	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed C	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed D	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed E	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed F	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed G	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed H	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed I	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Feed J	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water A	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water B	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water C	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water D	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water E	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water F	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water G	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water H	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water I	E. Coli	< 1.0	MPN/100mL
7/8/2014	RWPF Source Water J	E. Coli	< 1.0	MPN/100mL
7/8/2014	Moss Creek A	E. Coli	< 1.0	MPN/100mL
7/8/2014	Moss Creek B	E. Coli	**1.0**	MPN/100mL
7/8/2014	Moss Creek C	E. Coli	< 1.0	MPN/100mL
7/8/2014	Finished A	E. Coli	< 1.0	MPN/100mL
7/8/2014	Finished B	E. Coli	< 1.0	MPN/100mL
7/8/2014	Finished C	E. Coli	< 1.0	MPN/100mL
7/8/2014	AOP Feed A	E. Coli	< 1.0	MPN/100mL
7/8/2014	AOP Feed B	E. Coli	< 1.0	MPN/100mL
7/8/2014	AOP Feed C	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Concen A	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Concen B	E. Coli	< 1.0	MPN/100mL
7/8/2014	RO Concen C	E. Coli	< 1.0	MPN/100mL
2/10/2015	Finished A	E. Coli	< 1.0	MPN/100mL
2/10/2015	Finished B	E. Coli	< 1.0	MPN/100mL
2/10/2015	Finished C	E. Coli	< 1.0	MPN/100mL
2/10/2015	Raw Inf A	E. Coli	**5.2**	MPN/100mL
2/10/2015	Raw Inf B	E. Coli	**4.1**	MPN/100mL
2/10/2015	Raw Inf C	E. Coli	**11.8**	MPN/100mL
2/10/2015	Moss Creek A	E. Coli	**6.3**	MPN/100mL
2/10/2015	Moss Creek B	E. Coli	**8.6**	MPN/100mL
2/10/2015	Moss Creek C	E. Coli	**14.6**	MPN/100mL

Table A.13

Analytical Results for E. Coli Samples (Analyzed by City of Odessa Water Quality Lab)

Date	Sample Name	Parameter	Results	Units
6/2/2015	Product Water A	E. Coli	< 1.0	MPN/100mL
6/2/2015	Product Water B	E. Coli	< 1.0	MPN/100mL
6/2/2015	Product Water C	E. Coli	< 1.0	MPN/100mL
6/2/2015	MF Source Water A	E. Coli	**1.0**	MPN/100mL
6/2/2015	MF Source Water B	E. Coli	**2.0**	MPN/100mL
6/2/2015	MF Source Water C	E. Coli	< 1.0	MPN/100mL
6/2/2015	Moss Creek A	E. Coli	**2.0**	MPN/100mL
6/2/2015	Moss Creek B	E. Coli	**3.1**	MPN/100mL
6/2/2015	Moss Creek C	E. Coli	**1.0**	MPN/100mL
9/16/2015	Moss Creek A	E. Coli	< 1.0	MPN/100mL
9/16/2015	Moss Creek B	E. Coli	**2.0**	MPN/100mL
9/16/2015	Moss Creek C	E. Coli	**1.0**	MPN/100mL
9/16/2015	Product Water A	E. Coli	< 1.0	MPN/100mL
9/16/2015	Product Water B	E. Coli	< 1.0	MPN/100mL
9/16/2015	Product Water C	E. Coli	< 1.0	MPN/100mL
9/16/2015	MF Source Water A	E. Coli	< 1.0	MPN/100mL
9/16/2015	MF Source Water B	E. Coli	< 1.0	MPN/100mL
9/16/2015	MF Source Water C	E. Coli	< 1.0	MPN/100mL

Notes:

Detections are shown in bold. Non-detects are shown as detection limits with a preceding "<."

Table A.14

Yeast Estrogen Screen (Yes) Assay Qualitative Results (SNWA Laboratory)

Date	Sample Location	Result[1)]
7/17/2014	Moss Creek Lake	**Present**
7/17/2014	RWPF Influent	Absent
7/17/2014	RO Feed	Absent
7/17/2014	AOP Feed	Absent
7/17/2014	Finished water	Absent
7/17/2014	Field Blank	Absent
2/10/2015	Moss Creek Lake	Absent
2/10/2015	RWPF Influent	Absent
2/9/2015	RO Feed	Absent
2/9/2015	AOP Feed	Absent
2/9/2015	Field Blank	Absent

Notes

1) Quantitative results were not available. A result reported as "present" indicates estrogenic activity in the low ng/L range.

Table A.15

Results from Onsite Adenosine Triphosphate Testing (cATP/mL)

Sample Location	Mean of Two Samples			Mean of	"Standard Deviation" of Two Samples			St'd Deviation of
Sample Date	2/10/2015	6/1/2015	9/15/2015	All Data Points	2/10/2015	6/1/2015	9/15/2015	All Data Points
MF Source (before chloramines)	1.71E+02	1.51E+01	4.79E+00	6.38E+01	2.49E+01	2.91E-01	5.54E-01	8.42E+01
MF Feed (after chloramines)	7.02E+01	3.69E+02	6.69E+01	1.69E+02	1.89E+01	3.04E+00	8.22E+00	1.55E+02
MF Filtrate	5.16E+01	1.78E+01	5.11E-01	2.33E+01	9.29E+00	1.76E+00	8.55E-02	2.36E+01
RO Feed (After tank)	5.18E+01	1.38E+01	5.61E-01	2.21E+01	6.60E+00	3.24E+00	6.84E-03	2.40E+01
AOP Feed (RO Permeate)	1.73E-01	2.62E-02	4.34E-02	8.08E-02	7.43E-02	1.43E-02	2.71E-02	8.01E-02
Product Water	1.54E-01	6.45E-02	6.45E-02	9.43E-02	5.31E-03	2.00E-02	4.85E-02	5.18E-02
DI (from Lab)	2.98E+00	6.05E-02	not sampled	1.52E+00	no duplicate	no duplicate	not sampled	2.07E+00

Table A.16

Summary of Particle Counts and Turbidity Measured on Particle Count Samples (Carollo Internal Lab)

Date	Sample #	Sample Particle Counts						Sample Turbidity		
		Protozoa (5-15 um)			Bacteria (1-5 um)					
		MF Feed	MF Filtrate	Event LRV	MF Feed	MF Filtrate	Event LRV	MF Feed	MF Filtrate	Event LRV
		count[1)]	count	--	count	count	--	NTU	NTU	--
7/8/2014	1	1,936	1	3.08	5,620	3.7	3.17	1.41	0.34	0.75
7/8/2014	2	2,039	0		6,027	3.8		1.02	0.13	
7/8/2014	3	1,939	1		5,488	3.7		0.81	0.13	
7/8/2014	4	1,644	4		4,820	3.7		0.84	0.13	
2/10/2015	A	13,130	74	2.03	108,567	398	2.29	5.85	0.17	1.50
2/11/2015	B	10,284	257		100,160	1080		5.39	0.28	
2/12/2015	C	12,606	25		113,811	248		5.57	0.13	
2/13/2015	D	10,621	81		104,318	462		6.03	0.14	
6/2/2015	A	5495	42	2.45	13602	329	1.99	7.52	0.15	1.52
6/2/2015	B	5430	6		12987	46		6.08	0.22	
6/2/2015	C	2060	10		11031	64		3.14	0.13	
6/2/2015	D	5698	7		14962	99		7.11	0.23	
9/15/2015	A1	1,719	5	1.96	5708	85	1.22	2.01	0.26	0.95
9/15/2015	A2	1,624	27		4900	416		2.02	0.23	
9/15/2015	B1	1,522	19		4681	338		1.96	0.19	
9/15/2015	B2	898	12		2868	261		2.04	0.22	

Notes

1. Particle counts include all particles detected in the size range indicated for each pathogen type.

Table A.17

Field Measurements of Monochloramine, Ammonia, Total Chlorine (HACH Test Kits) and pH

	Date Collected	Monochloramine (mg/L)	Ammonia (mg/L)	Total Chlorine (mg/L)	pH
Product Water	NS				
AOP Feed	7/7/2014	1.78	0	1.9	
RO Feed	7/7/2014	2.16	0.14	3	6.5
RO Concentrate	7/7/2014	2.44	0.34	4.7	
Product Water	2/9/2015	0.23	0.01	0.1	
AOP Feed	2/9/2015	1.07	0	1.2	
RO Feed	2/9/2015	1.09	0.23	1.9	6.8
RO Concentrate	2/9/2015	1.11	0.32	1.8	6.57
Product Water	6/1/2015	0.23	0	0.5	
AOP Feed	6/1/2015	0.67	0	0.7	
RO Feed	6/1/2015	0.66	0.28	0.98	
RO Concentrate	6/1/2015	0.68	0.55	1.7	6.58
RW Water (before tank)	6/1/2015	0.08	0.04	1.1	6.3
Product Water	9/14/2015	0.16	0	0.5	5.25
AOP Feed	9/14/2015	0.92	0	1	5.2
RO Feed	9/14/2015	0.99	0	1.3	6.53
RO Concentrate	9/14/2015	1.05	0.12	2.4	6.95
RW Water (before tank)	9/14/2015	2.04, 1.4, 1.89	0, OR, 0.16	2.4, 0.4	6.77
MF Feed	9/14/2015	0.91, 0.09	0.47, 0.11	2.5, 0.4	6.74

Note: NS = not sampled, OR = out of range

Table A.18

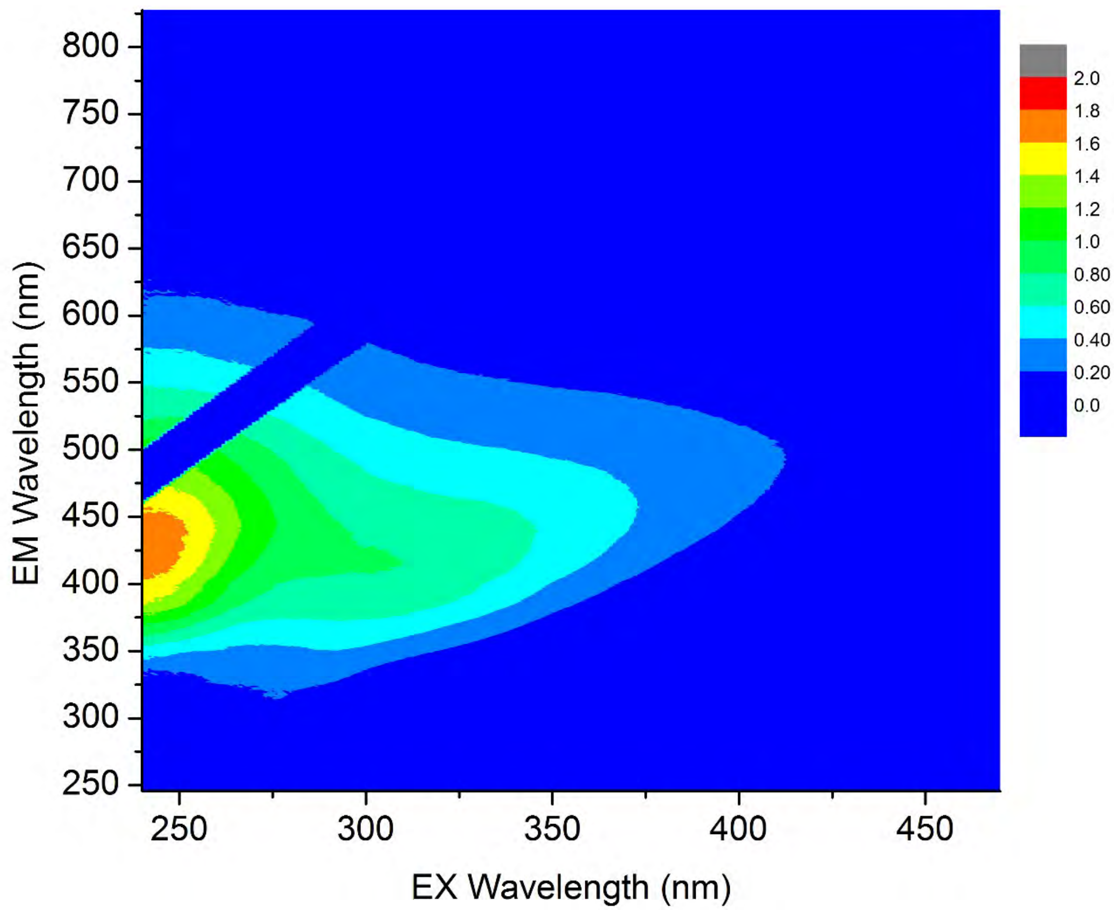
Analytical Results for 1,4-Dioxane Samples (Analyzed by Eurofins / Eaton Analytical)

Date	Sample Location	Analyte	Result		Units
4/18/2016	Influent	1,4-Dioxane		**0.36**	ug/L
4/18/2016	Product Water	1,4-Dioxane	<	0.07	ug/L
5/19/2016	Influent	1,4-Dioxane		**0.29**	ug/L
5/19/2016	RO Feed	1,4-Dioxane		**0.26**	ug/L
5/19/2016	AOP Feed	1,4-Dioxane	<	0.07	ug/L
5/19/2016	Product Water	1,4-Dioxane	<	0.07	ug/L
5/19/2016	Moss Creek Lake	1,4-Dioxane	<	0.07	ug/L

Notes:

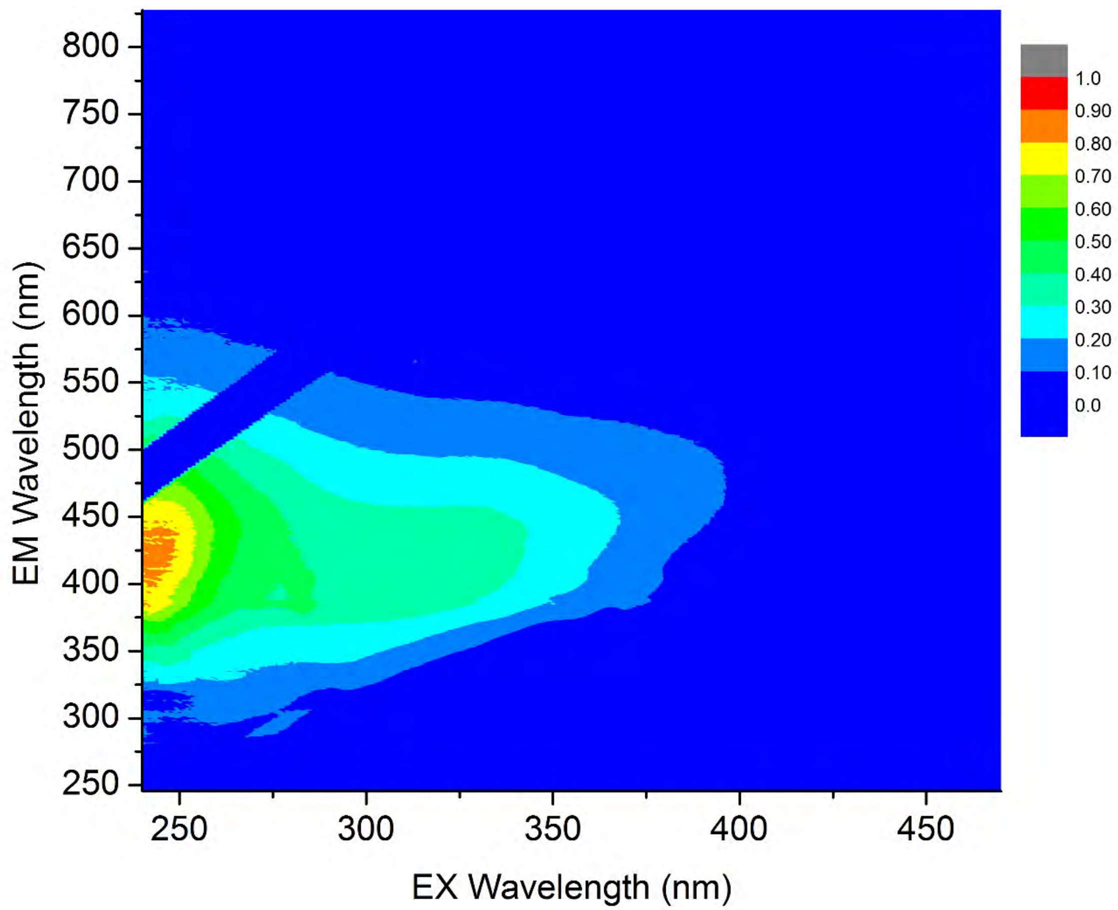
Analysis for 1,4-dioxane was added at the end of the test schedule due to an original omission from the analyte list. Since it was detected in the influent in April 2016, a full set of sample analyses was conducted across the treatment train in May 2016.

Figure A.1 Moss Creek Lake EEM - July 2014



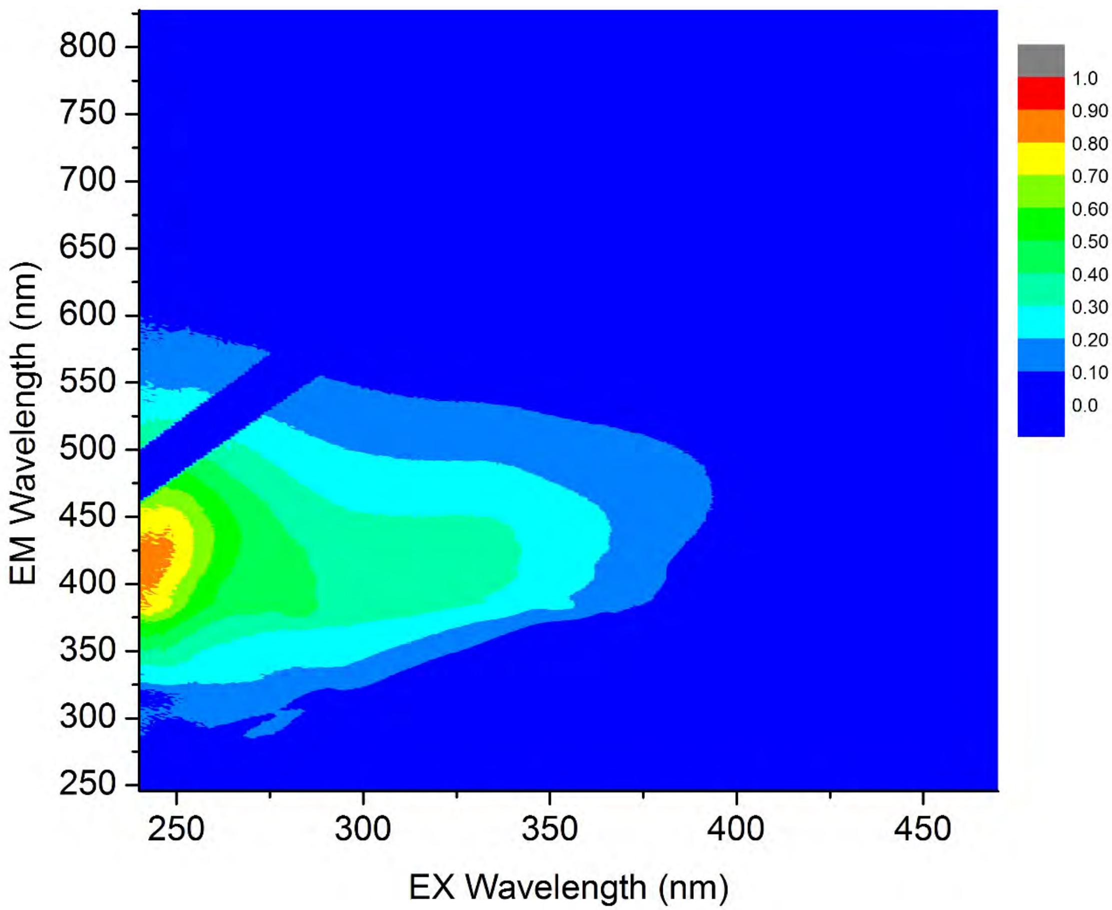
Sample Date: 7/8/2014
Location: Moss Creek Lake
ID: TWDB 14060422-001

Figure A.2 RWPF Influent EEM - July 2014



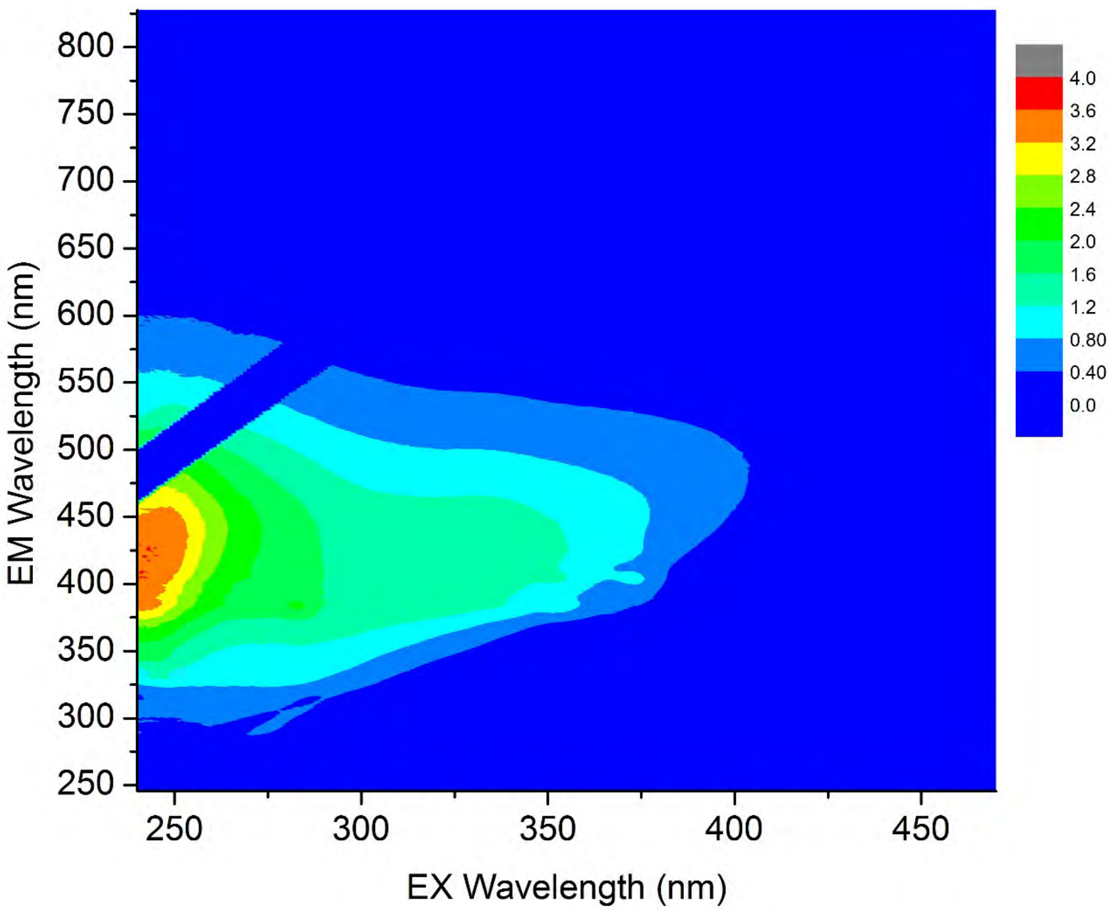
Sample Date: 7/7/2014
Location: RWPF Influent
ID: TWDB 14060422-002

Figure A.3 RO Feed EEM - July 2014



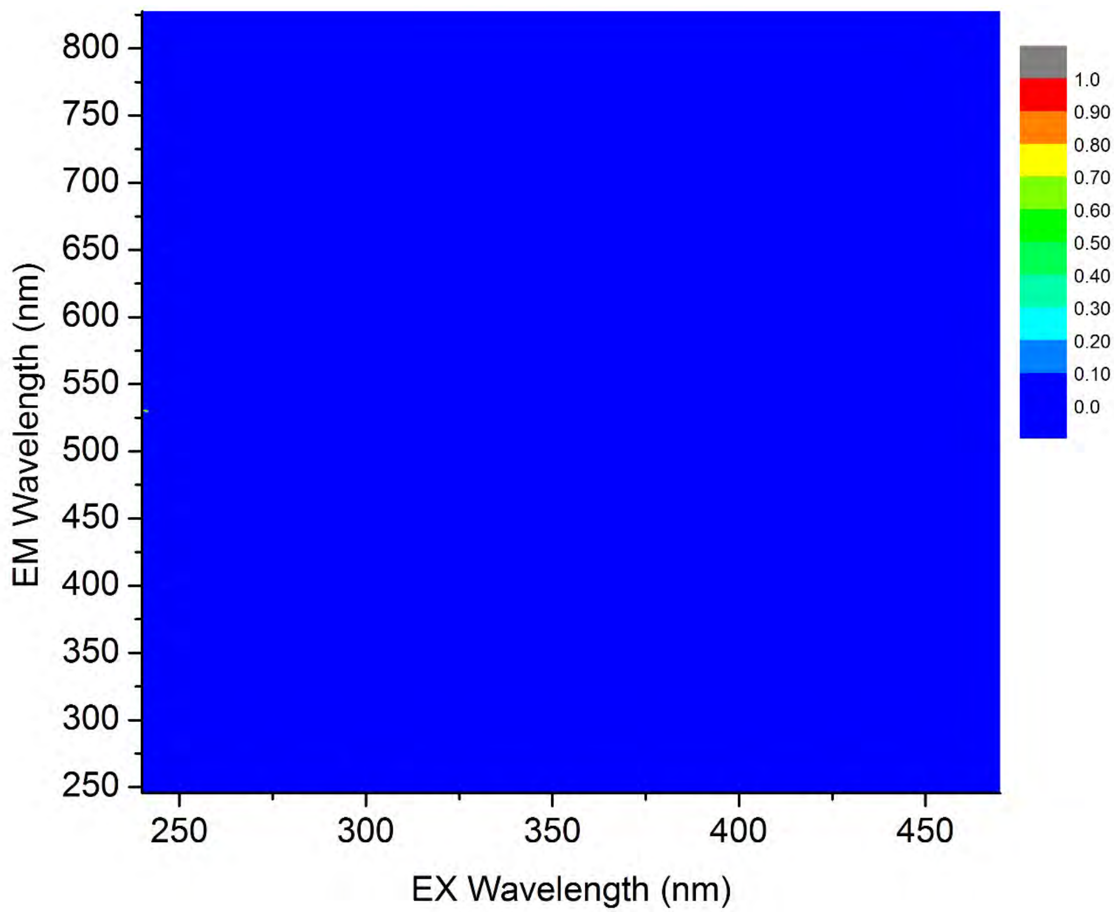
Sample Date: 7/7/2014
Location: RO Feed
ID: TWDB 14060422-003

Figure A.4 RO Concentrate EEM - July 2014



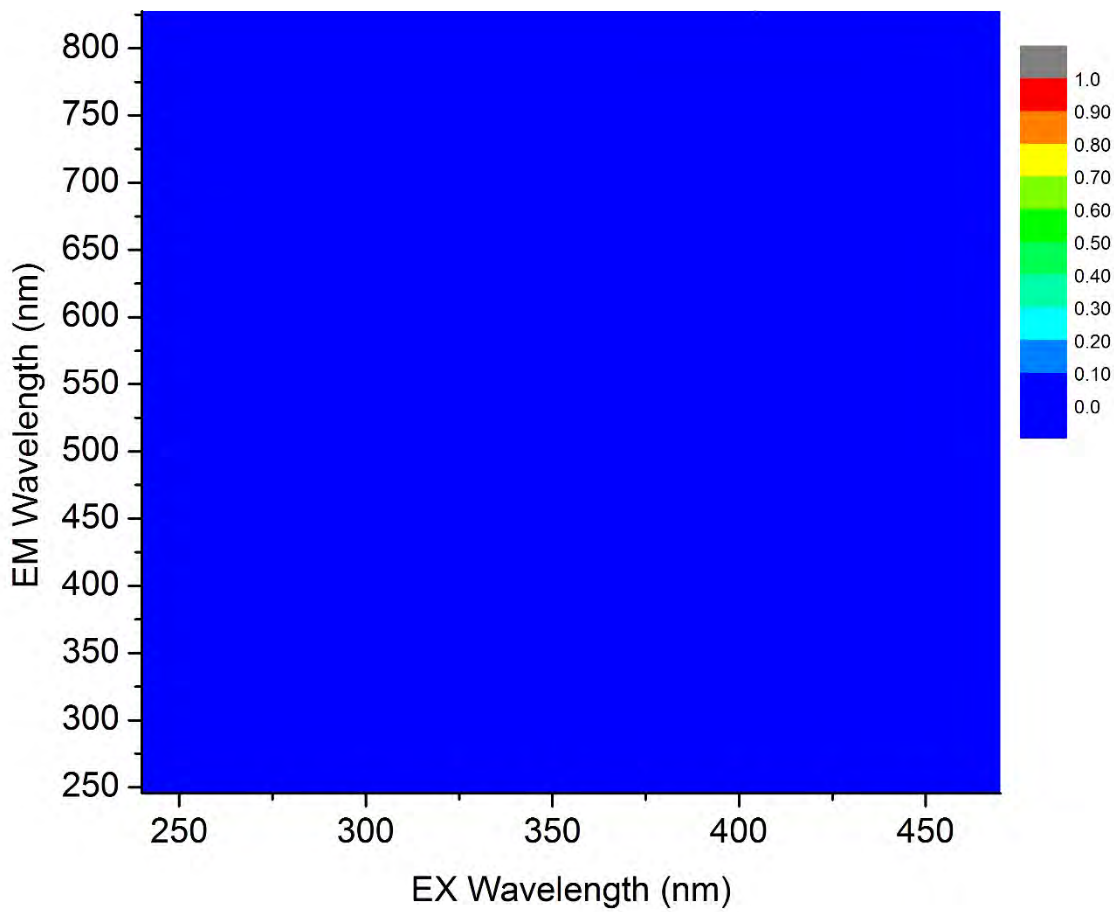
Sample Date: 7/7/2014
Location: RO Concentrate
ID: TWDB 14060422-004

Figure A.5 AOP Feed EEM - July 2014



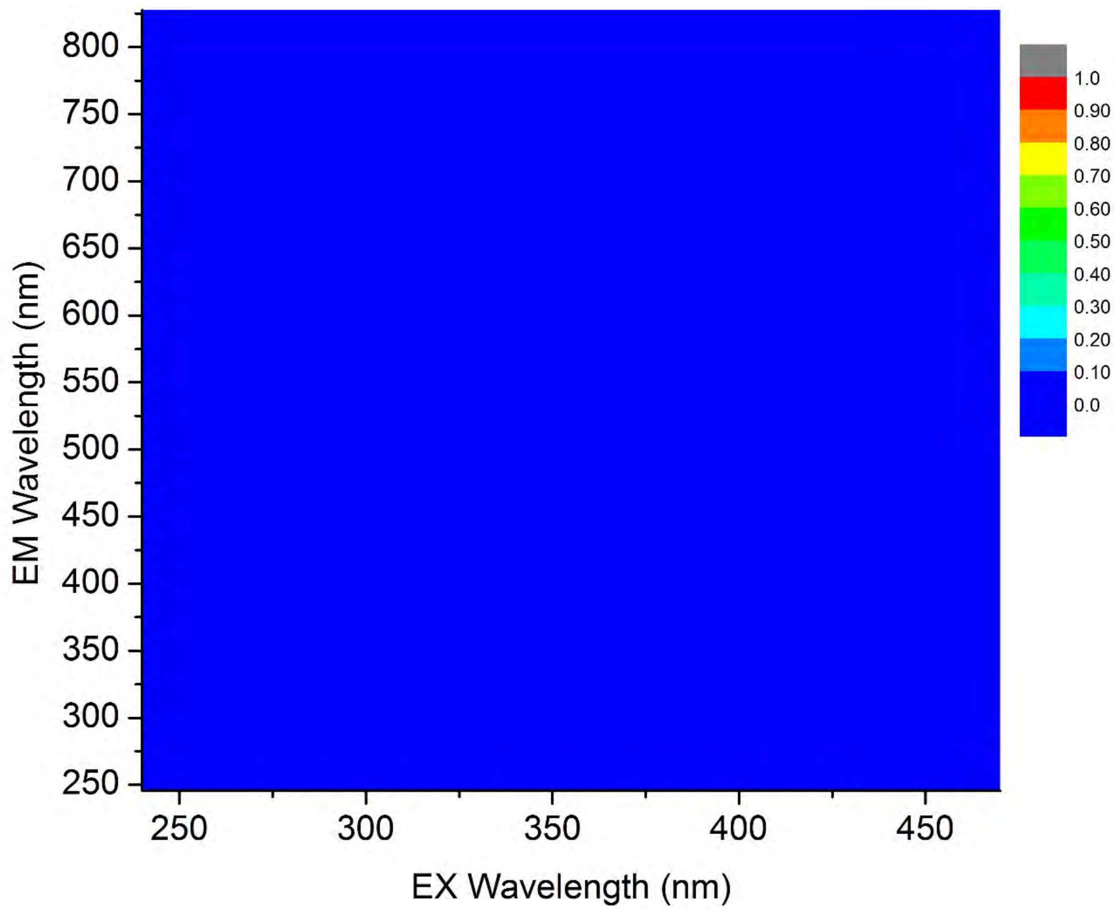
Sample Date: 7/7/2014
Location: AOP Feed
ID: TWDB 14060422-005

Figure A.6 AOP Feed Duplicate - July 2014



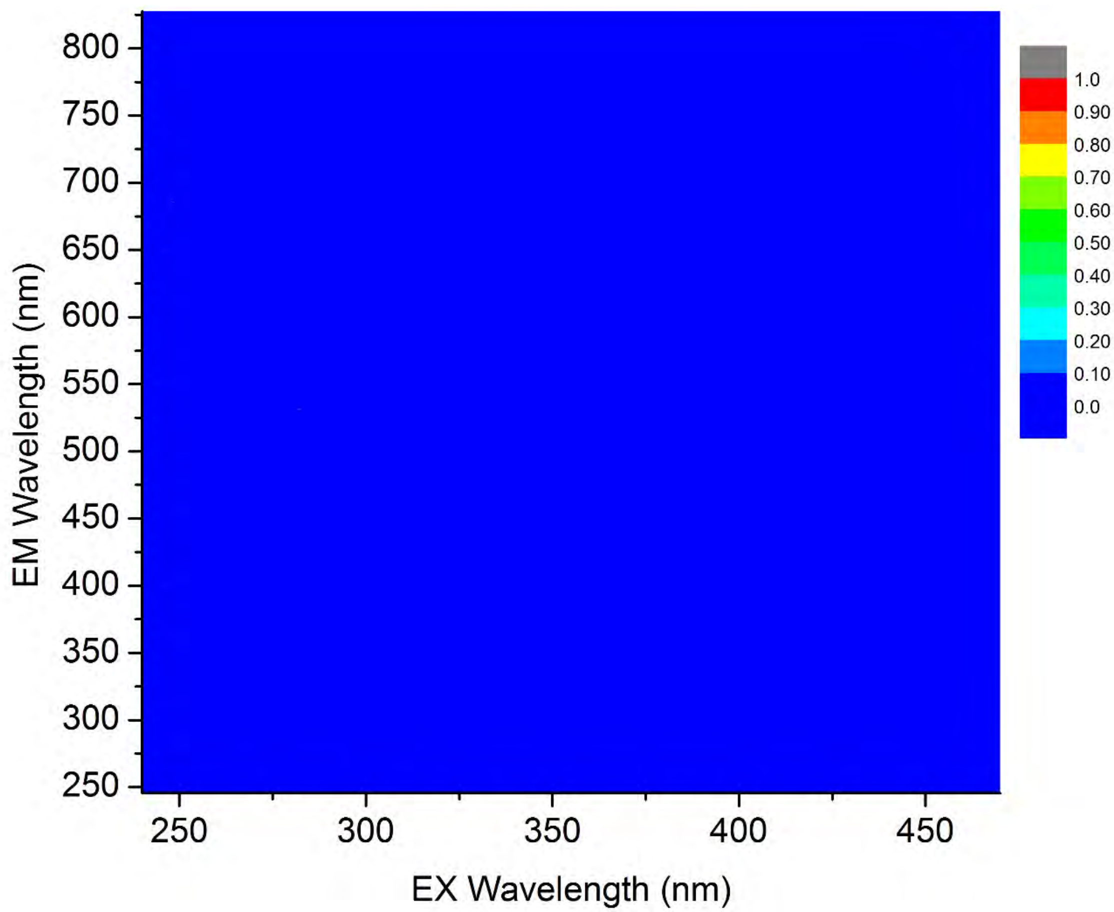
Sample Date: 7/7/2014
Location: AOP Feed Duplicate
ID: TWDB 14060422-005 dup

Figure A.7 Product Water EEM - July 2014



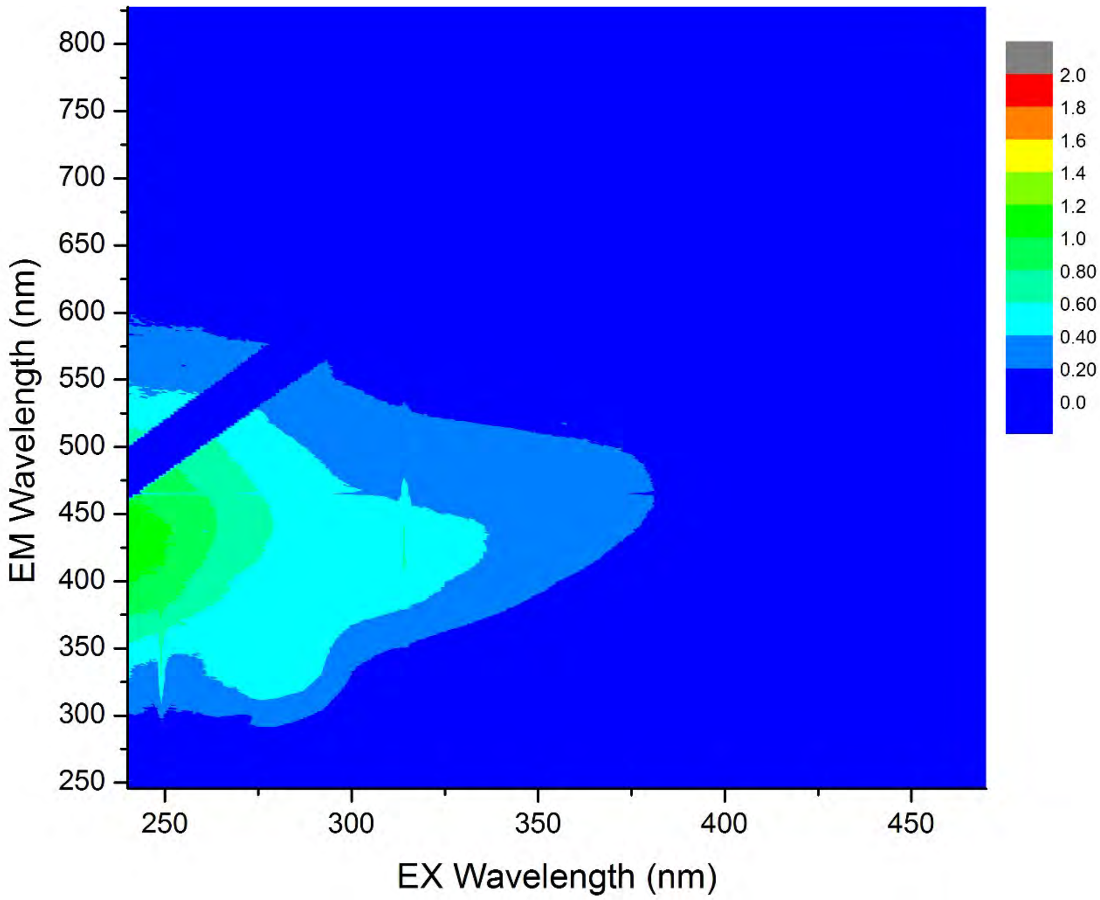
Sample Date: 7/7/2014
Location: Product Water
ID: TWDB 14060422-006

Figure A.8 Field Blank EEM - July 2014



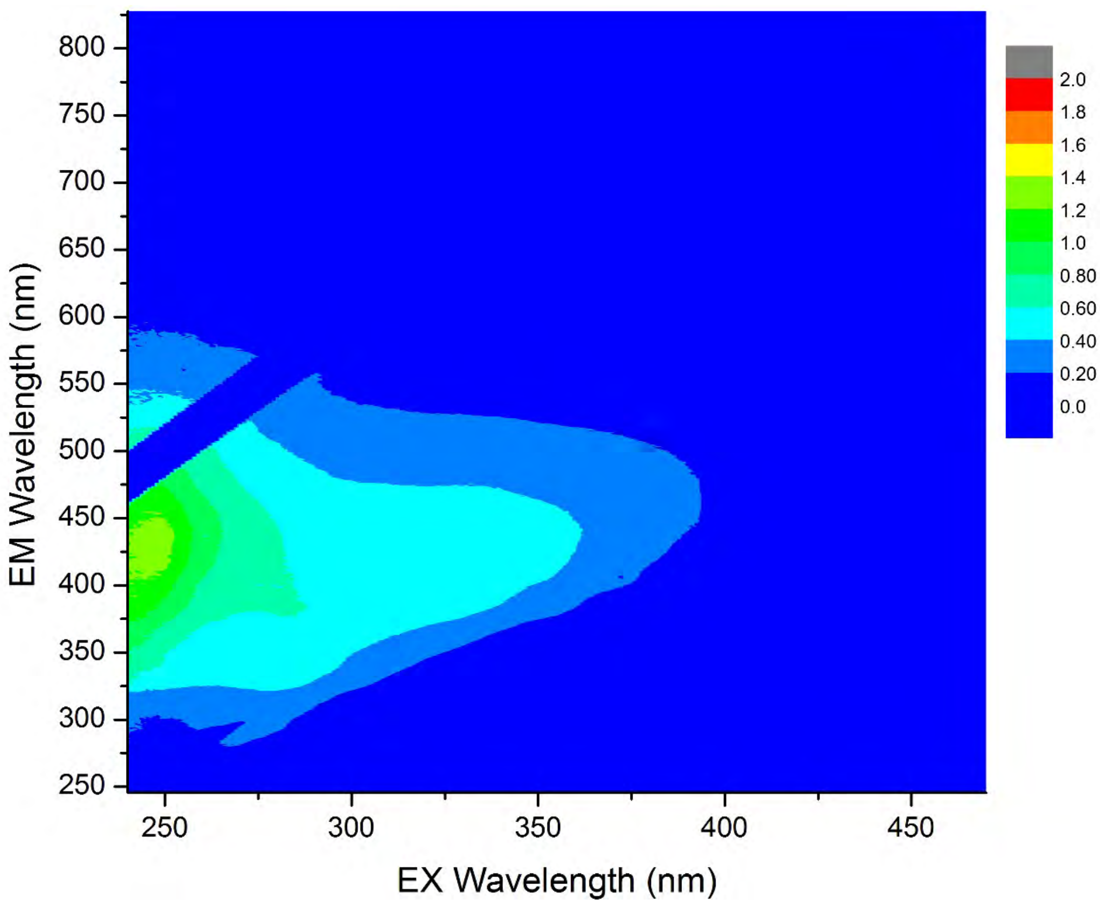
Sample Date: 7/7/2014
Location: Field Blank
ID: TWDB 14060422-007

Figue A.9 Moss Creek Lake - February 2015



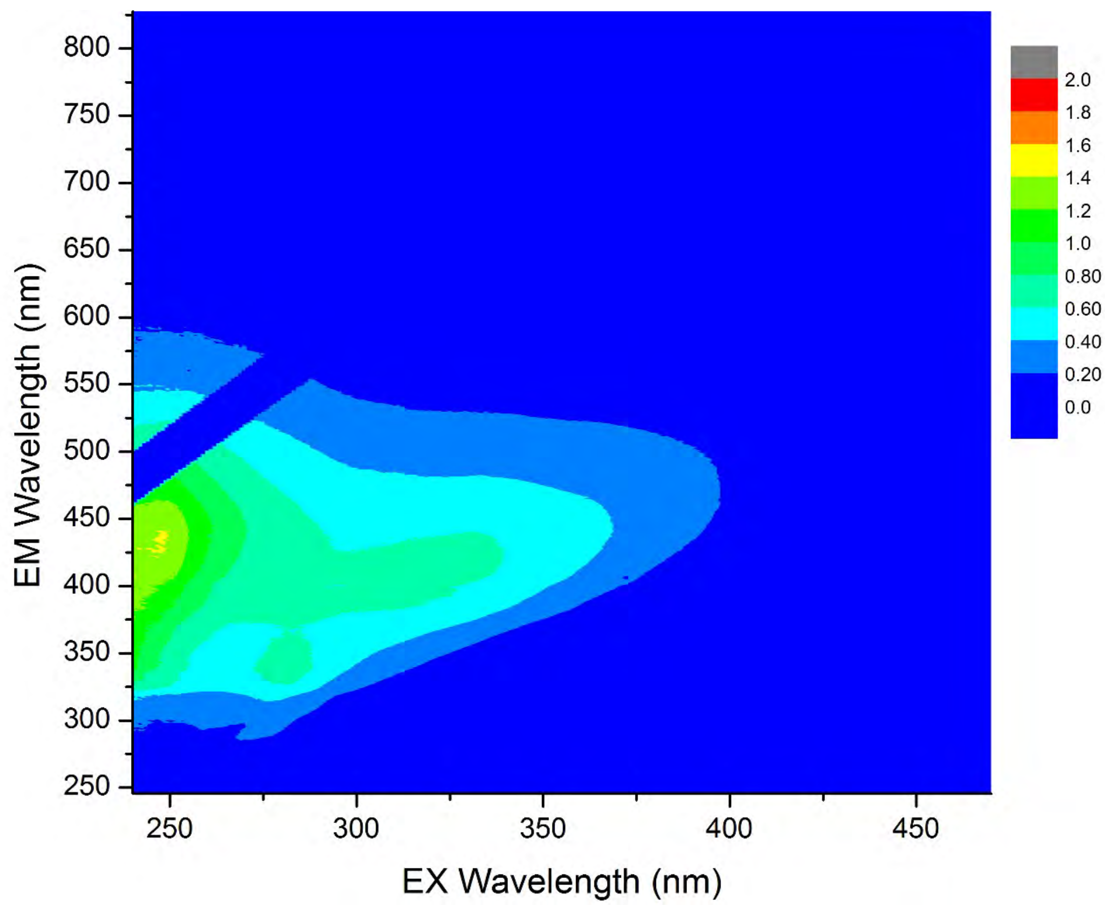
Sample Date: 2/10/2015
Location: Moss Creek Lake
ID: TWDB 15010437-001

Figure A.10 RWPF Influent EEM - February 2015



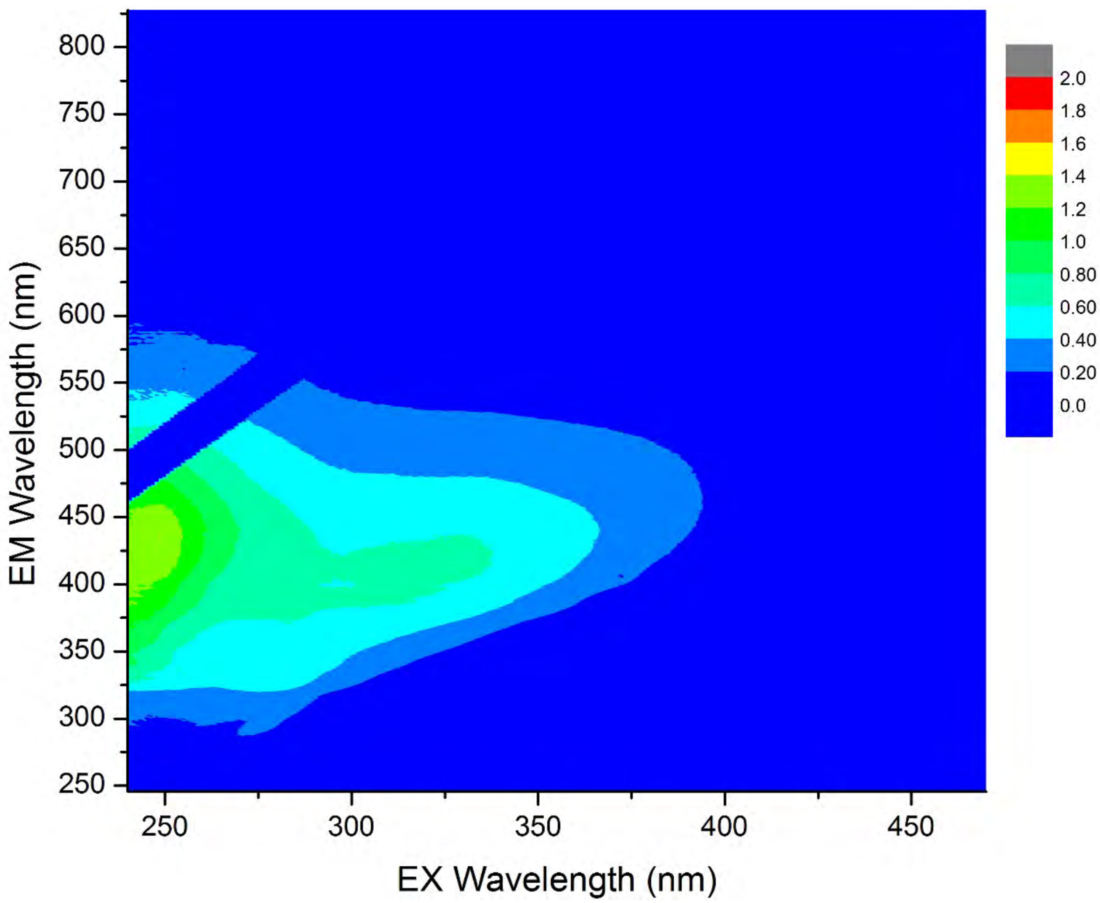
Sample Date: 2/10/2015
Location: RWPF Influent
ID: TWDB 15010437-002

Figure A.11 RO Feed EEM - February 2015



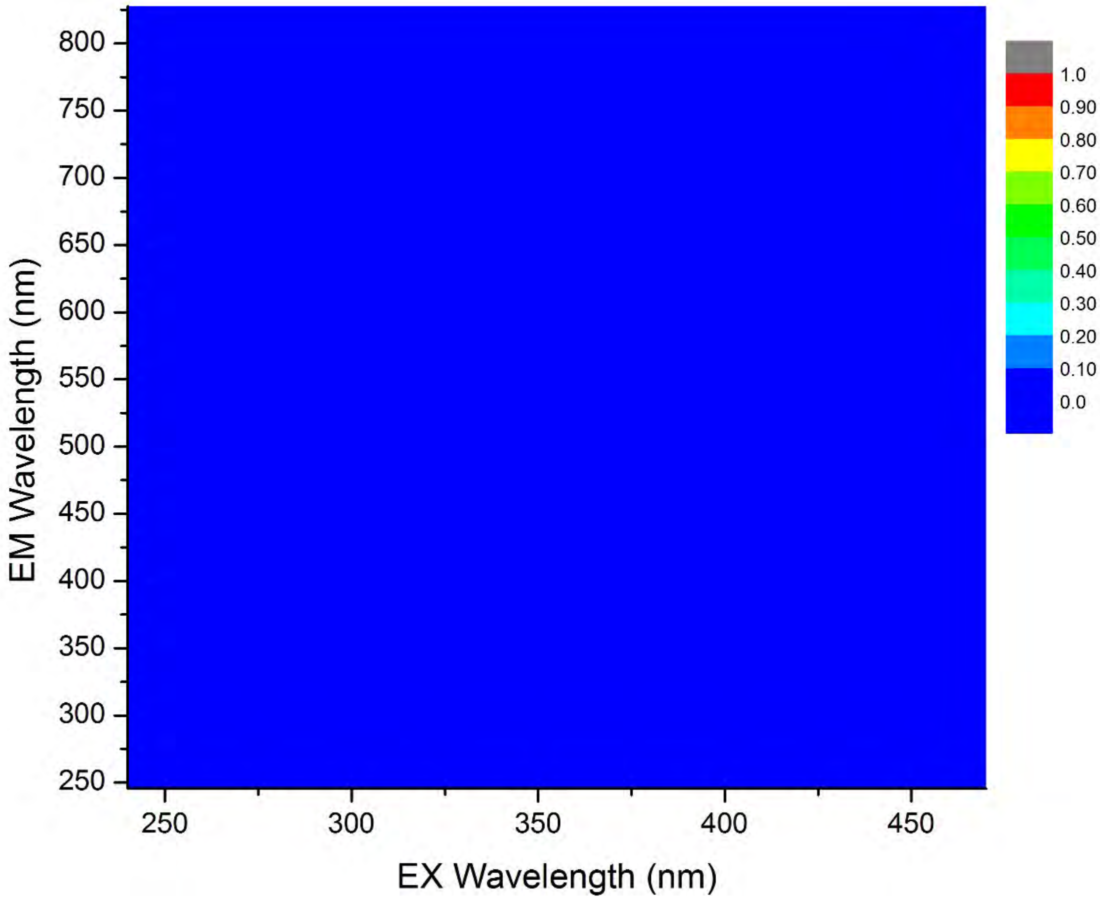
Sample Date: 2/9/2015
Location: RO Feed
ID: TWDB 15010437-003

Figure A.12 RO Concentrate EEM - February 2015



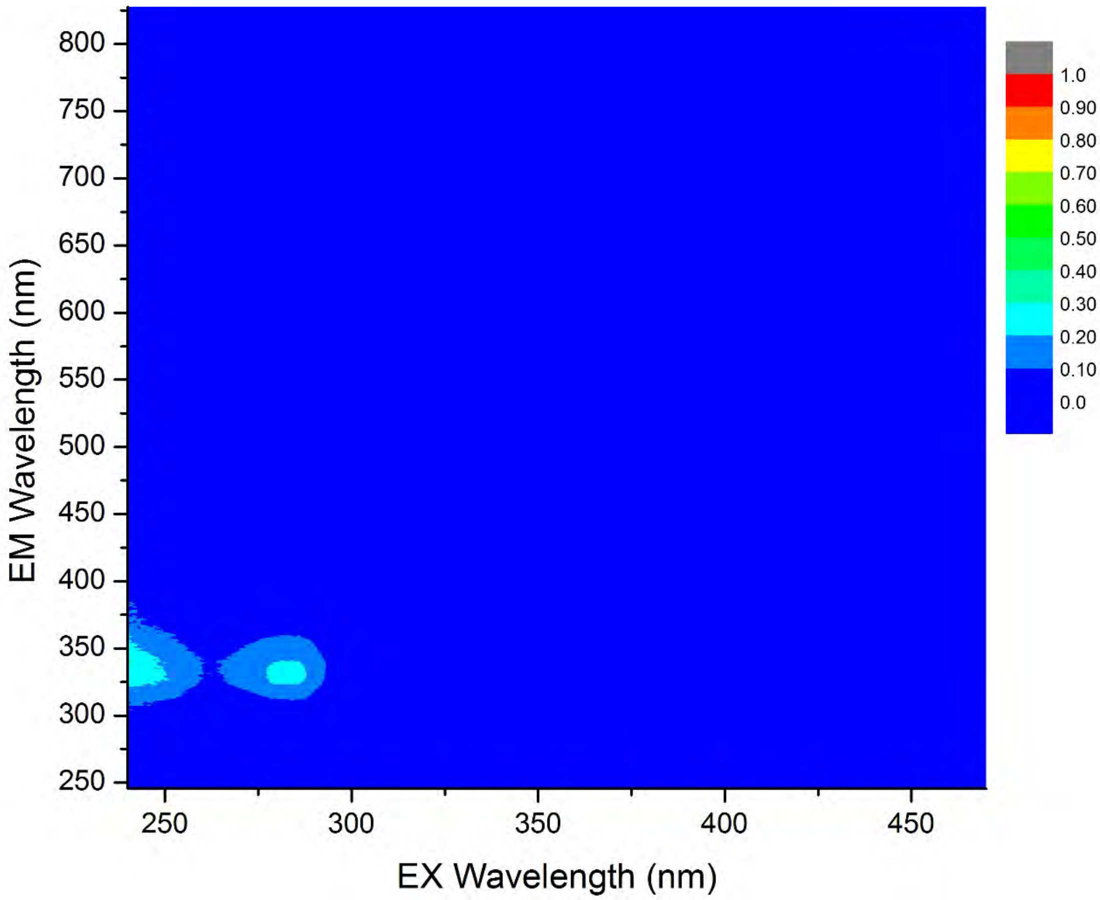
Sample Date: 2/9/2015
Location: RO Concentrate
ID: TWDB 15010437-004

Figure A.13 AOP Feed EEM - February 2015



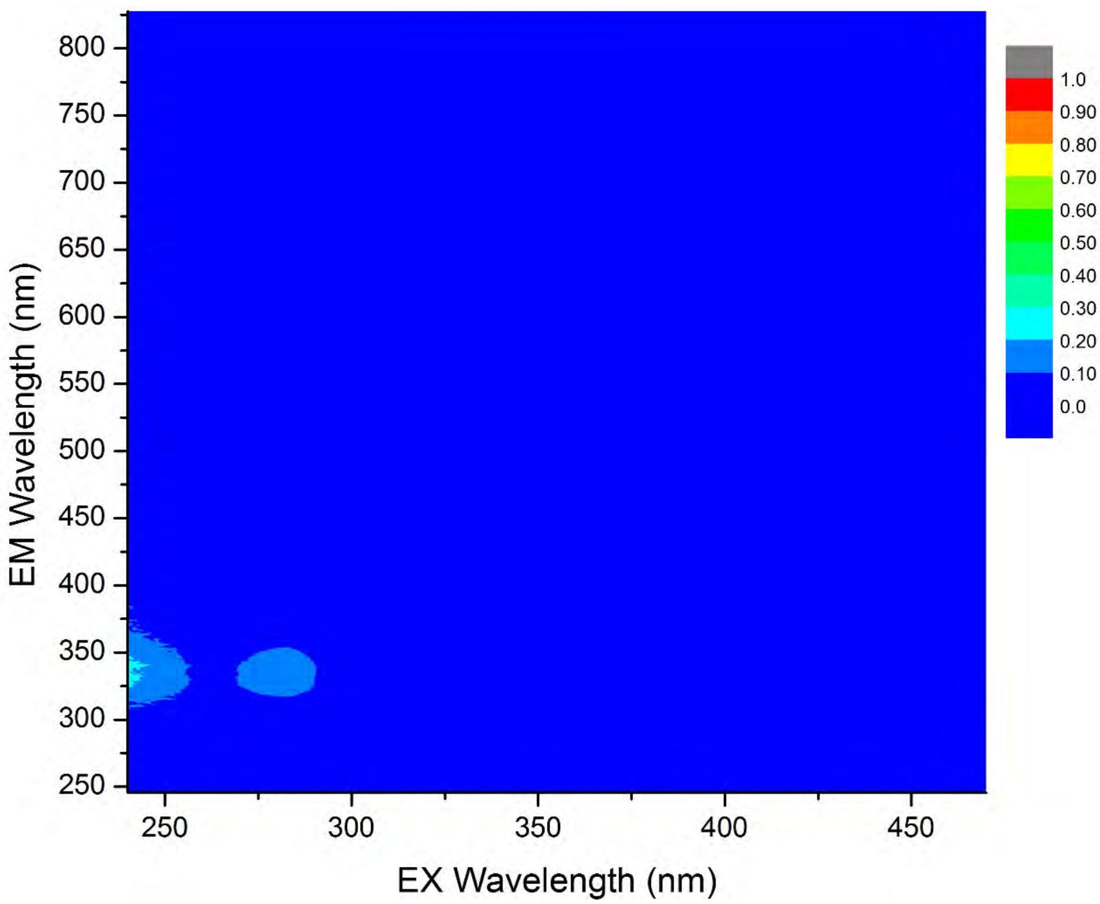
Sample Date: 2/9/2015
Location: AOP Feed
ID: TWDB 15010437-005

Figure A.14 Product Water EEM - February 2015



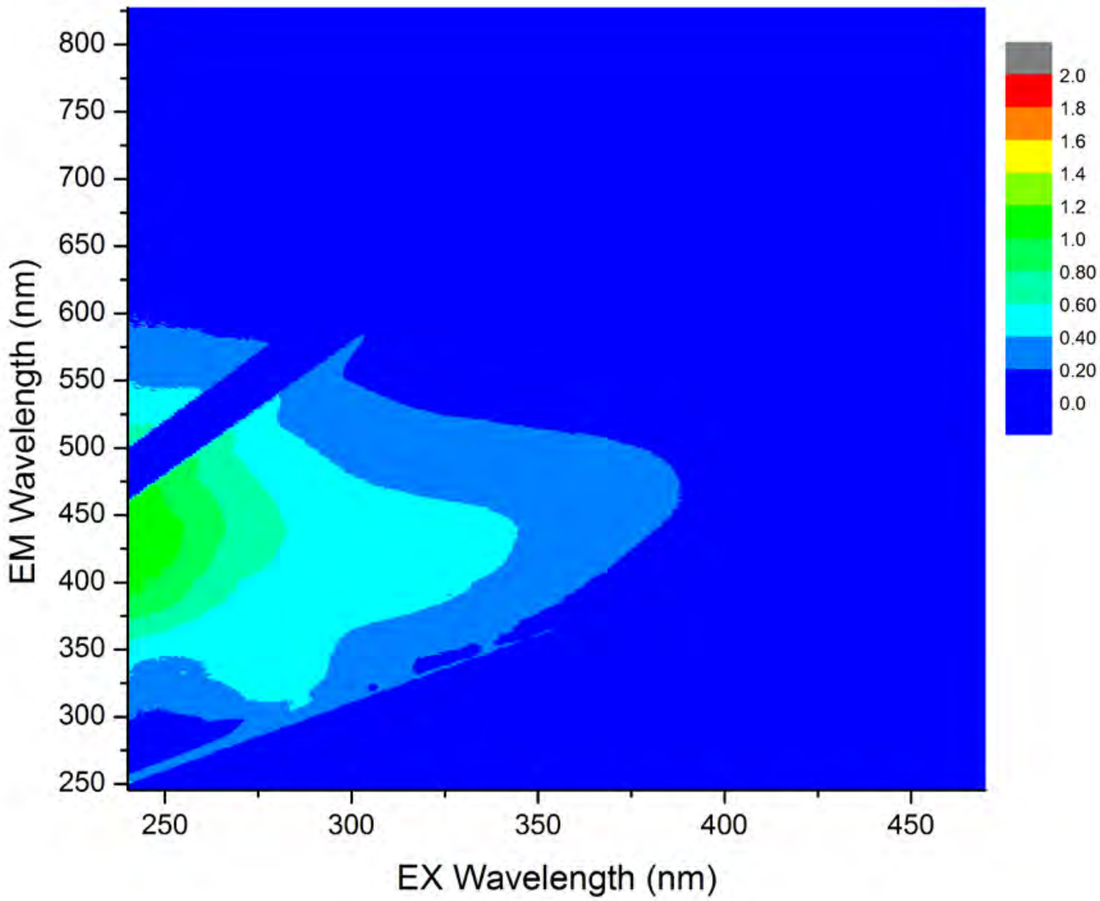
Sample Date: 2/9/2015
Location: Product Water
ID: TWDB 15010437-006

Figure A.15 Field Blank EEM - February 2015



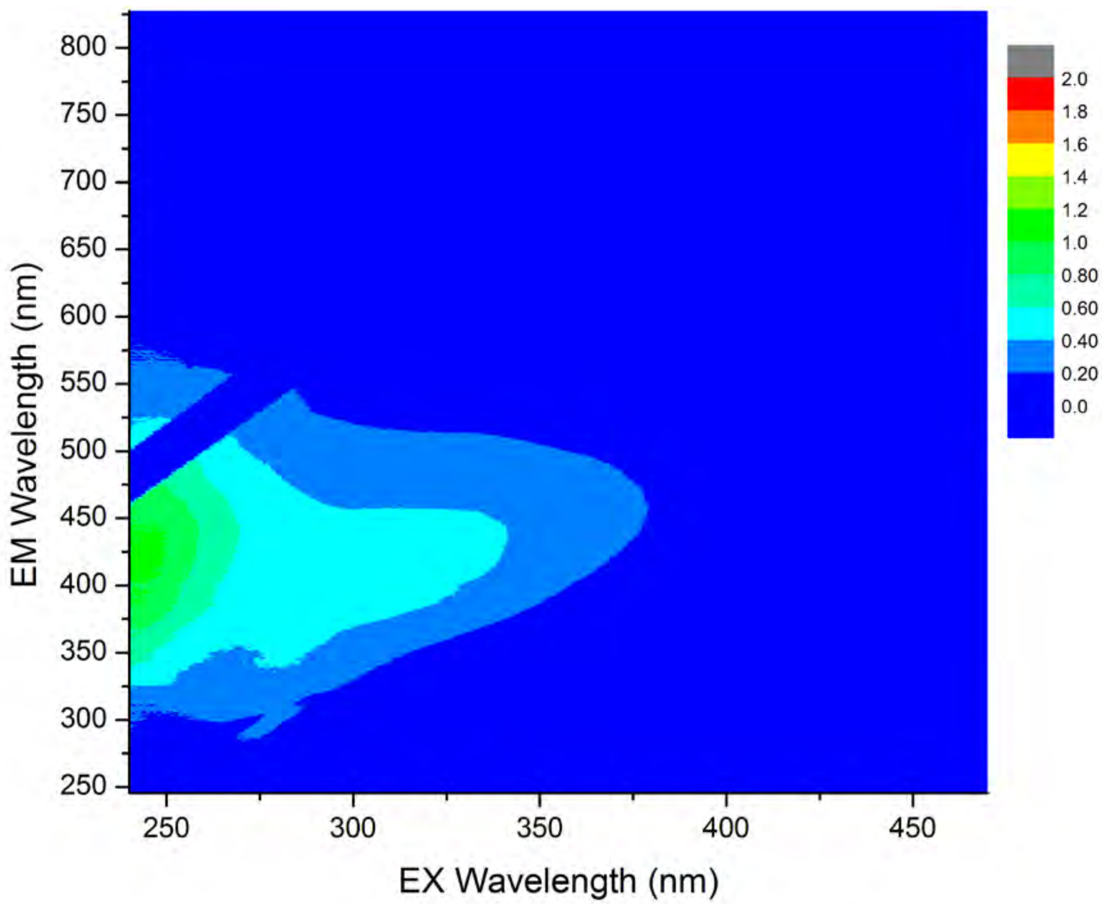
Sample Date: 2/9/2015
Location: Field Blank
ID: TWDB 15010437-007

Figure A.16 Moss Creek Lake EEM - June 2015



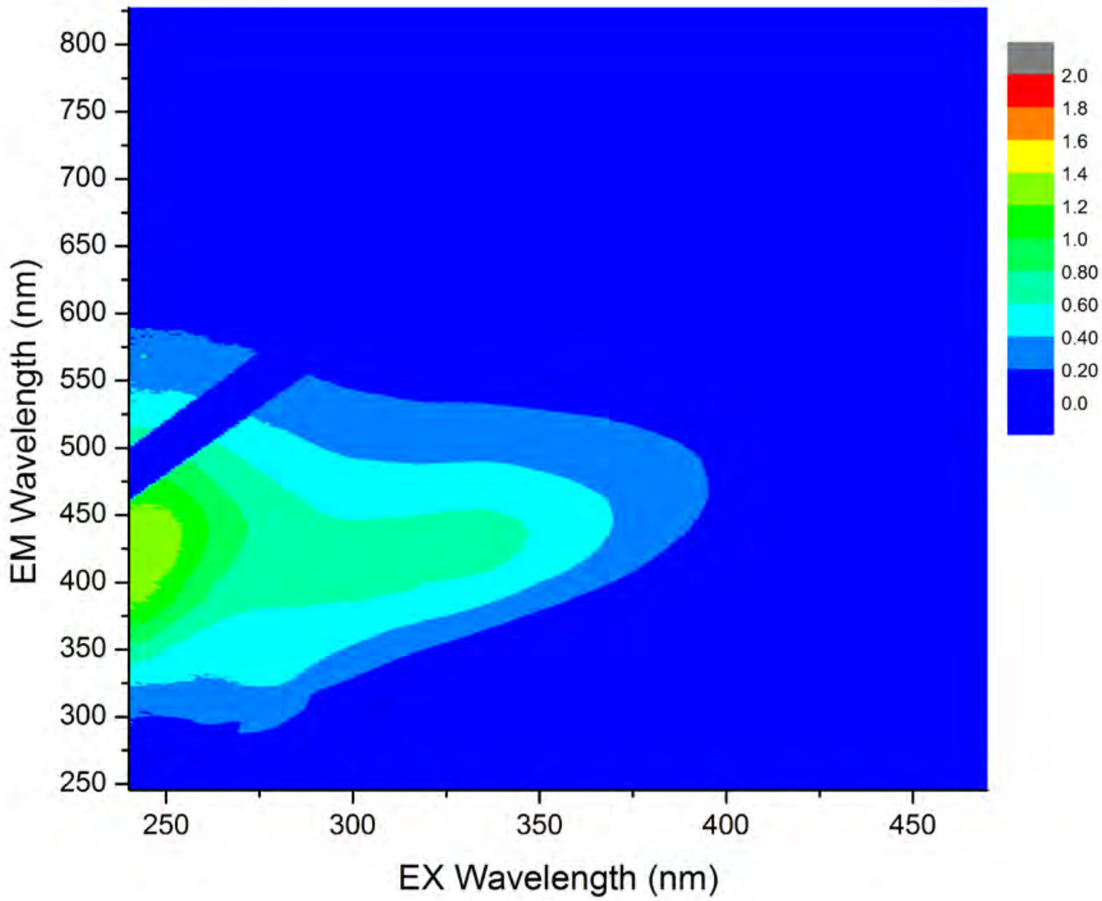
Sample Date: 6/2/2015
Location: Moss Creek Lake
ID: TWDB 15050416-001

Figure A.17 RWPF Influent EEM - June 2015



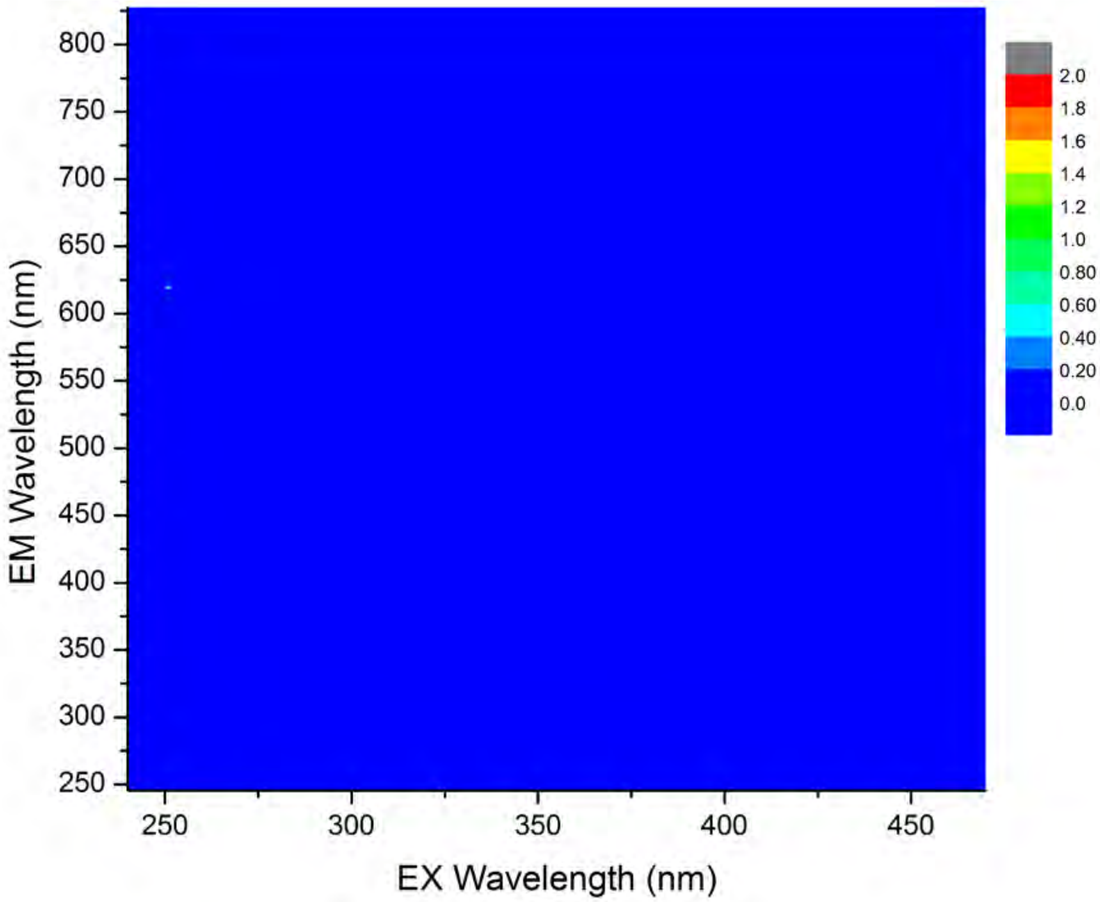
Sample Date: 6/1/2015
Location: RWPF Influent
ID: TWDB 15050416-002

Figure A.18 RO Feed EEM - June 2015



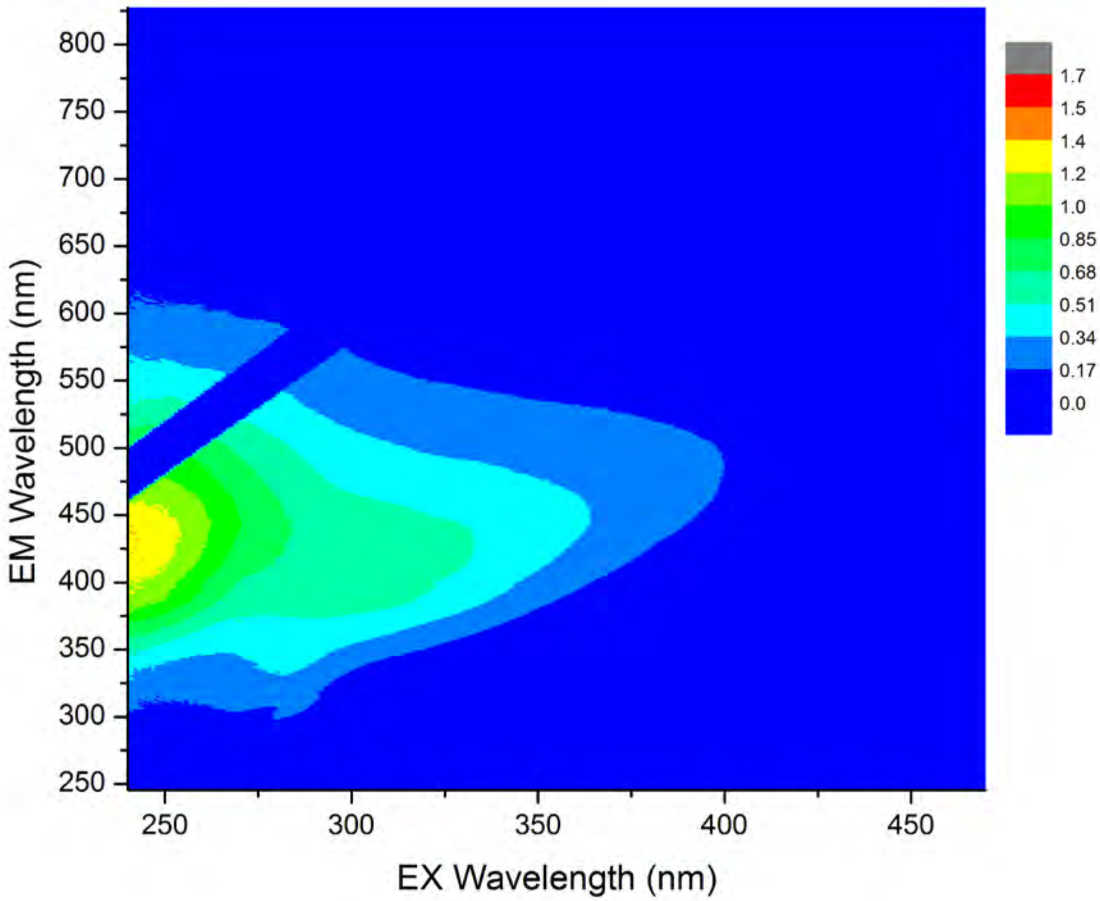
Sample Date: 6/1/2015
Location: RO Feed
ID: TWDB 15050416-003

Figure A.19 AOP Feed EEM - June 2015



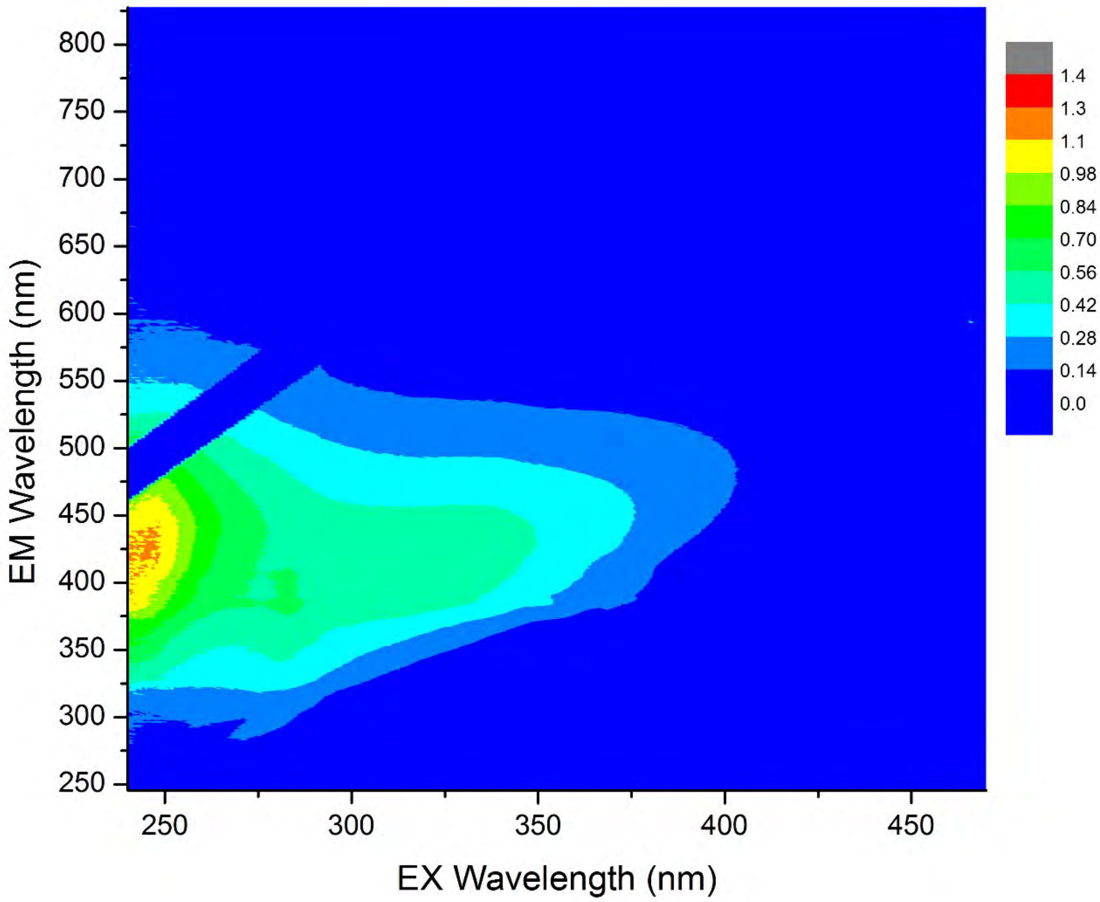
Sample Date: 6/1/2015
Location: AOP Feed
ID: TWDB 15050416-004

Figure A.20 Moss Creek Lake EEM - September 2015



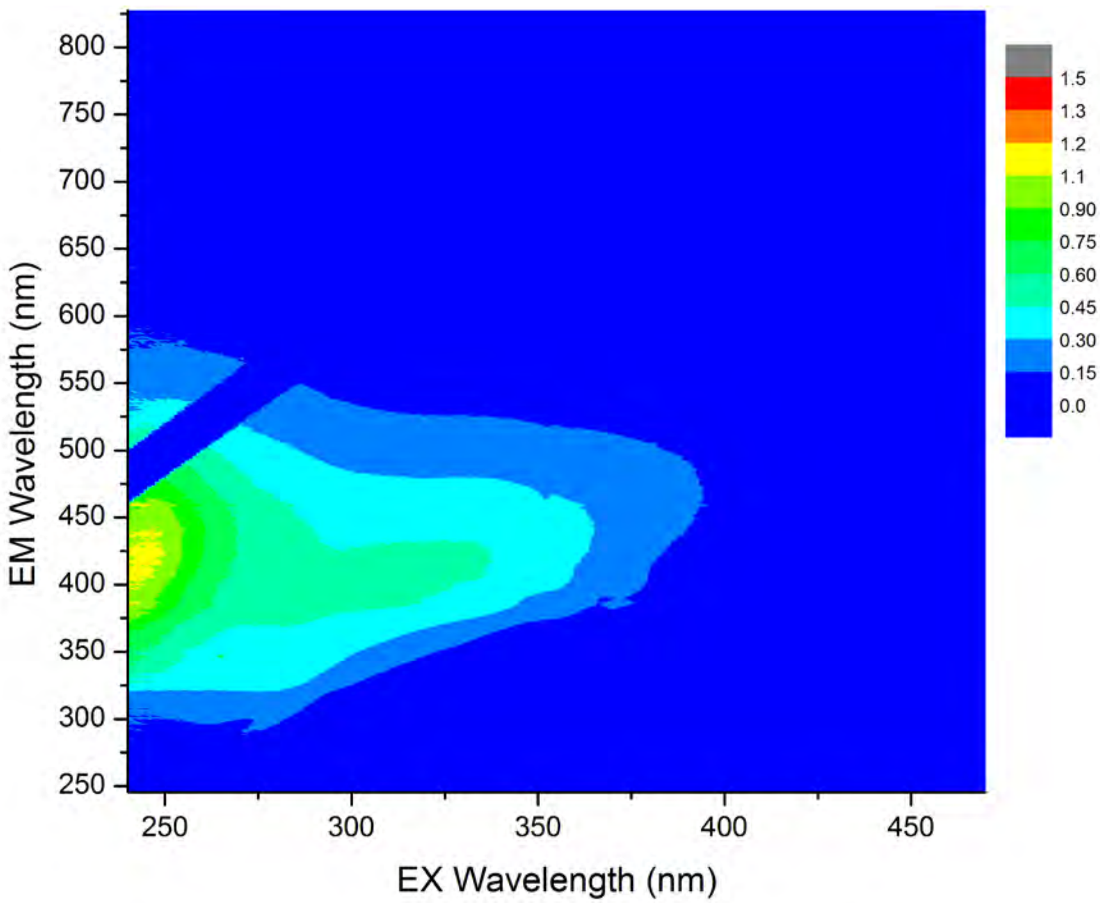
Sample Date: 9/16/2015
Location: Moss Creek Lake
ID: TWDB 15080563-001

Figure A.21 RWPF Influent EEM - September 2015



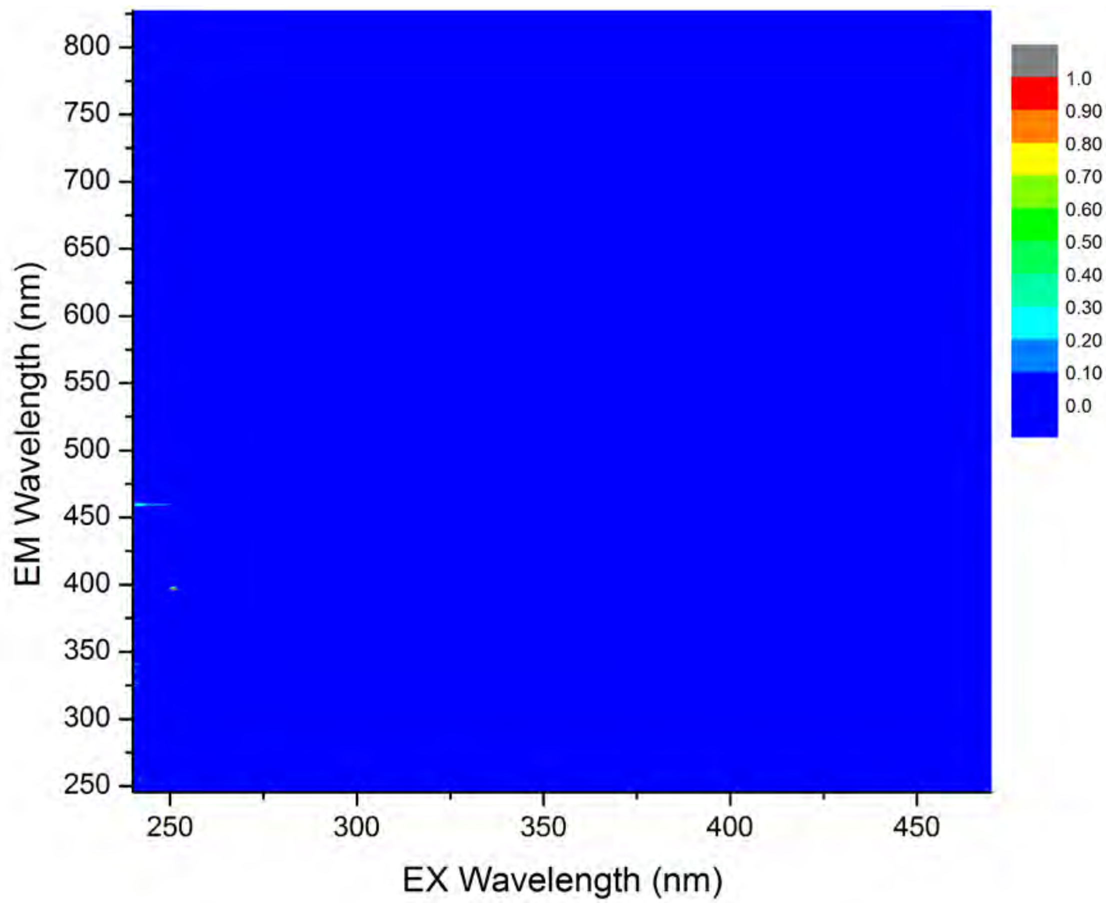
Sample Date: 9/15/2015
Location: RWPF Influent
ID: TWDB 15080563-002

Figure A.22 RO Feed EEM - September 2015



Sample Date: 9/15/2015
Location: RO Feed
ID: TWDB 15080563-003

Figure A.23   AOP Feed EEM - September 2015



Sample Date: 9/15/2015
Location: AOP Feed
ID: TWDB 15080563-004

Figure A.24 Particle Size Distribution for Samples Collected 8 July 2014

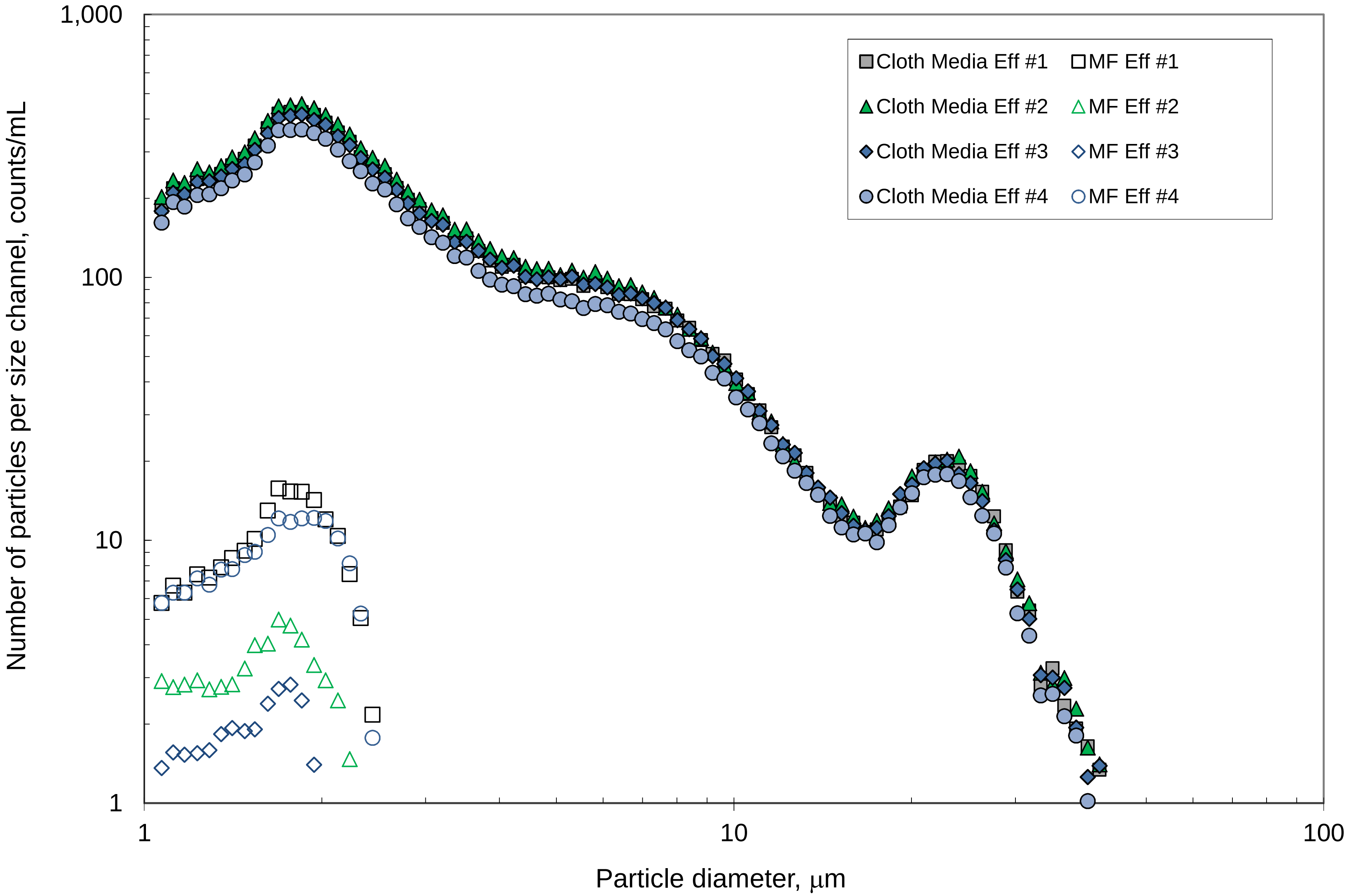


Figure A.25 Particle Size Distribution for Samples Collected 10 February 2015

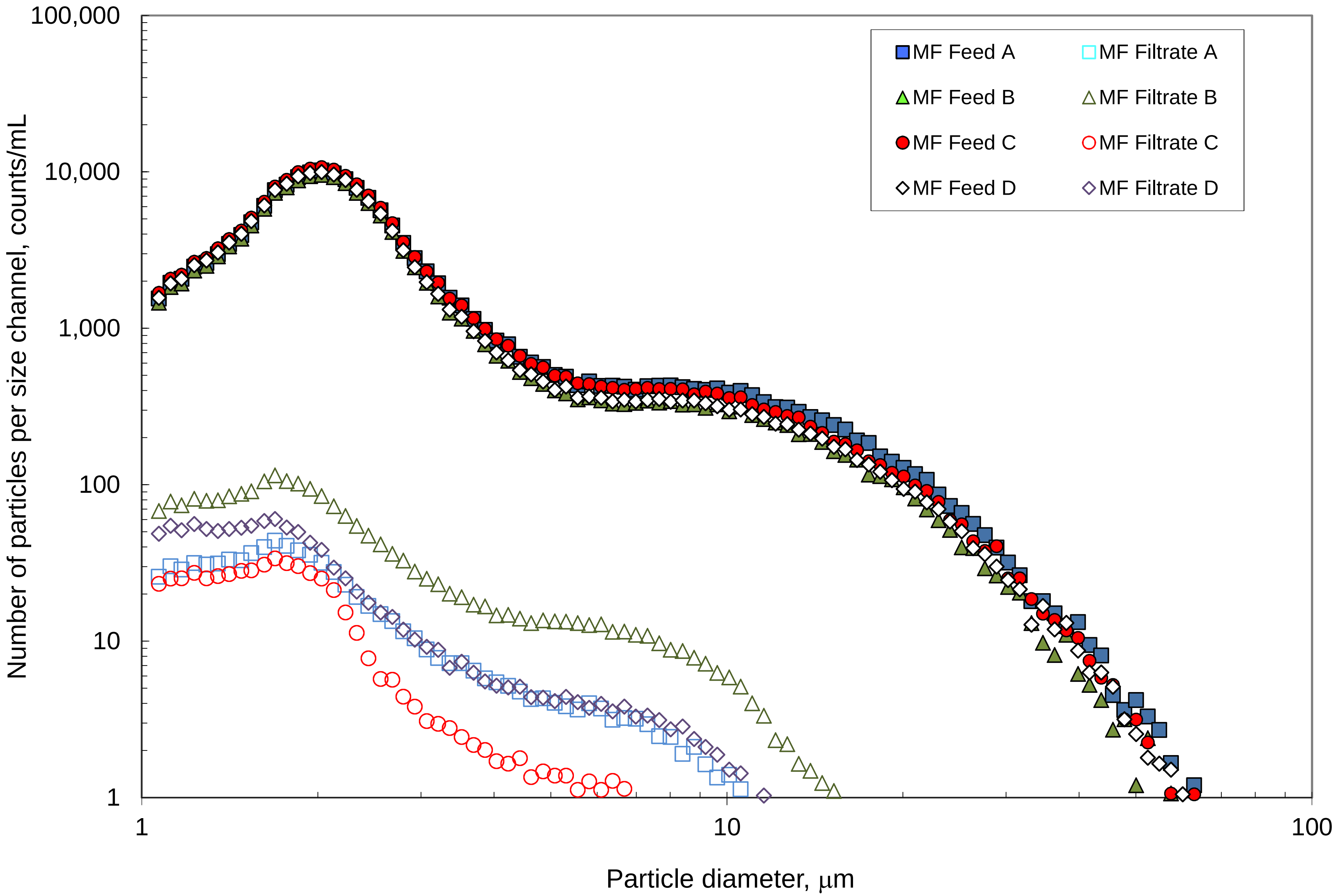


Figure A.26   Particle Size Distribution for Samples Collected 2 June 2015

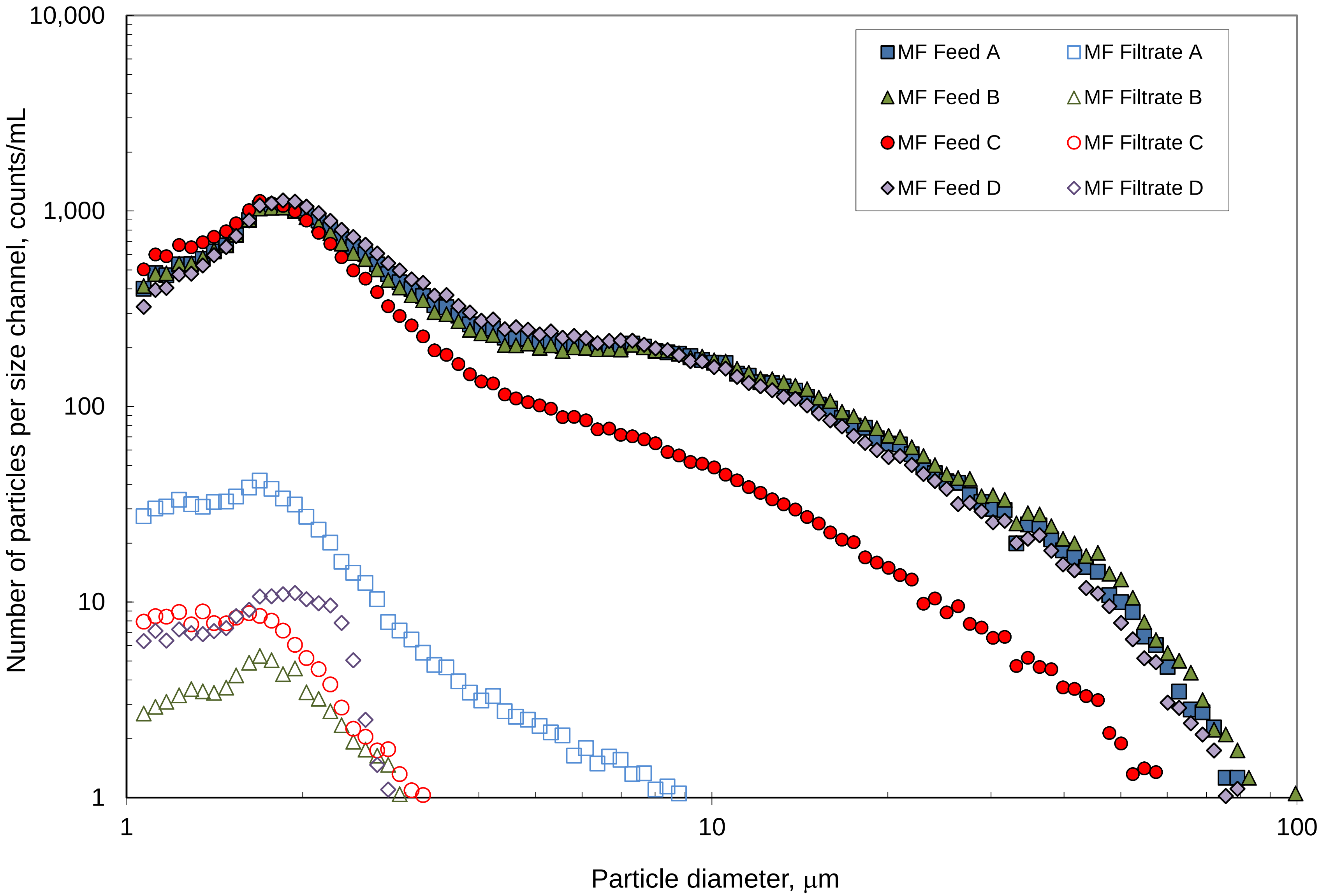


Figure A.27 Particle Size Distribution for Samples Collected 16 September 2015

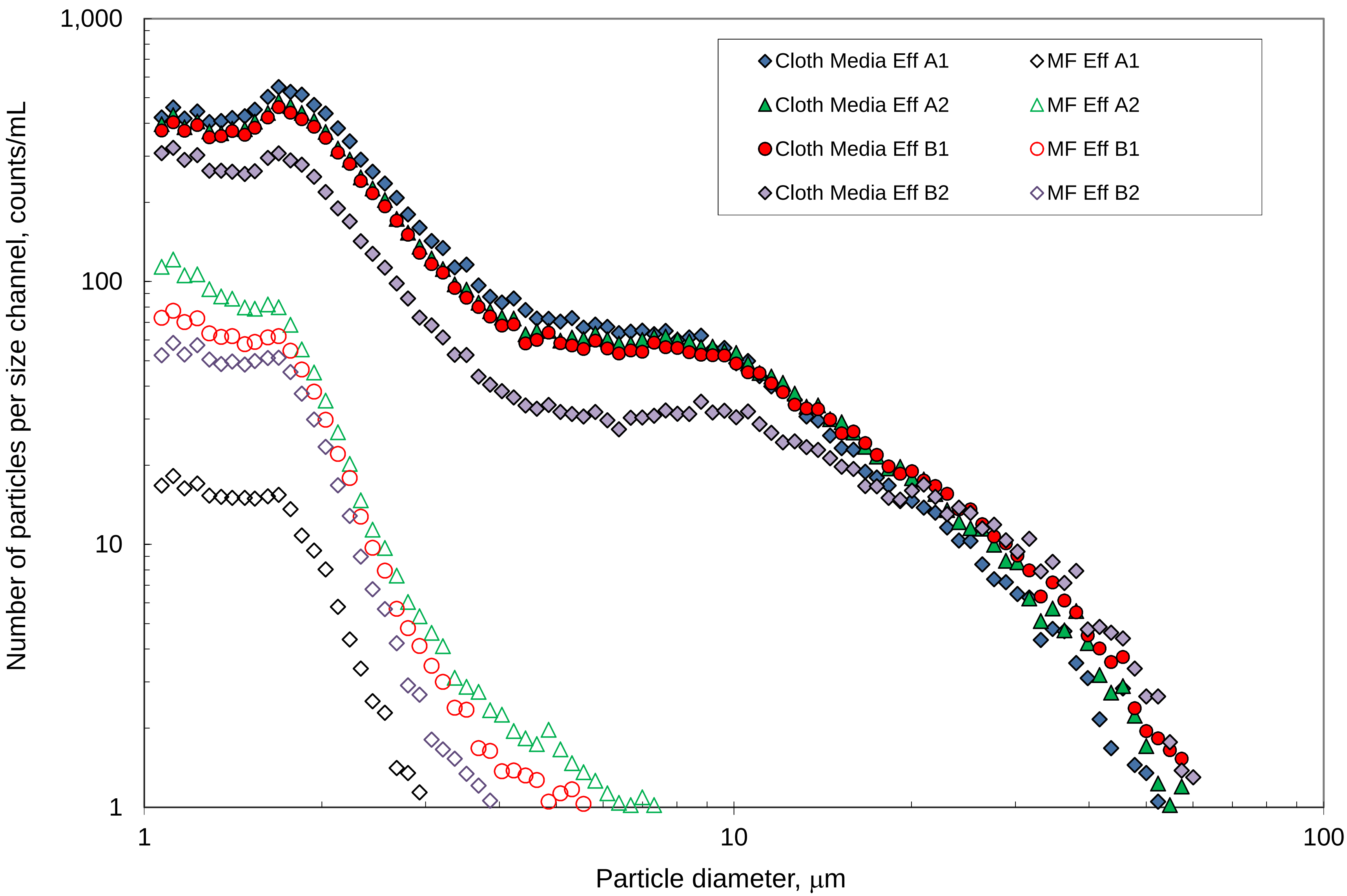


Figure A.28 Particle Size Distribution for Samples Collected 16 December 2015

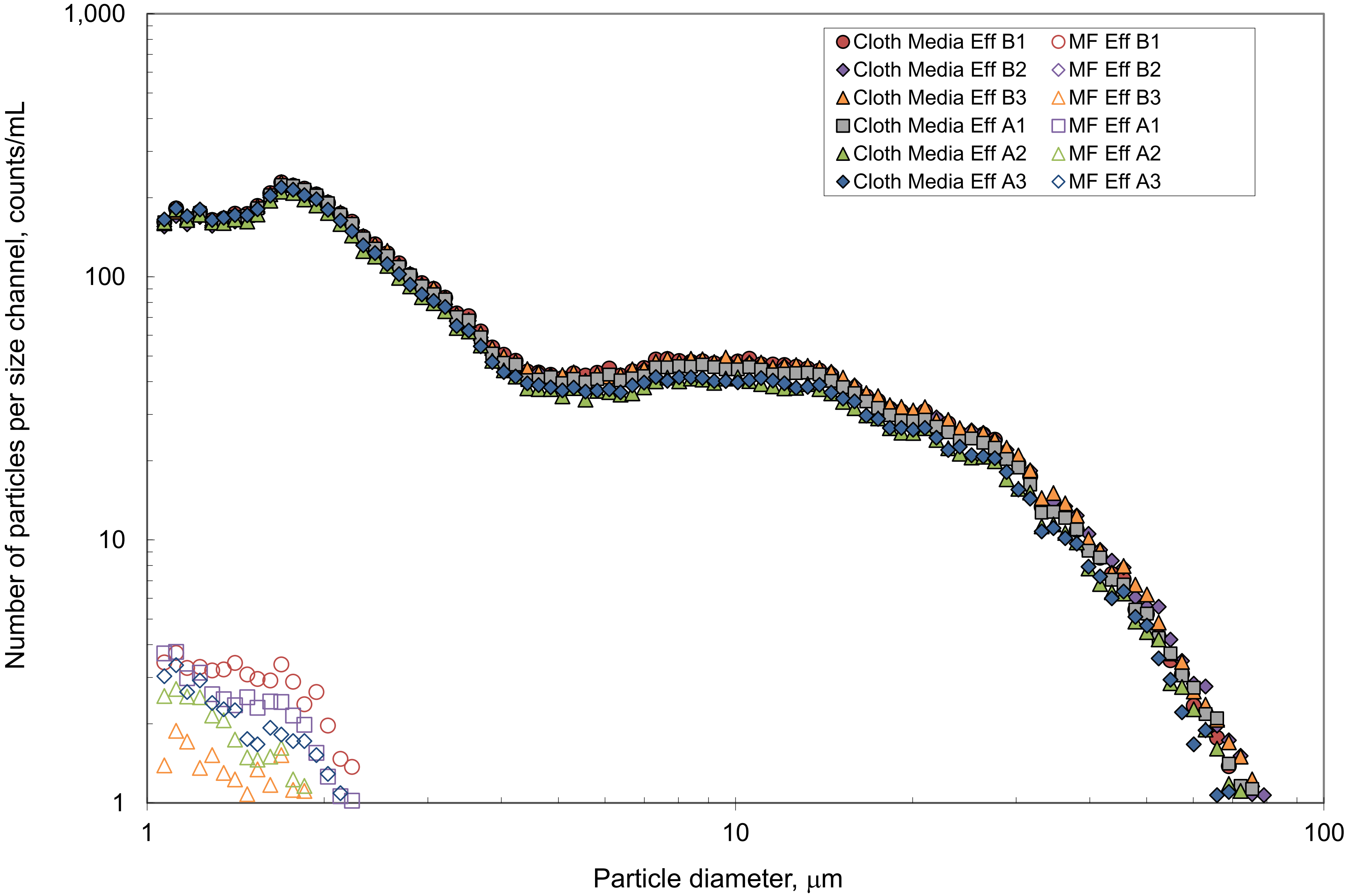


Figure A.29 Particle Size Distribution for Samples Collected
19 January 2016

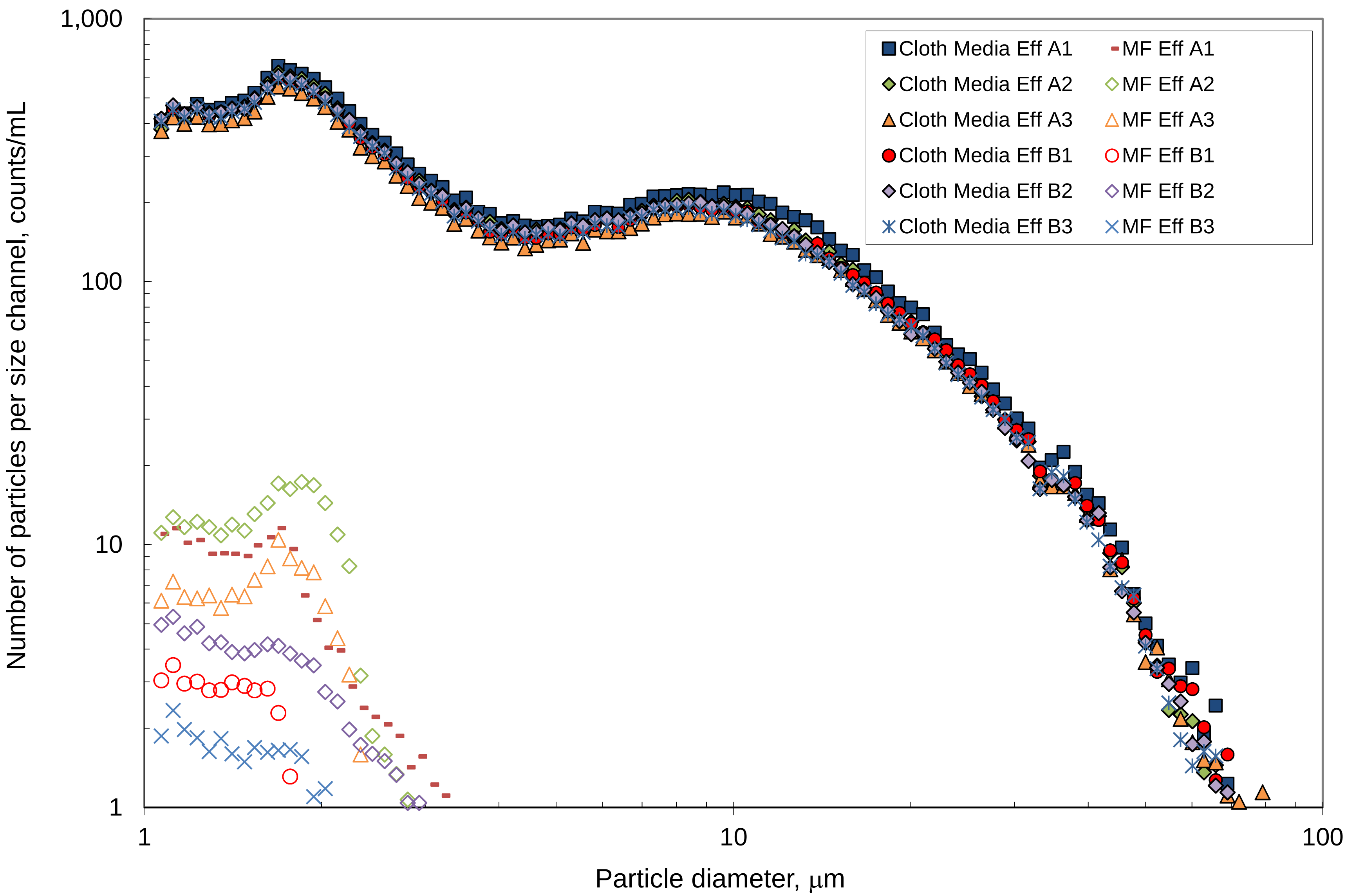


Figure A.30 Particle Size Distribution for Samples Collected
24 February 2016

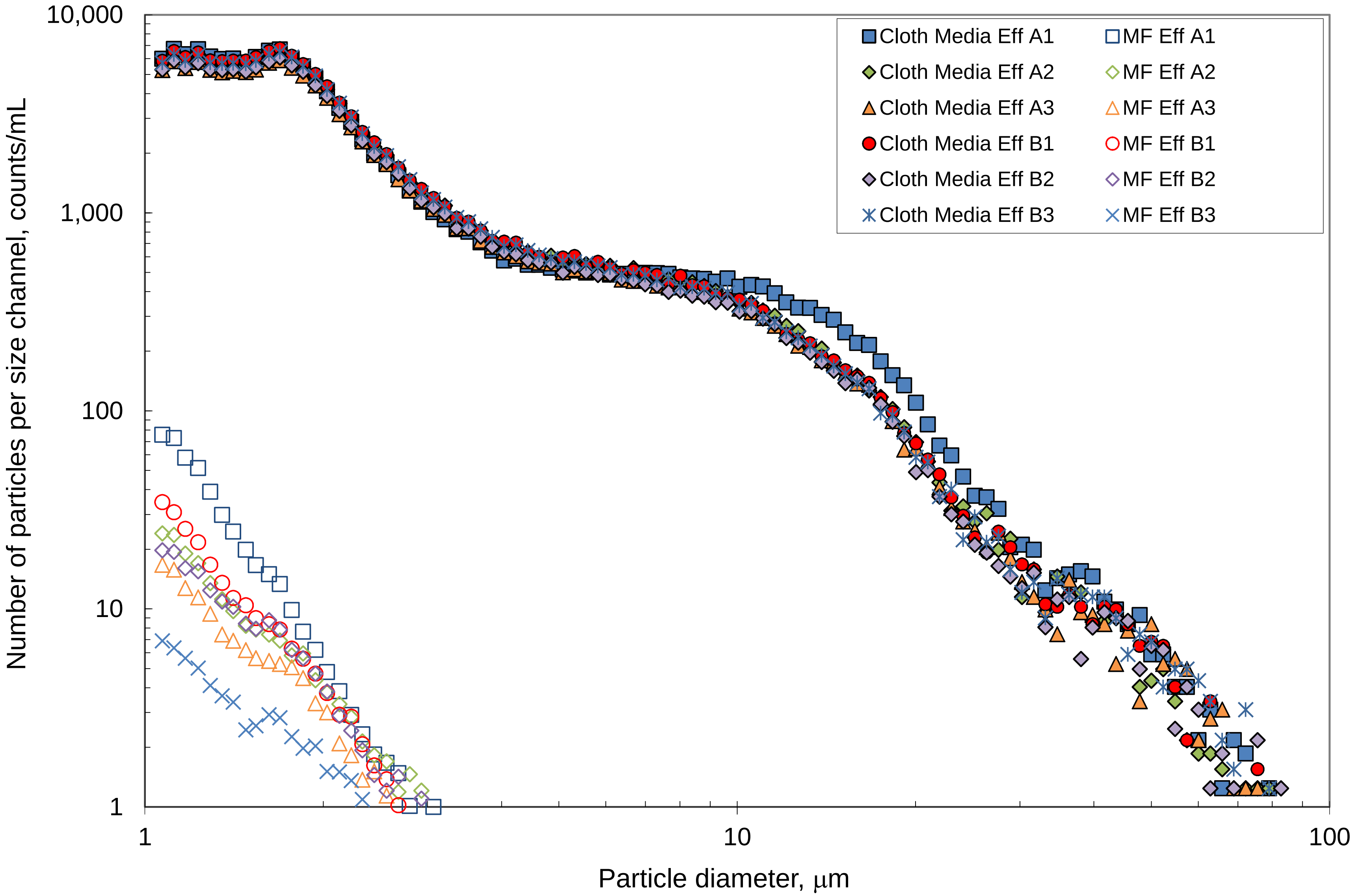
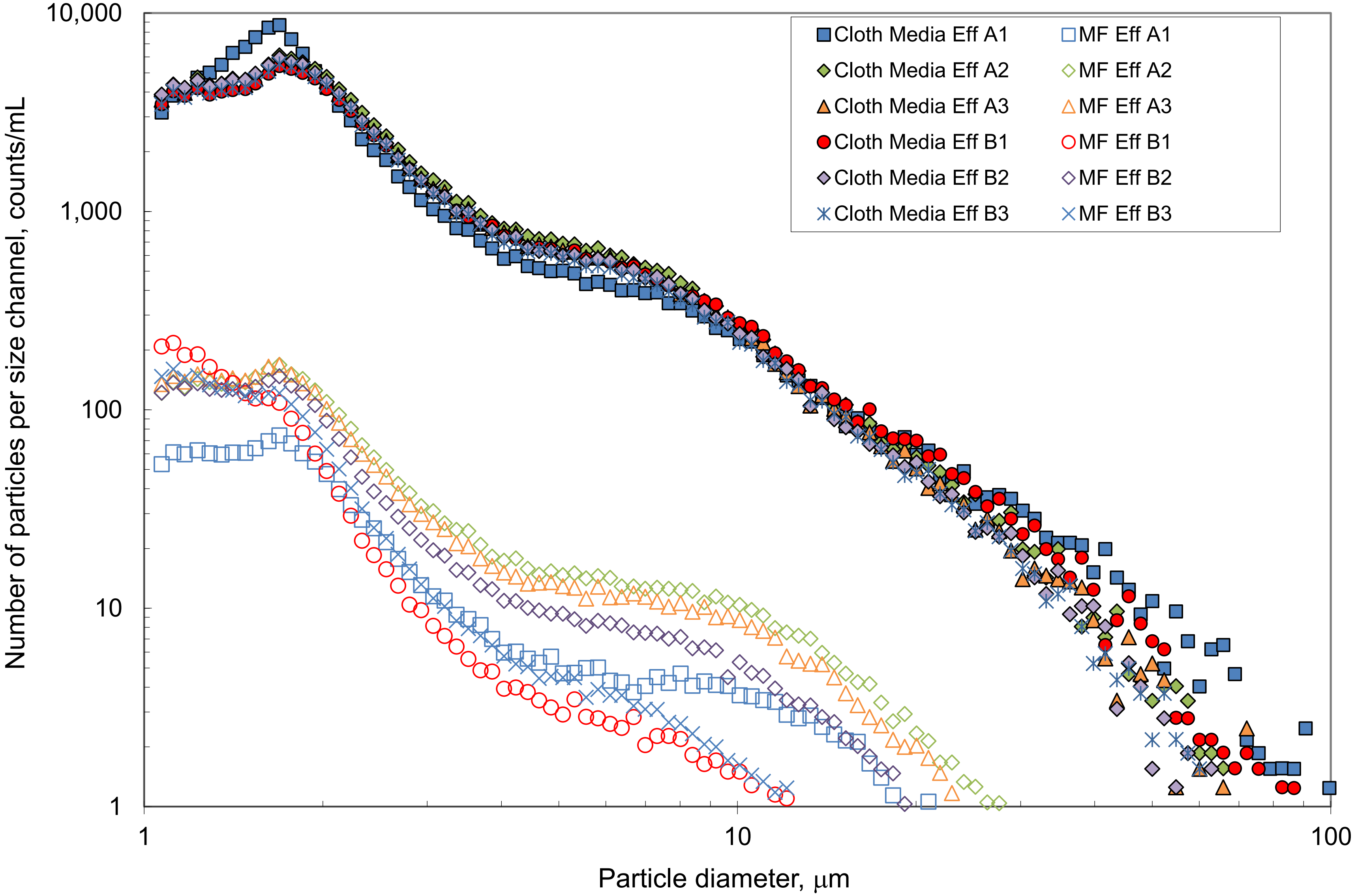


Figure A.31 Particle Size Distribution for Samples Collected 13 April 2016



Laboratory Reports for Samples Sent to Certified Laboratories

Accurate Environmental Laboratories

November 29, 2013

Client: Colorado River Municiple Water District

400 E. 24th Street

Big Springs, TX 79720

Requested By: John Burch

National Environmental Laboratory Accreditation Program

Kansas CERT # E-10219

Sample Project Name:

Date Samples Received: November 19, 2013 Time: 12:05 sample temp upon arrival at lab = 1°C - On Ice

Matrix: Waste Water

Lab Log Numbers: **3K19031-01** **3K19031-02**

Work Order: 3K19031

Report # 3K19031-1129130845

EPA Lab ID#'s Stillwater OK00092 Tulsa OK00983 OKC OK00129 ICR OK 001

Oklahoma Certification: Stillwater WasteWater, DEQ 8316/ Drinking Water, DEQ D9602
Tulsa WasteWater, DEQ 9905 / Drinking Water, DEQ D9901
Oklahoma City WasteWater DEQ 7202 / Drinking Water, DEQ D9937

Kansas Certification: Stillwater NELAP CERT # E-10219

Arkansas Certification: Stillwater WasteWater & Solids CERT # 11-059-0

Method Reference: 40 CFR 136, 141, and 261 Methods for Chemical Analysis of Water and Wastes EPA-600/4-79-020, March 1983. Test Methods for Evaluating Solid Wastes, SW-846, Final Update III. Standard Methods 1998 (20th Edition) and Standard Methods 2005 (21st Edition) for the Examination of Water and Wastewater.

Analysis Reference: If qualifiers present in "Prep Info" or "Analysis Info", then analysis performed as follows: @= Tulsa Lab and * = OKC Lab. If no qualifiers present, then analysis performed at Stillwater Lab.

Accurate Environmental Laboratories certify that the test results performed at the Stillwater lab meet all requirements of NELAP. Any exceptions to this can be found in the report footer or Quality Control Section of the report.

Sample: ***Product Water*** **Location Code:** **PWSID#:**

Collection Type: Grab Sample Time: 11/18/13 14:10 **Lab Log#** 3K19031-01

Method/Parameter	Test	Result		Notes	PQL#	Prep Info	Analysis Info
Cryptosporidium EPA 1623	Cryptosporidium	ND	oocysts/L	ND	0.00	11/20/13 10:30 *RE	11/25/13 11:15 *MH
Giardia EPA 1623	Giardia	ND	cysts/L	ND	0.00	11/20/13 10:30 *RE	11/25/13 11:15 *MH
Crypto Giardia Sample Volume	Volume	10.00	Liters		0.01	11/19/13 15:15 *RE	11/19/13 15:25 *MH

Sample: ***Wastewater Effluent*** **Location Code:** **PWSID#:**

Collection Type: Grab Sample Time: 11/18/13 14:00 **Lab Log#** 3K19031-02

Method/Parameter	Test	Result		Notes	PQL#	Prep Info	Analysis Info
Cryptosporidium EPA 1623	Cryptosporidium	ND	oocysts/L	ND	0.00	11/20/13 10:30 *RE	11/25/13 14:45 *MH
Giardia EPA 1623	Giardia	0.580	cysts/L		0.00	11/20/13 10:30 *RE	11/25/13 14:45 *MH
Crypto Giardia Sample Volume	Volume	5.14	Liters	Z-01	0.01	11/19/13 15:30 *RE	11/19/13 15:40 *MH

Notes and Definitions

Z-01	Pellet size greater than 0.5 mL
ND	ND = analyte not detected in sample.
MCL	Analyte concentration may exceed Maximum Contaminant Limit (MCL) for EPA Primary or Secondary Drinking Water Regulations.
###	Analyte concentration may exceed regulatory limit.
PQL	Practical Quantitation Limit - the method reporting limit (MRL) adjusted for any dilutions or other changes made to the sample to deal with interferences/matrix effects
BPQL	Below Practical Quantitation Limit (if applicable).

The "Prep Date" of the QC analysis coincides with the characters of the appropriate QC Lab ID. (Example: S 9 A 02 15 - BLK = 2009, Jan 2, Batch #15 - Blank)

Lab Manager

Quality Control Data

Blank Data

QC Lab #	Test Group	Test	Result		PQL	Flags
S3K1309-BLK1	Cryptosporidium EPA 1623	Cryptosporidium	BPQL	oocysts/L	0.00	ND
S3K1309-BLK1	Giardia EPA 1623	Giardia	BPQL	cysts/L	0.00	ND

Laboratory Control Sample Data

Lab QC#	Test Group	Test Name	LCS Result	Spike Level	Units	% Rec.	Control Limits	Flags
S3K1309-BS1	Cryptosporidium EPA 1623	Cryptosporidium	11.1	19.91	oocysts/L	56	22 - 100	
S3K1309-BS1	Giardia EPA 1623	Giardia	11.9	19.98	cysts/L	60	22 - 100	

*** Complete Entire COC to be in Compliance***

RUSH Due Date

Accurate Environmental Labs

Chain of Custody

Client Name- Colorado River Municipal Water District

Project Name-

Accurate Work Order #	Date Sample Taken	Time Sample Taken	Matrix or Source (Refer. below)	Grab (G) or Comp (C)	Client I.D. / Sample Location or DEQ / EPA Location Code	Filtered Amount (Liters)	Turbidity (NTU)	# of Container	Cryptosporidium and Giardia (10 liter Plastic)	~~C/G Matrix Spike~~ CRYPTOSPORIDIUM AND GIARDIA (10 liter Plastic)
3K19031										
-01	18 NOV 2013	14:10	~~DW~~ O	G	PRODUCT WATER		~~2.18~~	1	×	
-02		14:00	~~DW~~ WW	G	WASTEWATER EFFLUENT		2.986	1		×

On-Site Info

Matrix Codes **DW** = *Drinkingwater*; **WW** = *Wastewater*; **SL** = *Sludge*; **O** = *Other* RECLAIMED WATER
FS = *Flowing Stream*; **RL** = *Reservoir/Lake*; **GWUDI** = *Groundwater under direct influence of surface water*

Field Instrument Calibration -

Meter Type	Standards	Final Read.	Date , Time	Initials

Comments

REC. ON ICE

-- All Crypto/Giardia samples must be shipped over-night the same day of sampling --
-- All samples are scheduled to be disposed of in 4 weeks of receipt at Accurate. --
-- Hazardous samples will be returned to client or will be disposed of for a fee --

Certification by Company Official: I hereby certify that the above sampling occurred during a period such that the sample(s) is/are representative of a typical operating day discharge for the above facility.
Signature: John A. Burch Date/Time: 18 NOV 2013 16:00

Sampled By: JOHN A. BURCH Company: CRMWD 16:00 Sample Method:

Relinquished By: John A. Burch Date/Time: 18 NOV 2013 ~~1700~~ Received By: Date/Time:

☐ Relinquished to Lab By: / ☐ Relq'd to Log-In Fridge By: FedEx Date/Time: 11-19-13 1205 Received at Lab By: [signature] Rec'd °C: 1°C Date/Time: 11-19-13 1205

Reporting Requirements (standard 10 working days) | **Compliance** *Reporting?* *Yes or No* (DMR, PWS, LT2) | **PWS ID #** | ***RUSH*** *Request* (if available) ______ (Working Days)

Mail Report To: Colorado River Municipal Water District
Attn: John Burch
Address: ~~401 East 24th Street~~ P.O. BOX 869
Big Spring, TX 79721
Office #: (432) 267-6341 Fax #: (432) 267-3121 Cell#: (432) 213-0346
Email: jburch@crmwd.org

REPORT CAN BE ATTACHED ~~TO AS~~ EMAIL SUBMITTAL

Mail Invoice To: INVOICE CAN BE ATTACHED AS EMAIL SUBMITTAL
Address: SAME
Phone #: Fax #: ( )
Bid # -
PO # -

www.accuratelabs.com (800) 516-5227	505 South Lowry Street **Stillwater, OK** 74074 Phone: (405) 372-5300 Fax: (405) 372-5396	6558 E. 40th Street **Tulsa, OK** 74074 Phone: (918) 663-5400 Fax: (918) 663-6300	12036 N. Pennsylvania **Oklahoma City, OK** 73120 Phone: (405) 751-3132 Fax: (405) 751-3108

Accurate

Client Colorado River Municipale Water District

Lab Work Order 3L 310/8-02A

Date 1-7-13

The purpose of this enclosure is to better explain the extra charges for your *Cryptosporidium* and *Giardia* analyses.

LT2 Sample Volume Requirements from the "Source Water Monitoring Guidance Manual for Public Water Systems for the Final Long Term 2 Enhanced Surface Water Treatment Rule" Section 4.1.2.2 are as follows:

> "Under the LT2 Rule *Cryptosporidium* sample volume requirements [40CFR § 141.704(a)(1)], PWSs are required to analyze, at a minimum, either:
>
> - 10 L of sample, or
> - 2 ml of packed pellet volume, or
> - As much volume as two filters can accommodate before clogging."
>
> If a sample has a packed pellet more than 0.5ml, it must be divided into subsamples per section 13.2.4 of EPA Method 1623. A subsample can hold a volume of no more than 0.5ml of pellet (EPA 1623, section 13.2).

The checked boxes below indicate the characteristics and charges of sample Waste Water Effluent

☐	The sample clogged 1 filter necessitating an extra analysis and filter for an extra charge of $______.
☒	The sample used 1 filter but had a packed pellet of >0.5ml. Actual pellet size was 3.5 ml necessitating preparation and analysis of 4 subsamples at $ 487.50 each. For billing purposes that's equivalent to an extra charge of $ 1462.50 .
☐	The sample clogged 2 filters and had a packed pellet of >0.5ml. Actual pellet size was ____ ml necessitating preparation and analysis of ____ subsamples. For billing purposes, that's equivalent to a charge of one extra sample (this includes the extra filter charge) of $_____ and $_____ per remaining subsample(s) for a total extra charge of $______ .

Remember: Sample line should be flushed of stagnant water and debris before sampling (LT2 Rule *Cryptosporidium* and *E. coli* Sample Collection Recommendations: A pocket Guide).

Accurate Environmental Labs

Revised 6-30-09

Accurate

Client Colorado River Municipal Water District

Lab Work Order 3L31018-02B

Date 1-7-13

The purpose of this enclosure is to better explain the extra charges for your *Cryptosporidium* and *Giardia* analyses.

LT2 Sample Volume Requirements from the "Source Water Monitoring Guidance Manual for Public Water Systems for the Final Long Term 2 Enhanced Surface Water Treatment Rule" Section 4.1.2.2 are as follows:

> "Under the LT2 Rule *Cryptosporidium* sample volume requirements [40CFR § 141.704(a)(1)], PWSs are required to analyze, at a minimum, either:
>
> - 10 L of sample, or
> - 2 ml of packed pellet volume, or
> - As much volume as two filters can accommodate before clogging."
>
> If a sample has a packed pellet more than 0.5ml, it must be divided into subsamples per section 13.2.4 of EPA Method 1623. A subsample can hold a volume of no more than 0.5ml of pellet (EPA 1623, section 13.2).

The checked boxes below indicate the characteristics and charges of sample Waste Water Effluent MS

☐	The sample clogged 1 filter necessitating an extra analysis and filter for an extra charge of $______.
☒	The sample used 1 filter but had a packed pellet of >0.5ml. Actual pellet size was 3.5 ml necessitating preparation and analysis of 4 subsamples at $487.50 each. For billing purposes that's equivalent to an extra charge of $ 1462.50 .
☐	The sample clogged 2 filters and had a packed pellet of >0.5ml. Actual pellet size was _____ml necessitating preparation and analysis of _____subsamples. For billing purposes, that's equivalent to a charge of one extra sample (this includes the extra filter charge) of $_______and $_______ per remaining subsample(s) or a total extra charge of $__________ .

Remember: Sample line should be flushed of stagnant water and debris before sampling (LT2 Rule *Cryptosporidium* and *E. coli* Sample Collection Recommendations: A pocket Guide).

Accurate Environmental Labs

Revised 6-30-09

Accurate
Environmental Laboratories

January 08, 2014

Client: Colorado River Municipile Water District

400 E. 24th Street

Big Springs, TX 79720

Requested By: John Burch

National Environmental Laboratory Accreditation Program
Kansas CERT # E-10219

Sample Project Name:

Date Samples Received: December 31, 2013 Time: 11:07 sample temp upon arrival at lab = 2°C - On Ice

Matrix: Waste Water

Lab Log Numbers: **3L31018-01** **3L31018-02**

Work Order: 3L31018

Report # 3L31018-0108141331

EPA Lab ID#'s Stillwater OK00092 Tulsa OK00983 OKC OK00129 ICR OK 001

Oklahoma Certification: Stillwater WasteWater, DEQ 8316/ Drinking Water, DEQ D9602
Tulsa WasteWater, DEQ 9905 / Drinking Water, DEQ D9901
Oklahoma City WasteWater DEQ 7202 / Drinking Water, DEQ D9937

Kansas Certification: Stillwater NELAP CERT # E-10219

Arkansas Certification: Stillwater WasteWater & Solids CERT # 11-059-0

Method Reference: 40 CFR 136, 141, and 261 Methods for Chemical Analysis of Water and Wastes EPA-600/4-79-020, March 1983. Test Methods for Evaluating Solid Wastes, SW-846, Final Update III. Standard Methods 1998 (20th Edition) and Standard Methods 2005 (21st Edition) for the Examination of Water and Wastewater.

Analysis Reference: If qualifiers present in "Prep Info" or "Analysis Info", then analysis performed as follows: @= Tulsa Lab and * = OKC Lab. If no qualifiers present, then analysis performed at Stillwater Lab.

Accurate Environmental Laboratories certify that the test results performed at the Stillwater lab meet all requirements of NELAP. Any exceptions to this can be found in the report footer or Quality Control Section of the report.

Sample: ***Product Water*** **Location Code:** **PWSID#:**

Collection Type: Grab Sampled: 12/30/13 11:50 Stained: 01/01/14 17:00 **Lab Log#** 3L31018-01

Method/Parameter	Test	Result		Notes	PQL#	Elution Info	Analysis Info
Cryptosporidium EPA 1623	Cryptosporidium	ND	oocysts/L	ND	0.00	12/31/13 13:50 *MH	01/02/14 13:57 *MH
Giardia EPA 1623	Giardia	ND	cysts/L	ND	0.00	12/31/13 13:50 *MH	01/02/14 13:57 *MH
Crypto/Giardia Spiked Sample Volume	Volume	9.75	Liters		0.01	12/31/13 12:30 *MH	12/31/13 12:35 *MH
Crypto Giardia Sample Volume	Volume	9.75	Liters		0.01	12/31/13 11:48 *MH	12/31/13 11:53 *MH

Sample: ***Wastewater Effluent*** **Location Code:** **PWSID#:**

Collection Type: Grab Sampled: 12/30/13 12:05 Stained: 01/01/14 17:00 **Lab Log#** 3L31018-02

Method/Parameter	Test	Result		Notes	PQL#	Elution Info	Analysis Info
Cryptosporidium EPA 1623	Cryptosporidium	ND	oocysts/L	ND	0.00	12/31/13 13:50 *MH	01/03/14 09:40 *RE
Giardia EPA 1623	Giardia	0.170	cysts/L		0.00	12/31/13 13:50 *MH	01/03/14 09:40 *RE
Crypto/Giardia Spiked Sample Volume	Volume	6.00	Liters		0.01	12/31/13 13:13 *MH	12/31/13 13:18 *MH
Crypto Giardia Sample Volume	Volume	5.86	Liters		0.01	12/31/13 12:50 *MH	12/31/13 12:55 *MH

Notes and Definitions

ND	ND = analyte not detected in sample.
MCL	Analyte concentration may exceed Maximum Contaminant Limit (MCL) for EPA Primary or Secondary Drinking Water Regulations.
###	Analyte concentration may exceed regulatory limit.
PQL	Practical Quantitation Limit - the method reporting limit (MRL) adjusted for any dilutions or other changes made to the sample to deal with interferences/matrix effects
BPQL	Below Practical Quantitation Limit (if applicable).

The "Prep Date" of the QC analysis coincides with the characters of the appropriate QC Lab ID. (Example: S 9 A 02 15 - BLK = 2009, Jan 2, Batch #15 - Blank)

Lab Manager

505 S. Lowry Street ■ Stillwater, OK 74074 ■ 405-372-5300 ■ Fax: 405-372-5396

Quality Control Data

Blank Data

QC Lab #	Test Group	Test	Result		PQL	Flags
S3L2613-BLK1	Cryptosporidium EPA 1623	Cryptosporidium	BPQL	oocysts/L	0.00	ND
S3L2613-BLK1	Giardia EPA 1623	Giardia	BPQL	cysts/L	0.00	ND

Laboratory Control Sample Data

Lab QC#	Test Group	Test Name	LCS Result	Spike Level	Units	% Rec.	Control Limits	Flags
S3L2613-BS1	Cryptosporidium EPA 1623	Cryptosporidium	8.70	19.03	oocysts/L	46	22 - 100	
S3L2613-BS1	Giardia EPA 1623	Giardia	8.60	19.04	cysts/L	45	22 - 100	

Matrix Spike Data

QC Lab #	Test Group	Test Name	Sample Result	Units	Spike Result	Spike Level	% Rec.	Acceptance Limits	Flags
S3L2613-MS1	Cryptosporidium EPA 1623	Cryptosporidium	BPQL	oocysts/L	11.3	19.03	59	13 - 111	
S3L2613-MS2	Cryptosporidium EPA 1623	Cryptosporidium	BPQL	oocysts/L	3.83	19.03	20	13 - 111	
S3L2613-MS1	Giardia EPA 1623	Giardia	BPQL	cysts/L	12.1	19.04	64	15 - 118	
S3L2613-MS2	Giardia EPA 1623	Giardia	0.170	cysts/L	5.17	19.04	26	15 - 118	

* Complete Entire COC to be in Compliance*

RUSH Due Date

Accurate Environmental Labs

Chain of Custody

Client Name- Colorado River Municipal Water District

Project Name-

Accurate Work Order #	Date Sample Taken	Time Sample Taken	Matrix or Source (Refer. below)	Grab (G) or Comp (C)	Client I.D. / Sample Location or DEQ / EPA Location Code	Field Results: Filtered Amount (Liters)	Field Results: Turbidity (NTU)		Sample Preserv. & Container → / Analysis Requested → / # of Container ↓	10 liter Plastic: Cryptosporidium and Giardia	10 liter Plastic: C/G Matrix Spike					
3L3/08																
-01	30 DEC 2013	1150/1155	O	G	Product Water				2	X	X					
-02	30 DEC 2013	1205/1215	WW	G	Wastewater Effluent				2	X	X					

On-Site Info

Matrix Codes DW = *Drinkingwater ;* WW = *Wastewater ;* SL = *Sludge ;* O = *Other* RECLAIMED WATER
FS= *Flowing Stream;* RL= *Reservoir/Lake;* GWUDI= *Groundwater under direct influence of surface water*

Field Instrument Calibration -

Meter Type	Standards	Final Read.	Date , Time	Initials

Comments 2 COOLERS FEDEX

on ice 2.0°C

-- All Crypto/Giardia samples must be shipped over-night the day of sampling --
-- All Crypto/Giardia samples must arrive at the lab on ice between 1- 10°C. --
-- Hazardous samples will be returned to client or will be disposed of for a fee --

Certification by Company Official: I hereby certify that the above sampling occurred during a period such that the sample(s) is/are representative of a typical operating day discharge for the above facility.

Signature: John D Burch Date/Time: 30 DEC 2013 16:30 h

Sampled By: John D Burch Company: CRMWD Sample Method:

Relinquished By: John D Burch Date/Time: 30 DEC 2013 16:00 h Received By: [signature] Date/Time: 12-31-13 1107

☐ Relinquished to Lab By: Date/Time

☐ Relq'd to Log-In Fridge By: Received at Lab By: Rec'd °C Date/Time

Reporting Requirements (standard 10 working days) | **Compliance** *Reporting?* *Yes or No* (DMR, PWS, LT2) | **PWS ID #** | ***RUSH*** *Request* (if available) ________ (Working Days)

Mail Report To: Colorado River Municipal Water District
Attn: John Burch

Address: P.O. Box 869
Big Spring, TX 79721
EMAIL REPORT

Phone #: (432) 267-6341 Fax #: (432) 267-3121 Cell#: (432) 213-0346

Email: jburch@crmwd.org

Mail Invoice To:

Bid # -

Address EMAIL INVOICE

PO # -

Phone #: Email: jbirch@crmwd.org

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 140273-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Wastewater Effluent
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	John D. Burch	**Customer Sample No.:**	None Given
Matrix:	Waste Water, treated	**Date/Time Received:**	2/25/2014 9:12:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.1 C
Sample Collection Date:	2/24/2014	**Container Type:**	10 L Cubitainer
Sample Time:	11:25:00 AM		

Comments: 1 additional slide was viewed per Eva Steinle-Darling in result of pellet size after concentration. Calculated Results: <0.2 Oocysts/ L (Crypto), 2.0 Cysts/ L (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/28/14-1547	Filter Type	Envirochek HV
Filter Serial #		Sample Vol Filtered	11.0 L
Sample Vol Examined	5.5 L	Number of Filters	1
Resuspended Conc. Vol.	20 mL	Pellet Volume	4.0 mL
Elution date	2/25/14	Elution Time	0958
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	11

Sample Q. C

OPR Crypto Results	56 %
OPR Giardia Results	20 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/18/2014

Report Date

Richard E Danil

Signature

Quality Checked KTucker

BioVir LABORATORES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 273-1
Client #: CAR010K
Date Rec'd: 2/25/14
Time Rec'd: 09:12
Temp Rec'd: 0.1°C

ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING TX 79721	SAMPLE DATE: 24 FEB 2014 / SAMPLE TIME: 11:35h
Contact Name: JOHN O. BURCH Tel: 432 2676341	Water Temp (C): / Turbidity (NTU): 11:25h
NAME OF SAMPLER: JOHN O. BURCH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: WASTE WATER EFFLUENT	Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other:
SAMPLE LOCATION: RW PF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: ______ Liters Grab Volume: ~10 Liters

JDB

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John D Burch	DATE / TIME: 24 FEB 2014 17:00h
RECEIVED BY:	DATE / TIME: 2/25/14 09:12

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 140273-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	John D. Burch	**Customer Sample No.:**	None Given
Matrix:	Waste Water, not otherwise spe	**Date/Time Received:**	2/25/2014 9:12:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.1 C
Sample Collection Date:	2/24/2014	**Container Type:**	10 L Cubitainer
Sample Time:	11:25:00 AM		
Comments:	Sample= Reclaimed Water, Calculated Results: <0.1 Oocysts/ L (Crypto), <0.1 Cysts/ L (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	
Sample Vol Filtered	11.0 L	Sample Vol Examined	11.0 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	2/25/14	Elution Time	0958
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	2/28/14-1605

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	56 %
OPR Giardia Results	20 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.

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3/18/2014

Report Date

Richard E Danil

Signature

Quality Checked KTucker

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 273-2
Client #: CAR 010K TX
Date Rec'd: 2/25/14
Time Rec'd: 09:12
Temp Rec'd: 0.1°C ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O BOX 869 BIG SPRING TX 79721	SAMPLE DATE: 24 FEB 2014 — SAMPLE TIME: 11:25
Contact Name: JOHN D. BURCH Tel: 432 267 6341	Water Temp (C): — Turbidity (NTU):
NAME OF SAMPLER: JOHN D BURCH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: PRODUCT WATER	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: ______ Liters Grab Volume: 10 Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John D Burch	DATE / TIME: 24 FEB 2014 17:00h
RECEIVED BY:	mc DATE / TIME: 2/25/14 09:12

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140400-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH/ Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Water, not otherwise specified	**Date/Time Received:**	3/20/2014 9:38:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.1 C
Sample Collection Date:	3/18/2014	**Container Type:**	10 L Cubitainer
Sample Time:	11:08:00 AM		

Comments: Turbidity=1.16 NTU Calculated Results: <0.1 Oocysts/ L (Crypto), <0.1 Cysts/ L (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	3/21/14	Elution Time	1107
Resample	Yes	Original Sample Date	2/24/14
Analyst	kw	Analysis Date / Time	3/26/14-1701

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	64 %
OPR Giardia Results	48 %
Method Blank Results	0

4/4/2014
Report Date

Richard E Danil
Signature

Quality Checked KTucker

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 400-1
Client #: CAR010K
Date Rec'd: 3/20/14
Time Rec'd: 09:38
Temp Rec'd: 0.1°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79721	SAMPLE DATE: 18 MAR 2014 — SAMPLE TIME: 11:08
Contact Name: JOHN D. BURCH Tel: 4322676341	Water Temp (C): — Turbidity (NTU):
NAME OF SAMPLER: RH ~~[illegible]~~ / HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE ~~SOURCE~~: IN PRODUCT WATER	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☒ Other: RECLAIMED WATER
SAMPLE LOCATION: RWTF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: ______ Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 3/20/14 09:38

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140400-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Wastewater Effluent
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH/ Hildreth	**Customer Sample No.:**	Wastewater Effluent
Matrix:	Waste Water, treated	**Date/Time Received:**	3/20/2014 9:38:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.1 C
Sample Collection Date:	3/18/2014	**Container Type:**	10 L Cubitainer
Sample Time:	11:01:00 AM		

Comments: Sample okay to run at volume of 7.75 L per Eva Steinle-Darling. Turbidity= 14.4 NTU
Calculated Results: 5.2 Oocysts/ L (Crypto), 39.0 Cysts/ L (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	3/26/14-1735	Filter Type	Envirochek HV
Filter Serial #		Sample Vol Filtered	7.75 L
Sample Vol Examined	7.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	3/21/14	Elution Time	1107
Resample	Yes	Original Sample Date	2/24/14
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	40
Analyte 2	Giardia
No. of Giardia	302

Sample Q. C

OPR Crypto Results	64 %
OPR Giardia Results	48 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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4/4/2014

Richard E Danielson

Report Date **Signature**

Quality Checked KTucker

400-2 JMC

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY
SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 400-2
Client #: CARO10K
Date Rec'd: 3/20/14
Time Rec'd: 09:38
Temp Rec'd: 0.1°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79721	SAMPLE DATE: 18 MAR 2014 / SAMPLE TIME: 11:~~08~~ 01
Contact Name: JOHN D. BURCH Tel: 4322676341	Water Temp (C): / Turbidity (NTU): JDB
NAME OF SAMPLER: RH ~~Burch~~ / HILORETA	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: IO WASTEWATER EFFLUENT	Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☒ Matrix Spike Grab ☐ Regular Filtered Sample ☐ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: ______ Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John D. Burch	DATE / TIME: 19 MAR 2014 17:00
RECEIVED BY:	JMC DATE / TIME: 3/20/14 09:38

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140729-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Big Spring
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Waste Water, treated	**Date/Time Received:**	5/16/2014 9:17:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.4 C
Sample Collection Date:	5/14/2014	**Container Type:**	10 L Cubitainer
Sample Time:	2:53:00 PM		

Comments: Turbidity = 0.30 NTU Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia).

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	5/19/14-1400	Filter Type	Envirochek HV
Filter Serial #		Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	5/16/14	Elution Time	1026
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	69 %
OPR Giardia Results	37 %
Method Blank Results	0

5/30/2014
Report Date

Richard E Danil
Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 229-1
Client #: CAR010K
Date Rec'd: 5/16/14
Time Rec'd: 09:17
Temp Rec'd: 0.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING TX 79721 Contact Name: JOHN BURCH Tel: 432 267 6341	SAMPLE DATE: 14 MAY 2014 — SAMPLE TIME: 14:53 Water Temp (C): — Turbidity (NTU):
NAME OF SAMPLER: HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: RECLAIMED WATER
SAMPLE SOURCE:	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ____ Gallons ____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: ____ Liters Grab Volume: ____ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS: note: label: Big Spring site: - product water
rec'd w/ice single ziplocked → water bath line

RELINQUISHED BY: John D. Burch	DATE / TIME: 15 MAY 2014 15:00
RECEIVED BY:	ML DATE / TIME: 5/16/14 09:17

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140729-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Big Spring
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH Hildreth	**Customer Sample No.:**	Waste Water Effluent
Matrix:	Waste Water, treated	**Date/Time Received:**	5/16/2014 9:17:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.4 C
Sample Collection Date:	5/14/2014	**Container Type:**	10 L Cubitainer
Sample Time:	3:10:00 PM		

Comments: Turbidity = 4.04 NTU Calculated Results: <0.2 Oocysts / Liter (Crypto), 2.0 Cysts / Liter (Giardia). One extra slide examined.0

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	5/19/14-1445	Filter Type	Envirochek HV
Filter Serial #		Sample Vol Filtered	11.0 L
Sample Vol Examined	5.5 L	Number of Filters	1
Resuspended Conc. Vol.	20 mL	Pellet Volume	4.0 mL
Elution date	5/16/14	Elution Time	1026
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	11

Sample Q. C

OPR Crypto Results	69 %
OPR Giardia Results	37 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

5/30/2014
Report Date

Richard E Danil
Signature

Quality Checked LBarriga

LAB USE ONLY:
LIMS #: 729-2
Client #: CAR010K
Date Rec'd: 5/16/14
Time Rec'd: 09:17
Temp Rec'd: 0.4°C

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING TX 79721	SAMPLE DATE: 14 MAY 20~~1~~4	SAMPLE TIME: 15:10
	Water Temp (C):	Turbidity (NTU): 4.04
Contact Name: JOHN BURCH Tel: 432 267 6341	TREATMENT CHARACTERISTICS (Check One):	
NAME OF SAMPLER: HILDRETH	Raw Surface Water ☐	Treated Drinking Water ☐
SAMPLE SOURCE:	Treated Wastewater ☒	Wastewater ☐
	Ground Water ☐	Other:
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No	
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)	
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒	Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐	
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐	
	Filtered Volume: ______ Liters	Grab Volume: ______ Liters

Client Sample ID: WASTE WATER EFFLUENT	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
☒	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS: note: label: Site - Big Spring Wastewater effluent

rec'd w/ice single ziplocked - water bath - Jmc

RELINQUISHED BY: John A Burch	DATE / TIME: 15 MAY 2014	15:00
RECEIVED BY: Jmc	DATE / TIME: 5/16/14	09:17

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140889-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Big Spring
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	6/13/2014 9:25:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.9 C
Sample Collection Date:	6/11/2014	**Container Type:**	
Sample Time:	2:10:00 PM		
Comments:	Turbidity= 1.60 NTU Calculated Results: < 0.1 Oocysts/ L (Crypto), < 0.1 Cysts/ L (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	6/17/14-1112	Filter Type	Envirochek HV
Filter Serial #	N/A	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.2 mL
Elution date	6/13/14	Elution Time	1111
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	57 %
OPR Giardia Results	56 %
Method Blank Results	0

6/25/2014

Report Date

Richard E Danil

Signature

Quality Checked KTucker

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LAB USE ONLY:
LIMS #: 889-1
Client #: CAR010K
Date Rec'd: 6/13/14
Time Rec'd: 09:25
Temp Rec'd: 0.9°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District P.O. Box 869 Big Spring TX 79721	SAMPLE DATE: 6-11-2014 / SAMPLE TIME: 14:10
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): / Turbidity (NTU): 1.60
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE SOURCE:	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: ______ Liters Grab Volume: ______ Liters

Client Sample ID: MF SOURCE WATER*	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:
* PREVIOUSLY LABELLED WASTEWATER EFFLUENT

RELINQUISHED BY: Jacob Lauer	DATE / TIME: 6-12-14 15:30
RECEIVED BY:	DATE / TIME: 6/13/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 140889-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Drinking Water	**Date/Time Received:**	6/13/2014 9:25:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	0.9 C
Sample Collection Date:	6/11/2014	**Container Type:**	10 L Cubitainer
Sample Time:	3:55:00 PM		

Comments: Matrix= Reclaimed Water, Calculated Results: < 0.1 Oocysts/ L (Crypto), < 0.1 Cysts/ L (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	N/A
Sample Vol Filtered	11.0 L	Sample Vol Examined	11.0 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	6/13/14	Elution Time	1111
Resample	No	Original Sample Date	
Analyst	SM	Analysis Date / Time	6/17/14-1117

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	57 %
OPR Giardia Results	56 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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6/25/2014

Report Date

Richard E Danielson

Signature

Quality Checked KTucker

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(Please fill out applicable areas, sign and return to BioVir with the sample.)
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LAB USE ONLY:	
LIMS #:	889-2
Client #:	CARO10K
Date Rec'd:	6/13/14
Time Rec'd:	09:25
Temp Rec'd:	0.9°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District P.O. Box 869 Big Spring TX. 79727	SAMPLE DATE: 6-11-2014	SAMPLE TIME: 15:55
	Water Temp (C):	Turbidity (NTU): NA
Contact Name: John D. Burch Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):	
NAME OF SAMPLER: Robert Hildreth	Raw Surface Water ☐ Treated Drinking Water ☐	
SAMPLE SOURCE: ID Product Water	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No	
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**	
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐	
Meter Start: Meter Stop:	Regular Filtered Sample ☐	
Total Volume: ________ Gallons ________ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐	
	Filtered Volume: ________ Liters Grab Volume: ________ Liters	

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Jacob Laird	DATE / TIME: 6-12-14 15:30
RECEIVED BY: [signature]	DATE / TIME: 6/13/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 140923-007

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** RWPF influent (WW effluent)-R1
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Eva Steinle-Darling **Customer Sample No.:** N/A
Matrix: Waste Water, treated **Date/Time Received:** 7/9/2014 9:25:00 AM
Sample Point ID: Tap by turbidimeter **Check-in Temp. (0-20C)** 7.2 C
Sample Collection Date: 7/8/2014 **Container Type:** HV Envirochek
Sample Time: 1:10:00 PM
Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	7/17/14-1131	Filter Type	Envirochek HV
Filter Serial #	266057	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

8/13/2014
Report Date

Richard E Danielson
Signature

Quality Checked LBarriga

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LAB USE ONLY:
LIMS #: 923-7
Client #: CAR010K
Date Rec'd: 9/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 13:10
	Water Temp (C): — Turbidity (NTU): 1.0
Contact Name: John Burch Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: RWPF influent (WW effluent) — R1	Treated Wastewater ☑ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: tap by turbidimeter	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: _____ Gallons _____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: _____ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: [signature]	DATE / TIME: 7/9/14 09:25

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LAB Sample ID: 140923-008

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No: CAR010K **Purchase Order No:** N/A

PWS ID: N/A **Facility ID:** RWPF influent (WW effluent)-R2

Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Eva Steinle-Darling	**Customer Sample No.:**	N/A
Matrix:	Waste Water, treated	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	Tap by turbidimeter	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/8/2014	**Container Type:**	HV Envirochek
Sample Time:	1:10:00 PM		

Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	7/17/14-1136	Filter Type	Envirochek HV
Filter Serial #	266052	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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8/13/2014

Report Date

Richard E Danielson

Signature

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LAB USE ONLY:
LIMS #: 923-8
Client #: CARO1OK
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 13:10
	Water Temp (C): — Turbidity (NTU): 1.0
Contact Name: John Burch Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: RWPF influent (WW effluent) - R2	Treated Wastewater ☑ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: tap by turbidimeter	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: ____ Gallons ____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: Mn	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 140923-009

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	N/A
Matrix:	Water, Treated	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/7/2014	**Container Type:**	HV Envirochek
Sample Time:	4:25:00 PM		

Comments: Groundwater Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	7/17/14-1141	Filter Type	Envirochek HV
Filter Serial #	266048	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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8/13/2014

Report Date

Richard E Danil

Signature

Quality Checked LBarriga

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-9
Client #: CAR010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District PO Box 869 Big Spring, TX, 79721	SAMPLE DATE: 7-7-2014 / SAMPLE TIME: 16:25
	Water Temp (C): / Turbidity (NTU):
Contact Name: John Burch Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Robert Hildreth	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Product Water	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☒ Other: Reclaimed water
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: _____ Gallons _____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: _____ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: Jmc	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 141228-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Water, Treated	**Date/Time Received:**	8/27/2014 9:30:00 AM
Sample Point ID:	Product Water	**Check-in Temp. (0-20C)**	9.4 C
Sample Collection Date:	8/26/2014	**Container Type:**	HV Envirochek
Sample Time:	1:55:00 PM		

Comments: Reclaimed groundwater. Calculated Results: <0.09 Oocysts / Liter (Crypto), <0.09 Cysts / Liter (Giardia).

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	9/2/14-0937	Filter Type	Envirochek HV
Filter Serial #	517368	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	8/28/14	Elution Time	0736
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	75 %
OPR Giardia Results	54 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

9/22/2014

Report Date

Richard E Danielson

Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1228-1
Client #: CAR010K
Date Rec'd: 8/27/14
Time Rec'd: 09:30
Temp Rec'd: 9.4°C

jw

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District P.O. Box 869 Big Spring, TX. 79720	SAMPLE DATE: 8-26-14 / SAMPLE TIME: 13:55
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): / Turbidity (NTU): N/A
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Product Water	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed water
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ____ Gallons ____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: ____ Liters Grab Volume: ____ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 8-26-14 15:08
RECEIVED BY: jmc	DATE / TIME: 8/27/14 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 141228-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	8/27/2014 9:30:00 AM
Sample Point ID:	Source Water	**Check-in Temp. (0-20C)**	9.4 C
Sample Collection Date:	8/26/2014	**Container Type:**	HV Envirochek
Sample Time:	2:20:00 PM		
Comments:	Calculated Results: 0.09 Oocysts / Liter (Crypto), <0.09 Cysts / Liter (Giardia).		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	9/2/14-0950	Filter Type	Envirochek HV
Filter Serial #	517381	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.3 mL
Elution date	8/28/14	Elution Time	0736
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	1
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	75 %
OPR Giardia Results	54 %
Method Blank Results	0

9/22/2014

Report Date

Richard E Danil

Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1228-2
Client #: CAR010K
Date Rec'd: 8/27/14
Time Rec'd: 09:30
Temp Rec'd: 9.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal water District PO Box 869 Big Spring, TX 79720	SAMPLE DATE: 8-26-14 / SAMPLE TIME: 14:20
	Water Temp (C): / Turbidity (NTU): 0.9
Contact Name: John Burch Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Robert Hildreth	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Source Water	Treated Wastewater ☒ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: ______ Liters Grab Volume: ______ Liters

Client Sample ID: Source Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Jarod Laird	DATE / TIME: 8-26-14 15:08
RECEIVED BY: [signature]	DATE / TIME: 8/27/14 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 141734-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	Product Water
Matrix:	Water, Treated	**Date/Time Received:**	12/17/2014 11:00:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	12/16/2014	**Container Type:**	HV Envirochek
Sample Time:	9:48:00 AM		
Comments:	Calculated Results: < 0.1 Oocysts/ L (Crypto), < 0.1 Cysts/ L (Giardia)		

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	12/23/14-1353	Filter Type	Envirochek HV
Filter Serial #	539085	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	12/18/14	Elution Time	0845
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	50 %
OPR Giardia Results	59 %
Method Blank Results	0

1/6/2015

Report Date

Richard E Danielson

Signature

Quality Checked KTucker

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1734-1
Client #: CAR010K
Date Rec'd: 12/17/14
Time Rec'd: 11:00
Temp Rec'd: 3.0°C
ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District PO Box 869 Big Spring TX 79720	SAMPLE DATE: 12-16-14 / SAMPLE TIME: 09:48 am
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): 19.835 / Turbidity (NTU): N/A
NAME OF SAMPLER: J. Laird	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Product Water	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed water
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Jacob Laird	DATE / TIME: 12-16-14 16:15
RECEIVED BY: JML	DATE / TIME: 12/17/14 11:00

UPS

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 141734-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	12/17/2014 11:00:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	12/16/2014	**Container Type:**	HV Envirochek
Sample Time:	10:21:00 AM		

Comments: Turbidity= 1.29 NTU Calculated Results: 0.3 Oocysts/ L (Crypto), 0.6 Cysts/ L (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	12/23/14-1415	Filter Type	Envirochek HV
Filter Serial #	539055	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	12/18/14	Elution Time	0845
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	3
Analyte 2	Giardia
No. of Giardia	6

Sample Q. C

OPR Crypto Results	50 %
OPR Giardia Results	59 %
Method Blank Results	0

1/6/2015

Report Date

Richard E Danil

Signature

Quality Checked KTucker

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1734-2
Client #: CAR010K
Date Rec'd: 12/17/14
Time Rec'd: 11:00
Temp Rec'd: 3.0°C ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District PO Box 869 Big Spring, TX 79720	SAMPLE DATE: 12-16-14 / SAMPLE TIME: 10:21 am
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): 18.333 / Turbidity (NTU): 1.29
NAME OF SAMPLER: J. Laird	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Source water	Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: _____ Gallons _____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: _____ Liters

Client Sample ID: Source Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Jacob Laird	DATE / TIME: 12-16-14 16:15
RECEIVED BY: [signature]	DATE / TIME: 12/17/14 11:00

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150175-007

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	MF Source Water #1
Matrix:	Waste Water, treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	MF Source Water #1	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	5:30:00 PM		

Comments: Turbidity = 2.62 Calculated Result: <0.1 Oocysts / Liter (Crypto), 0.6 Cysts / Liter (Crypto)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/16/15-1507	Filter Type	Envirochek HV
Filter Serial #	552470	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	2/12/15	Elution Time	0730
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	6

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/25/2015

Report Date

Richard E Danielson

Signature

Quality Checked LBarriga

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150175-008

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Sutherland	**Customer Sample No.:**	MF Source Water #2
Matrix:	Waste Water, treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	MF Source Water #2	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	5:30:00 PM		
Comments:	Turbidity = 2.62 Calculated Result: 0.1 Oocysts / Liter (Crypto), 0.8 Cysts / Liter (Crypto)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/16/15-1525	Filter Type	Envirochek HV
Filter Serial #	551867	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	2/12/15	Elution Time	0738
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	1
Analyte 2	Giardia
No. of Giardia	8

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.

MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/25/2015

Report Date

Richard E Danielson

Signature

Quality Checked LBarriga

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 150175-015

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	none given	**Customer Sample No.:**	RWPF Product Water
Matrix:	Water, Treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	Product Water	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	4:45:00 PM		
Comments:	Calculated Result: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Crypto)		

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	2/16/15-1555	Filter Type	Envirochek HV
Filter Serial #	552474	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	2/12/15	Elution Time	0738
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/25/2015

Report Date

Richard E Danil

Signature

Quality Checked LBarriga

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 150363-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Source Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Source Water
Matrix:	Water, not otherwise specified	**Date/Time Received:**	3/12/2015 7:48:07 AM
Sample Point ID:	RWPT	**Check-in Temp. (0-20C)**	2.4C
Sample Collection Date:	3/10/2015	**Container Type:**	HV Envirochek
Sample Time:	1:20:00 PM		

Comments: Calculated results 0.4 Oocysts / Liter (Crypto), 325 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	552376
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	2
Resuspended Conc. Vol.	10 mL	Pellet Volume	2.0 mL
Elution date	3/12/15	Elution Time	0758
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	3/17/15-1445

Sample Results

Analyte	Crypto
No. of Crypto	4
Analyte 2	Giardia
No. of Giardia	3494

Sample Q. C

OPR Crypto Results	77 %
OPR Giardia Results	76 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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3/25/2015
Report Date

Richard E Danielson
Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

FEDEX FO ICE

LAB USE ONLY:
LIMS #: 363-1
Client #: CAR010K
Date Rec'd: 3-12
Time Rec'd: 0727
Temp Rec'd: 2.4

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79720	SAMPLE DATE: 03-10-15 — SAMPLE TIME: ON 1320 FILTER K 3/12
	Water Temp (C): — Turbidity (NTU):
Contact Name: JOHN BURCH — Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: R. HILDRETH	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: SOURCE WATER	Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: SOURCE WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 03-11-15 16:15
RECEIVED BY: K	DATE / TIME: 3-12 0727

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 150363-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Robert Hildreth
Customer Sample No.: Product Water
Matrix: Water, Treated
Date/Time Received: 3/12/2015 7:48:07 AM
Sample Point ID: RWPF
Check-in Temp. (0-20C) 2.4C
Sample Collection Date: 3/10/2015
Container Type: HV Envirochek
Sample Time: 1:00:00 PM
Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia).

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	3/17/15-1400	Filter Type	Envirochek HV
Filter Serial #	552367	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	3/12/15	Elution Time	0758
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	77 %
OPR Giardia Results	76 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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3/25/2015
Report Date

Richard E Danielson
Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

FLPACK FO ICE

LAB USE ONLY:	
LIMS #:	363-2
Client #:	CAR010K
Date Rec'd:	3-12
Time Rec'd:	0727
Temp Rec'd:	2.4

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79720	SAMPLE DATE: 03-10-15 — SAMPLE TIME: 13:00
Contact Name: JOHN BURCH Tel: 432-267-6341	Water Temp (C): — Turbidity (NTU): N/A
NAME OF SAMPLER: ROBERT HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: PRODUCT WATER	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: _____ Gallons _____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: _____ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 03-11-15 16:15
RECEIVED BY: KW	DATE / TIME: 3.12 0727

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150568-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Raw Water	**Date/Time Received:**	4/16/2015 9:25:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	1.9C
Sample Collection Date:	4/14/2015	**Container Type:**	HV Envirochek
Sample Time:	12:39:00 PM		
Comments:	Turbidity not give. Calculated Resuls: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	552553
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	4/16/15
Elution Time	1222	Pellet Volume	0.1 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	SM	Analysis Date / Time	4/22/15-1130

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	52 %
OPR Giardia Results	40 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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5/7/2015

Report Date

Richard E Danielson

Signature

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BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 568-1
Client #: CAR010K
Date Rec'd: 4-16
Time Rec'd: 0925
Temp Rec'd: 1.9

ICG

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TEX 79720	SAMPLE DATE: 4-14-2015 / SAMPLE TIME: 12:39
	Water Temp (C): / Turbidity (NTU): N/A
Contact Name: JOHN BURCH Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: ROBERT HILDRETH	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: ~~RWPF~~ RH PRODUCT WATER	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☒ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 04-15-15 / 16:00
RECEIVED BY:	DATE / TIME: 4/16/15 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 150568-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	4/16/2015 9:25:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	1.9C
Sample Collection Date:	4/14/2015	**Container Type:**	HV Envirochek
Sample Time:	2:30:00 PM		

Comments: Turbidity = 2.25 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	4/22/15-1135	Filter Type	Envirochek HV
Filter Serial #	552571	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	4/16/15	Elution Time	1301
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	52 %
OPR Giardia Results	40 %
Method Blank Results	0

5/7/2015

Report Date

Richard E Danil

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

ICC

LAB USE ONLY:
LIMS #: 568-2
Client #: CARO10K
Date Rec'd: 4-16
Time Rec'd: 0925
Temp Rec'd: 1.9

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79720
Contact Name: Tel:

SAMPLE DATE: 4-14-2015
SAMPLE TIME: 14:30
Water Temp (C):
Turbidity (NTU): 2.25

NAME OF SAMPLER: ROBERT HILDRETH

TREATMENT CHARACTERISTICS (Check One):
Raw Surface Water ☐ Treated Drinking Water ☐
Treated Wastewater ☒ Wastewater ☐
Ground Water ☐ Other: ______

SAMPLE SOURCE: SOURCE WATER

SAMPLE LOCATION: RWPF

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No (circled: No)

SAMPLE DESCRIPTION (MPA)
SAMPLE VOLUME: (Meter #)
Meter Start: Meter Stop:
Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)
Regular Grab Sample ☒ Matrix Spike Grab ☐
Regular Filtered Sample ☐
Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: SOURCE WATER
P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA <u>WITH</u> GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA <u>WITHOUT</u> FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Robert Hildreth
DATE / TIME: 04-15-15 / 16:00
RECEIVED BY: JMC
DATE / TIME: 4/16/15 09:25

fed ex

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150796-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Source Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH Hildreth	**Customer Sample No.:**	Source Water
Matrix:	Raw Water	**Date/Time Received:**	5/14/2015 7:42:27 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.6C
Sample Collection Date:	5/12/2015	**Container Type:**	HV Envirochek
Sample Time:	2:00:00 PM		

Comments: Turbidity = 3.22 NTU Calculated Results: <0.2 Oocysts/Liter (Crypto), 2.6 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	555929
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	5.4 L	Elution date	5/15/15
Elution Time	0733	Pellet Volume	4.0 mL
Resuspended Conc. Vol.	20 mL	No. of Slides Examined	2
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	5/20/15-1626

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	14

Sample Q. C

OPR Crypto Results	72 %
OPR Giardia Results	68 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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5/30/2015
Report Date

Richard E Danil
Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com FedEx FD ICE

LAB USE ONLY:	
LIMS #:	796-1
Client #:	CAR010K
Date Rec'd:	5-14
Time Rec'd:	0725
Temp Rec'd:	7.6

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUN. WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79720	SAMPLE DATE: 05-12-15 — SAMPLE TIME:
Contact Name: JOHN BURCH Tel: 432-267-6341	Water Temp (C): — Turbidity (NTU): 3.22
NAME OF SAMPLER: R. HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: SOURCE WATER	Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ____ Gallons ____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID: SOURCE WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

14:00 Sample time from label - [illegible]

RELINQUISHED BY:	[signature]	DATE / TIME:	05-13-15 16:15
RECEIVED BY:	K	DATE / TIME:	5-14 0740

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150796-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Water, Treated	**Date/Time Received:**	5/14/2015 7:42:27 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.6C
Sample Collection Date:	5/12/2015	**Container Type:**	HV Envirochek
Sample Time:	1:50:00 PM		

Comments: Turbidity not given. Calculated Results <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	5/20/15-1633	Filter Type	Envirochek HV
Filter Serial #	556926	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	5/15/15	Elution Time	0733
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	72 %
OPR Giardia Results	68 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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5/30/2015 Richard E Danielson

Report Date **Signature** **Quality Checked** EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 796-2
Client #: CAR010K
Date Rec'd: 5-14
Time Rec'd: 0725
Temp Rec'd: 3.6

ICE

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUN. WATER DISTRICT	SAMPLE DATE: 05-12-15 SAMPLE TIME: 13:50
	Water Temp (C): Turbidity (NTU): N/A
Contact Name: JOHN BURCH Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: R. HILDRETH	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: PRODUCT WATER	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☐ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 05-13-15 16:15
RECEIVED BY: [initials]	DATE / TIME: 5.14 0740

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150942-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	6/3/2015 7:40:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4 C
Sample Collection Date:	6/1/2015	**Container Type:**	HV Envirochek
Sample Time:	5:06:00 PM		

Comments: Turbidity = 6.2 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto) <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	6/9/15-1343	Filter Type	Envirochek HV
Filter Serial #	563051	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	6/3/15	Elution Time	0852
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	54 %
OPR Giardia Results	84 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.

MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

6/27/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 942-2
Client #: CARO10K
Date Rec'd: 6/3/15
Time Rec'd: 07:40
Temp Rec'd: 3.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79721	SAMPLE DATE: 0102 JUN 2015 jdB — SAMPLE TIME: 17:06
Contact Name: JOHN BURCH Tel: 432 2676341	Water Temp (C): — Turbidity (NTU): 6.2
NAME OF SAMPLER: LAIRD	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: MF SOURCE WATER	Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ______Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF SOURCE WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: JMC	DATE / TIME: 6/3/15 07:40
RECEIVED BY:	DATE / TIME:

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 150942-003

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	Product Water
Matrix:	Water, not otherwise specified	**Date/Time Received:**	6/3/2015 7:40:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4 C
Sample Collection Date:	6/1/2015	**Container Type:**	HV Envirochek
Sample Time:	4:35:00 PM		
Comments:	Turbidity = Not Given. Calculated Results: <0.1 Oocysts/Liter (Crypto) <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	563045
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	6/3/15	Elution Time	0852
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	6/9/15-1330

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	54 %
OPR Giardia Results	84 %
Method Blank Results	0

6/27/2015

Report Date

Richard E Danil

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)

Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 942-3
Client #: CARO10K
Date Rec'd: 6/3/15
Time Rec'd: 07:40
Temp Rec'd: 3.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DIST. P.O. BOX 869 BIG SPRING TX ~~79720~~ 79721

Contact Name: JOHN BURCH Tel: 432 2676341

NAME OF SAMPLER: LAIRD

SAMPLE SOURCE: PRODUCT WATER

SAMPLE LOCATION: RWPF

SAMPLE DATE: 01 JUN 2015

SAMPLE TIME: 16:35

Water Temp (C):

Turbidity (NTU):

TREATMENT CHARACTERISTICS (Check One):

Raw Surface Water ☐ Treated Drinking Water ☐

Treated Wastewater ☐ Wastewater ☐

Ground Water ☐ ☒ Other: RECLAIMED WATER

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)

SAMPLE VOLUME: (Meter #)

Meter Start: Meter Stop:

Total Volume: ________ Gallons ________ Liters

SAMPLE DESCRIPTION (G/C)

Regular Grab Sample ☒ NO Matrix Spike Grab ☐

Regular Filtered Sample ☒ YES

Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.75 Liters Grab Volume: ________ Liters

Client Sample ID: PRODUCT WATER

P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 6/3/15 07:40
RECEIVED BY:	DATE / TIME:

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 151414-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	RH Hildreth	**Customer Sample No.:**	None Given
Matrix:	Waste Water, treated	**Date/Time Received:**	8/12/2015 7:25:55 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	1.5C
Sample Collection Date:	8/10/2015	**Container Type:**	HV Envirochek
Sample Time:	2:10:00 PM		
Comments:	Turbidity = 1.63 NTU Calculated Results: 13.4 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	8/17/15-1028	Filter Type	Envirochek HV
Filter Serial #	566568	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.6 mL
Elution date	8/12/15	Elution Time	0804
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	144
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	86 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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8/24/2015

Report Date

Richard E Danil

Signature

Quality Checked EMoran

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

FROZEN ICE

LAB USE ONLY:	
LIMS #:	1414-1
Client #:	CAR010K
Date Rec'd:	8-12
Time Rec'd:	0725
Temp Rec'd:	1.5

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNI. WATER DIST.	SAMPLE DATE: 08-10-15 — SAMPLE TIME: ON FILTER 1410
	Water Temp (C): — Turbidity (NTU): 1.63
Contact Name: JOHN BURCH — Tel: 432-2676341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: R. HIGDRETT	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: SOURCE WATER	Treated Wastewater ☒ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 08-11-15 16:00
RECEIVED BY: KW	DATE / TIME: 8-12 0725

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 151414-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: RH Hildreth **Customer Sample No.:** None Given
Matrix: Water, Treated **Date/Time Received:** 8/12/2015 7:25:55 AM
Sample Point ID: RWPF **Check-in Temp. (0-20C)** 1.5C
Sample Collection Date: 8/10/2015 **Container Type:** HV Envirochek
Sample Time: 2:03:00 PM
Comments: Tubidity not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	8/17/15-1046	Filter Type	Envirochek HV
Filter Serial #	566488	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	8/12/15	Elution Time	0804
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	86 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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8/24/2015
Report Date

Richard E Danil
Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

FEDEX
ICE

LAB USE ONLY:	
LIMS #:	1414-2
Client #:	CARB010K
Date Rec'd:	8-12
Time Rec'd:	0725
Temp Rec'd:	1.5

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVERMUN WATER DIST.	SAMPLE DATE: 08-10-15 / SAMPLE TIME: 1403 ON FILTER
	Water Temp (C): / Turbidity (NTU): ~~.1613~~ RH N/A
Contact Name: JOHN BURCH / Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: R. HILDRETH	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: PRODUCT WATER	Treated Wastewater ~~☒~~ RH Wastewater ☐
	Ground Water ☐ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☒ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME:	08-11/15	16:00 ~~AH~~
RECEIVED BY: [signature]	DATE / TIME:	8-12	0725

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #1795

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 151671-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: G. Bruce / J. Laird **Customer Sample No.:** Product Water HVF
Matrix: Water, Treated **Date/Time Received:** 9/17/2015 9:30:00 AM
Sample Point ID: RWPF **Check-in Temp. (0-20C)** 8.6
Sample Collection Date: 9/16/2015 **Container Type:** HV Envirochek
Sample Time: 9:39:00 AM
Comments: Turbidity not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	9/24/15-1625	Filter Type	Envirochek HV
Filter Serial #	560551	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	9/18/15	Elution Time	0708
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	80 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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11/10/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1671 P-2
Client #: CAR010R
Date Rec'd: 9/17/15
Time Rec'd: 09:30
Temp Rec'd: 8.6°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO MUNICIPAL WATER DISTRICT 401 E. 24TH STREET BIG SPRING, TX 79720	SAMPLE DATE: 16 SEPT 2015 — SAMPLE TIME: 9:39 FILTER
Contact Name: JOHN O. BURCH Tel: 432 2676341	Water Temp (C): NA — Turbidity (NTU): NA 9:42 MS SPIKE GRAB
NAME OF SAMPLER: G. BRUCE / J. LAZCO	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ Other: RECLAIMED WATER
SAMPLE SOURCE: PRODUCT WATER	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (if Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☒
Total Volume: ______ Gallons ______ Liters	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
1 X	REGULAR SAMPLE
2 X	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John O. Burch	DATE / TIME: 16 SEPT 2015 - 14:00
RECEIVED BY:	DATE / TIME: 9/17/15 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

No [illegible] need in this cooler [illegible]

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LAB Sample ID: 151671-004

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** MF Source Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: G. Bruce / J. Laird **Customer Sample No.:** MF Source Water HVF
Matrix: Waste Water, treated **Date/Time Received:** 9/17/2015 9:30:00 AM
Sample Point ID: **Check-in Temp. (0-20C)** 2.8
Sample Collection Date: 9/16/2015 **Container Type:** HV Envirochek
Sample Time: 10:00:00 AM
Comments: Turbidity = 1.4 NTU Calculated Results: 1.9 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	9/25/15-1433	Filter Type	Envirochek HV
Filter Serial #	560568	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	9/18/15	Elution Time	0708
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	20
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	80 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

11/10/2015 Richard E Danielson

Report Date **Signature** **Quality Checked** EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 16714-5
Client #: CAR0101K
Date Rec'd: 9/17/15
Time Rec'd: 0930
Temp Rec'd: 2.8°C

ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT 401 E. 24TH STREET BIG SPRING, TX 79720
Contact Name: JOHN A. CHURCH Tel: 432.267.6341

SAMPLE DATE: 16 SEPT 2015
SAMPLE TIME: 10:00 FILTER

Water Temp (C): NA
Turbidity (NTU): 1.4

TREATMENT CHARACTERISTICS (Check One):
Raw Surface Water ☐ Treated Drinking Water ☐
Treated Wastewater ☒ Wastewater ☐
Ground Water ☐ Other: ____

10:02 MS GRAB

NAME OF SAMPLER: G. BRICE / J. LAZRO

SAMPLE SOURCE: MF SOURCE WATER

SAMPLE LOCATION:

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)
SAMPLE VOLUME: (Meter #)
Meter Start: Meter Stop:
Total Volume: ____ Gallons ____ Liters

SAMPLE DESCRIPTION (G/C)
Regular Grab Sample ☐ Matrix Spike Grab ☐
Regular Filtered Sample ☐
Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☒
Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID: MF SOURCE WATER
P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
4 X	REGULAR SAMPLE
5 X	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-025)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John A. Church DATE / TIME: 16 SEPT 2015 - 14:00

RECEIVED BY: [signature] DATE / TIME: 9/17/15 0930

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 151898-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	None Given
Matrix:	Raw Water	**Date/Time Received:**	10/15/2015 9:55:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	6.1
Sample Collection Date:	10/13/2015	**Container Type:**	
Sample Time:	3:50:00 PM		

Comments: Turbidity not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	563173
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	10/16/15
Elution Time	0930	Pellet Volume	0.1 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	10/23/15-1518

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	84 %
Method Blank Results	0

11/10/2015
Report Date

Richard E Danil
Signature

Quality Checked EMoran

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1898-1
Client #: CARoick
Date Rec'd: 10/15/15
Time Rec'd: 09:55
Temp Rec'd: 6.1°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District, 401 E. 24th Street, Big Spring Tx 79720 Contact Name: John Burch Tel: 432-267-6341	SAMPLE DATE: 10-13-15 SAMPLE TIME: ~~1350~~ 1550 RH Water Temp (C): N/A Turbidity (NTU): N/A
NAME OF SAMPLER: ROBERT HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Product Water	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (Q/C)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623 Cryptosporidium and Giardia (EPA 821-R-01-026)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622 Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 10/14/15 16:00
RECEIVED BY: [signature]	DATE / TIME: 10/15/15 09:55

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC. 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 151898-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** MF Source Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	None Given
Matrix:	Raw Water	**Date/Time Received:**	10/15/2015 9:55:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	6.1
Sample Collection Date:	10/13/2015	**Container Type:**	EV Filter
Sample Time:	4:00:00 PM		

Comments: Turbidity not given. Calculated Results:16.7 Oocysts/Liter (Crypto), 17.7 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	566571
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	10/16/15
Elution Time	0930	Pellet Volume	1.0 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	10/23/15-1710

Sample Results

Analyte	Crypto
No. of Crypto	180
Analyte 2	Giardia
No. of Giardia	190

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	84 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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11/10/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1898-2
Client #: CARO10R
Date Rec'd: 10/15/15
Time Rec'd: 0755
Temp Rec'd: [illegible]

Note: Please print clearly using waterproof ink.

COMPANY NAME & ADDRESS: Colorado River Municipal Water District, 401 E. 24th Street, Big Spring, TX 79720 Contact Name: John Burch Tel: 432-267-6341	SAMPLE DATE: 10-13-15 / SAMPLE TIME: 1600 Water Temp (C): N/A / Turbidity (NTU): N/A
NAME OF SAMPLER: ROBERT HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other:
SAMPLE SOURCE: MF Source Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled: No)
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 10/14/15 16:00
RECEIVED BY: [signature]	DATE / TIME: 10/15/15 0755

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 152265-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No: CAR010K **Purchase Order No:** N/A

PWS ID: N/A **Facility ID:** Product Water

Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Greg Bruce	**Customer Sample No.:**	Product Water
Matrix:	Water, not otherwise specified	**Date/Time Received:**	11/25/2015 10:20:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4C
Sample Collection Date:	11/23/2015	**Container Type:**	HV Envirochek
Sample Time:	1:45:00 PM		

Comments: Turbidity not given. <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	579189
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	11/25/15	Elution Time	1122
Resample	No	Original Sample Date	
Analyst	DL	Analysis Date / Time	12/2/15-1349

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C.

OPR Crypto Results	77 %
OPR Giardia Results	82 %
Method Blank Results	0

12/23/2015

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 2265-1
Client #: CAR010K
Date Rec'd: 11/25/15
Time Rec'd: 10:20
Temp Rec'd: 3.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water Distric, 401 E. 24th St., Big Spring, Tx 79720	SAMPLE DATE: 11.23.15 / SAMPLE TIME: 13:45
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): N/A / Turbidity (NTU): N/A
NAME OF SAMPLER: Greg Bruce	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Product Water	Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled: No)
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Greg Bruce	DATE / TIME: 11.24.15 15:15
RECEIVED BY: [signature]	DATE / TIME: 11/25/15 10:20

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

FedEx

LAB Sample ID: 152265-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Greg Bruce	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	11/25/2015 10:20:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4C
Sample Collection Date:	11/23/2015	**Container Type:**	HV Envirochek
Sample Time:	2:45:00 PM		
Comments:	Turbidity not given. 65.3 Oocysts/Liter (Crypto), 0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	12/2/15-1449	Filter Type	Envirochek HV
Filter Serial #	579188	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.6 mL
Elution date	11/25/15	Elution Time	1122
Resample	No	Original Sample Date	
Analyst	DL		

Sample Results

Analyte	Crypto
No. of Crypto	702
Analyte 2	Giardia
No. of Giardia	1

Sample Q. C.

OPR Crypto Results	77 %
OPR Giardia Results	82 %
Method Blank Results	0

12/23/2015

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 2265-2
Client #: CAR010K
Date Rec'd: 11/25/15
Time Rec'd: 10:20
Temp Rec'd: 3.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS:
Colorado River Municipal Water Distric
401 E. 24th St.
Big Spring, Tx 79720
Contact Name: John Burch Tel: 432-267-6341

NAME OF SAMPLER: Greg Bruce

SAMPLE SOURCE: MF Source Water

SAMPLE LOCATION: RWPF

SAMPLE DATE: 11.23.2015
SAMPLE TIME: 14:45
Water Temp (C): N/A
Turbidity (NTU): N/A

TREATMENT CHARACTERISTICS (Check One):
Raw Surface Water ☐ Treated Drinking Water ☐
Treated Wastewater ☒ Wastewater ☐
Ground Water ☐ Other: ______

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No (circled)

SAMPLE DESCRIPTION (MPA)
SAMPLE VOLUME: (Meter #)
Meter Start: Meter Stop:
Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)
Regular Grab Sample ☐ Matrix Spike Grab ☐
Regular Filtered Sample ☒
Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water
P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Greg Bruce DATE / TIME: 11.24.15 15:15

RECEIVED BY: [signature] DATE / TIME: 11/25/15 10:20

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 152396-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Water, not otherwise specified	**Date/Time Received:**	12/17/2015 9:45:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	2.4C
Sample Collection Date:	12/15/2015	**Container Type:**	HV Envirochek
Sample Time:	1:55:00 PM		

Comments: Turbidiy not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	579195
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	12/18/15	Elution Time	0856
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	12/24/15-1539

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	60 %
Method Blank Results	0

2/17/2016
Report Date

Richard E Danil
Signature

Quality Checked ElbaM

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 23961
Client #: CAR010K
Date Rec'd: 12/17/15
Time Rec'd: 0945
Temp Rec'd: 2.2°C

Note: Please print clearly using waterproof ink

Dif

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT
401 E 24th
BIG SPRING, TX 79720

Contact Name: JOHN BURCH Tel: 432-267-6341

NAME OF SAMPLER:

SAMPLE SOURCE: PRODUCT WATER

SAMPLE LOCATION: RWPF

SAMPLE DATE: 12-15-15

SAMPLE TIME: 13F55

Water Temp (C): N/A

Turbidity (NTU): N/A

TREATMENT CHARACTERISTICS (Check One):
- Raw Surface Water ☐
- Treated Drinking Water ☐
- Treated Wastewater ☐
- Wastewater ☐
- Ground Water ☒
- Other: RECLAIMED WATER

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No

[redacted]

SAMPLE VOLUME: (Meter #)

Meter Start: Meter Stop:

Total Volume: ________ Gallons ________ Liters

- Regular Grab Sample ☐
- Matrix Spike Grab ☐
- Regular Filtered Sample ☑
- Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.95 Liters Grab Volume: ________ Liters

Client Sample ID: PRODUCT WATER

P.O. #:

ASSAY REQUESTED: Please check one of the following

[redacted]

✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
[redacted]	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
[redacted]	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature] DATE / TIME: 12/16/15 16:00

RECEIVED BY: [signature] DATE / TIME: 12/17/15 09:45

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

fed ex

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 152396-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Filtrate
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Filtrate
Matrix:	Waste Water, treated	**Date/Time Received:**	12/17/2015 9:45:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	2.4C
Sample Collection Date:	12/15/2015	**Container Type:**	HV Envirochek
Sample Time:	2:05:00 PM		
Comments:	Turbidity = 0.018 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	12/24/15-1547	Filter Type	Envirochek HV
Filter Serial #	579196	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	12/18/15	Elution Time	0856
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	60 %
Method Blank Results	0

2/17/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)

Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 2396-2
Client #: CAR010K
Date Rec'd: 12/17/15
Time Rec'd: 09:45
Temp Rec'd: 2.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT, 401 E 24th ST, BIG SPRING, TX 79720 Contact Name: JOHN BURCH Tel: 432-267-6341	SAMPLE DATE: 12-15-15 | SAMPLE TIME: 14:05 Water Temp (C): N/A | Turbidity (NTU): 0.018
NAME OF SAMPLER: ROBERT HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE SOURCE: MF FILTRATE	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF FILTRATE	P.O. #:

ASSAY REQUESTED: Please check one of the following

✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 12/16/15 16:00
RECEIVED BY: [signature]	DATE / TIME: 12/17/15 09:45

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 152396-003

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	12/17/2015 9:45:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	2.4C
Sample Collection Date:	12/15/2015	**Container Type:**	HV Envirochek
Sample Time:	2:25:00 PM		
Comments:	Turbidity = 0.306 NTU. Calculated Results: 4.9 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	12/24/15-1611	Filter Type	Envirochek HV
Filter Serial #	579205	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.8 mL
Elution date	12/18/15	Elution Time	0856
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	53
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	60 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

2/17/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 2396-3
Client #: CAR010K
Date Rec'd: 12/17/15
Time Rec'd: 09:45
Temp Rec'd: 2.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNI. WATER DISTRICT 401 E 24th ST BIG SPRING, TX 79720	SAMPLE DATE: 12-15-15 / SAMPLE TIME: 14:25
Contact Name: JOHN BURCH Tel:	Water Temp (C): N/A / Turbidity (NTU): 1.306
NAME OF SAMPLER: ROBERT HILDRETH	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: MF SOURCE WATER	Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF SOURCE WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 12-16-15 16:00
RECEIVED BY: [signature]	DATE / TIME: 12/17/15 09:45

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 160176-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	1/21/2016 9:00:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	2.1C
Sample Collection Date:	1/19/2016	**Container Type:**	HV Envirochek filter
Sample Time:	3:34:00 PM		

Comments: Turbidity = 0.906 NTU Calculated Results: 2.2 Oocysts/Liter (Crypto), 5.2 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	1/26/16-1230	Filter Type	Envirochek HV
Filter Serial #	590351	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	1/22/16	Elution Time	1056
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	24
Analyte 2	Giardia
No. of Giardia	56

Sample Q. C

OPR Crypto Results	66 %
OPR Giardia Results	82 %
Method Blank Results	0

2/17/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1601761
Client #: CAR010K
Date Rec'd: 1.21.16
Time Rec'd: 0900 FedX
Temp Rec'd: 2.1°C Ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District 401 E. 24th St., Big Spring Tx 79720

Contact Name: John Burch Tel: 432-267-6341

NAME OF SAMPLER: Robert Hildreth

SAMPLE SOURCE: MF Source Water

SAMPLE LOCATION: RWPF

SAMPLE DATE: 1-19-16 SAMPLE TIME: 15:34

Water Temp (C): N/A Turbidity (NTU): 0.906

TREATMENT CHARACTERISTICS (Check One):
- Raw Surface Water ☐
- Treated Drinking Water ☐
- Treated Wastewater ☒
- Wastewater ☐
- Ground Water ☐
- Other: ______

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)

SAMPLE DESCRIPTION (MPA)

SAMPLE VOLUME: (Meter #)

Meter Start: Meter Stop:

Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)
- Regular Grab Sample ☐
- Matrix Spike Grab ☐
- Regular Filtered Sample ☒
- Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water

P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature] DATE / TIME: 1-20-16 16:30

RECEIVED BY: [signature] DATE / TIME: 1-21-16 0900

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 160176-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Water, Treated	**Date/Time Received:**	1/21/2016 9:00:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	2.1C
Sample Collection Date:	1/19/2016	**Container Type:**	
Sample Time:	3:52:00 PM		

Comments: Turbidity not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	1/26/16-1235	Filter Type	Envirochek HV
Filter Serial #	590366	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	1/22/16	Elution Time	1056
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	66 %
OPR Giardia Results	82 %
Method Blank Results	0

2/17/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

BioVir LABORATORIES ®

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 160176-2
Client #: CAR010K
Date Rec'd: 1.21.16
Time Rec'd: 0900 FedX
Temp Rec'd: 2.7 °C
FLR

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District 401 E. 24th St., Big Spring Tx 79720	SAMPLE DATE: 1-19-16 — SAMPLE TIME: 15:52
Contact Name: John Burch — Tel: 432-267-6341	Water Temp (C): N/A — Turbidity (NTU): N/A
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water
SAMPLE SOURCE: Product Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
[illegible]	[illegible]
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ________ Gallons ________ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ________ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

[illegible]	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
[illegible]	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
[illegible]	
	MPA <u>WITH</u> GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA <u>WITHOUT</u> FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 1-20-16 16:30
RECEIVED BY: [signature]	DATE / TIME: 1-21-16 0900

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 160176-003

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Filtrate
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Filtrate Water
Matrix:	Waste Water, treated	**Date/Time Received:**	1/21/2016 9:00:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	2.1C
Sample Collection Date:	1/19/2016	**Container Type:**	HV Envirochek filter
Sample Time:	4:02:00 PM		
Comments:	Turbidity = 0.026 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	1/26/16-1244	Filter Type	Envirochek HV
Filter Serial #	590352	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	1/22/16	Elution Time	1056
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	66 %
OPR Giardia Results	82 %
Method Blank Results	0

2/17/2016

Report Date

Richard E Danil

Signature

Quality Checked ElbaM

BioVir LABORATORIES®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1601763
Client #: CAR010K
Date Rec'd: 1-21-16 FedX
Time Rec'd: 0900
Temp Rec'd: 2.1°C Ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District, 401 E. 24th St., Big Spring TX 79720	SAMPLE DATE: 1.19.16 — SAMPLE TIME: 16:02
Contact Name: John Burch — Tel: 432-267-6341	Water Temp (C): N/A — Turbidity (NTU): 0.026
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: MF Filtrate Water	Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (No circled)
[illegible]	[illegible]
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☐
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Filtrate Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 1-20-16 16:30
RECEIVED BY: [signature]	DATE / TIME: 1-21-16 0900

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 160520-003

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** RWPF
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	M F source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	2/25/2016 9:30:00 AM
Sample Point ID:	None Given	**Check-in Temp. (0-20C)**	4.3C
Sample Collection Date:	2/23/2016	**Container Type:**	10 L Cubitainer
Sample Time:	10:40:00 AM		

Comments: Turbidity not given. Calculated Results: 42.8 Oocysts/Liter (Crypto), 18.4 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	3/1/16-1737	Filter Type	Envirochek HV
Filter Serial #	592850	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.9 mL
Elution date	2/26/16	Elution Time	0856
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	460
Analyte 2	Giardia
No. of Giardia	198

Sample Q. C

OPR Crypto Results	53 %
OPR Giardia Results	54 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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3/15/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1605203
Client #: CAR010
Date Rec'd: 2-25-16
Time Rec'd: 0930
Temp Rec'd: 4.3°

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District
401 E. 24th st, Big Spring, Tx 79720

Contact Name: John Burch Tel: 432-267-6341

SAMPLE DATE: 2-23-16
SAMPLE TIME: 10:40 AM

Water Temp (C): N/A
Turbidity (NTU): 8.5 - 12.5

NAME OF SAMPLER: Robert Hildreth

TREATMENT CHARACTERISTICS (Check One):
- Raw Surface Water ☐
- Treated Drinking Water ☐
- Treated Wastewater ☒
- Wastewater ☐
- Ground Water ☐
- Other: ______

SAMPLE SOURCE: MF Source Water

SAMPLE LOCATION: RWPF

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No (circled: No)

SAMPLE VOLUME: (Meter #)

Meter Start: Meter Stop:

Total Volume: ______ Gallons ______ Liters

- Regular Grab Sample ☐
- Matrix Spike Grab ☐
- Regular Filtered Sample ☒
- Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water

P.O. #:

ASSAY REQUESTED: Please check one of the following

X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Robert Hildreth DATE / TIME: 2-24-16 1600

RECEIVED BY: [signature] DATE / TIME: 2-25-16 0930 FedEx

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 160520-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.co	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Filtration Water
Matrix:	Waste Water, treat	**Date/Time Received:**	2/25/2016 9:30:00 AM
Sample Point ID:	None Given	**Check-in Temp. (0-20C)**	4.3C
Sample Collection Date:	2/23/2016	**Container Type:**	10 L Cubitainer
Sample Time:	11:30:00 AM		
Comments:	Turbidity = 0.02 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	3/1/16-1706	Filter Type	Envirochek HV
Filter Serial #	590367	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	2/26/16	Elution Time	0856
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	53 %
OPR Giardia Results	54 %
Method Blank Results	0

3/15/2016 — **Report Date**

Richard E Danielson — **Signature**

Quality Checked ElbaM

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Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1602520-1
Client #: AC010K
Date Rec'd: 2-25-16
Time Rec'd: 0930
Temp Rec'd: 4.3C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District, 401 E. 24th St, Big Spring, Tx 79720	SAMPLE DATE: 2-23-16 / SAMPLE TIME: 11:30am
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): N/A / Turbidity (NTU): .02
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ____
SAMPLE SOURCE: MF Filtrate Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ____ Gallons ____ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID: MF Filtrate Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Robert Hildreth	DATE / TIME: 2-24-16 1600
RECEIVED BY: [signature]	DATE / TIME: 2-25-16 0930 FedEx Ice

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 160520-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No: CAR010K — **Purchase Order No:** N/A

PWS ID: N/A — **Facility ID:** RWPF

Client Contact: Eva Steinle-Darling, ESD@carollo.co — **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Waste Water, treat	**Date/Time Received:**	2/25/2016 9:30:00 AM
Sample Point ID:	None Given	**Check-in Temp. (0-20C)**	4.3C
Sample Collection Date:	2/23/2016	**Container Type:**	10 L Cubitainer
Sample Time:	9:29:00 AM		

Comments: Turbidity not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	3/1/16-1710	Filter Type	Envirochek HV
Filter Serial #	592848	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	2/26/16	Elution Time	0856
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	53 %
OPR Giardia Results	54 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/15/2016 — Richard E Danil

Report Date — **Signature**

Quality Checked ElbaM

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 16D520-2
Client #: CAR010K
Date Rec'd: 2-25-16
Time Rec'd: 0930
Temp Rec'd: 4.3°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District, 401 E. 24th St., Big Spring, Tx 79720	SAMPLE DATE: 2-23-16 / SAMPLE TIME: 09:29am
Contact Name: John Burch Tel: 432-267-6341	Water Temp (C): N/A / Turbidity (NTU): N/A
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water
SAMPLE SOURCE: Product Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ____ Gallons ____ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 2-24-16 16:00
RECEIVED BY: [signature]	DATE / TIME: 2-25-16 0930 FedEx

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

KE

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LAB Sample ID: 160647-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	None Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	3/17/2016 8:56:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3C
Sample Collection Date:	3/15/2016	**Container Type:**	HV Envirochek filter
Sample Time:	9:45:00 AM		

Comments: Calculated Results: 0.6 Oocysts/Liter (Crypto), 0.8 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	03/24/16-1506	Filter Type	Envirochek HV
Filter Serial #	579194	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.9 mL
Elution date	03/18/16	Elution Time	0848
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	6
Analyte 2	Giardia
No. of Giardia	9

Sample Q. C

OPR Crypto Results	46 %
OPR Giardia Results	79 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/28/2016

Report Date

Richard E Daniel

Signature

Quality Checked ElbaM

161647-1

LAB USE ONLY:
LIMS #: ~~160244~~ MWP 3-17-16
Client #: CAR010K
Date Rec'd: 3-17-16
Time Rec'd: 0856
Temp Rec'd: 3.0

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

Note: Please print clearly using waterproof ink FedX-FCP

COMPANY NAME & ADDRESS: Colorado River Municipal Water Distric 401 E. 24th St., Big Spring, TX 79720
Contact Name: John Burch Tel: 432-267-6341

SAMPLE DATE: 3-15-16
SAMPLE TIME: 0945
Water Temp (C): N/A
Turbidity (NTU): 8.93

NAME OF SAMPLER: Robert Hildreth

SAMPLE SOURCE: MF Source Water

SAMPLE LOCATION: RWPF

TREATMENT CHARACTERISTICS (Check One):
- Raw Surface Water ☐
- Treated Drinking Water ☐
- Treated Wastewater ☒
- Wastewater ☐
- Ground Water ☐
- Other: ______

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)

SAMPLE VOLUME: (Meter #)
Meter Start: Meter Stop:
Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)

- Regular Grab Sample ☐
- Matrix Spike Grab ☐
- Regular Filtered Sample ☒
- Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water
P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature] DATE / TIME: 3-16-16 1600
RECEIVED BY: M Pray DATE / TIME: 3-17-16 0856

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

F:\WP\FORMS\Datasheets\G&C and MPA Data Sheet Rev 03-11-09.d

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LAB Sample ID: 160647-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	None Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Waste Water, treated	**Date/Time Received:**	3/17/2016 8:56:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3C
Sample Collection Date:	3/15/2016	**Container Type:**	HV Envirochek filter
Sample Time:	10:30:00 AM		
Comments:	Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	03/24/16-1521	Filter Type	Envirochek HV
Filter Serial #	577560	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	03/18/16	Elution Time	0848
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	46 %
OPR Giardia Results	79 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.

MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/28/2016 — **Report Date**

Richard E Danil — **Signature**

Quality Checked ElbaM

~~1602~~ 160647-2

BioVir LABORATORIES

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

MP 3.17.16

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: ~~160244~~
Client #: CAR010K
Date Rec'd: 3/16
Time Rec'd: 0856
Temp Rec'd: 3.0

Note: Please print clearly using waterproof ink

FedX 7C

COMPANY NAME & ADDRESS: Colorado River Municipal Water Distric 401 E. 24th St., Big Spring, Tx 79720 Contact Name: John Burch Tel: 432-267-6341	SAMPLE DATE: 3-15-16 SAMPLE TIME: 10:30AM Water Temp (C): N/A Turbidity (NTU): N/A
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water
SAMPLE SOURCE: Product Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 3.16.16 1600
RECEIVED BY: M Rojo	DATE / TIME: 3.17.16 0856

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 160762-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	4/14/2016 9:35:00 AM
Sample Point ID:	None Given	**Check-in Temp. (0-20C)**	5.4C
Sample Collection Date:	4/12/2016	**Container Type:**	HV Envirochek filter
Sample Time:	2:05:00 PM		
Comments:	Turbidity = 3.5 NTU Calculated Results: 1.2 Oocysts/Liter (Crypto), 46.5 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	04/20/16-2147	Filter Type	Envirochek HV
Filter Serial #	591967	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	10 mL	Pellet Volume	2.0 mL
Elution date	04/14/16	Elution Time	1040
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	13
Analyte 2	Giardia
No. of Giardia	500

Sample Q. C

OPR Crypto Results	73 %
OPR Giardia Results	86 %
Method Blank Results	0

4/26/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

160762-2

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: ~~160279~~
Client #: CAR010K
Date Rec'd: 4-14-16
Time Rec'd: 0935
Temp Rec'd: 5.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS:
Colorado River Municipal Water District
401 E. 24th St., Big Spring, Tx 79720
Contact Name: John Burch Tel: 432-267-6341

NAME OF SAMPLER:
Robert Hildreth / Greg B

SAMPLE SOURCE:
MF Source Water

SAMPLE LOCATION:
RWPF

SAMPLE DATE: 4.12.16
SAMPLE TIME: 14:05
Water Temp (C): N/A
Turbidity (NTU): 3.5

TREATMENT CHARACTERISTICS (Check One):
Raw Surface Water ☐ Treated Drinking Water ☐
Treated Wastewater ☒ Wastewater ☐
Ground Water ☐ Other: ______

DECHLORINATION/ DISINFECTANT NEUTRALIZATION
(If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)
SAMPLE VOLUME: (Meter #)
Meter Start: Meter Stop:
Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)
Regular Grab Sample ☐ Matrix Spike Grab ☐
Regular Filtered Sample ☒
Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water
P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Greg B DATE / TIME: 4.13.16 1600

RECEIVED BY: [signature] DATE / TIME: 4-14-16 FedX 0935 1C

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 160762-003

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** RWPF
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Filtrate Water
Matrix:	Waste Water, treated	**Date/Time Received:**	4/14/2016 9:35:00 AM
Sample Point ID:	None Given	**Check-in Temp. (0-20C)**	5.4C
Sample Collection Date:	4/12/2016	**Container Type:**	HV Envirochek filter
Sample Time:	2:20:00 PM		

Comments: Turbidity = 0.02 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	04/20/16-2103	Filter Type	Envirochek HV
Filter Serial #	579206	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	04/14/16	Elution Time	1040
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	73 %
OPR Giardia Results	86 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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4/26/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

1607623

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
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LAB USE ONLY:
LIMS #: ~~160244~~
Client #: CAR010K
Date Rec'd: 4-14-16
Time Rec'd: 0935
Temp Rec'd: 5.2°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water Distric 401 E. 24th St., Big Spring, Tx 79720

Contact Name: John Burch Tel: 432-267-6341

NAME OF SAMPLER: Robert Hildreth / Greg Burn

SAMPLE SOURCE: MF Filtrate Water

SAMPLE LOCATION: RWPF

SAMPLE DATE: 4.12.16

SAMPLE TIME: 14:20

Water Temp (C): N/A

Turbidity (NTU): .02

TREATMENT CHARACTERISTICS (Check One):
- Raw Surface Water ☐
- Treated Drinking Water ☐
- Treated Wastewater ☒
- Wastewater ☐
- Ground Water ☐
- Other: ______

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)

SAMPLE VOLUME: (Meter #)

Meter Start: Meter Stop:

Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)
- Regular Grab Sample ☐
- Matrix Spike Grab ☐
- Regular Filtered Sample ☒
- Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Filtrate Water

P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Greg Burn DATE / TIME: 4.13.16 16:00

RECEIVED BY: [signature] DATE / TIME: 4-14-16 FedX 0935 ice

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LAB Sample ID: 160762-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No: CAR010K **Purchase Order No:** N/A

PWS ID: N/A **Facility ID:** RWPF

Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Robert Hildreth **Customer Sample No.:** Product Water

Matrix: Waste Water, treated **Date/Time Received:** 4/14/2016 9:35:00 AM

Sample Point ID: None Given **Check-in Temp. (0-20C)** 5.4C

Sample Collection Date: 4/12/2016 **Container Type:** HV Envirochek filter

Sample Time: 1:55:00 PM

Comments: Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	04/20/16-2059	Filter Type	Envirochek HV
Filter Serial #	599048	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	04/14/16	Elution Time	1040
Resample	No	Original Sample Date	
Analyst	KW		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	73 %
OPR Giardia Results	86 %
Method Blank Results	0

4/26/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

160162-1

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
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LAB USE ONLY:
LIMS #: ~~160244~~
Client #: CAR010K
Date Rec'd: 4-14-16
Time Rec'd: 0935
Temp Rec'd: 5.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water Distric 401 E. 24th St., Big Spring, Tx 79720 Contact Name: John Burch Tel: 432-267-6341	SAMPLE DATE: 4-12-16 / SAMPLE TIME: 13:55 / Water Temp (C): N/A / Turbidity (NTU): N/A
NAME OF SAMPLER: Robert Hildreth / [signature]	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☒ Other: Reclaimed Water
SAMPLE SOURCE: Product Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 4-13-16 16:00
RECEIVED BY: [signature]	DATE / TIME: 4-14-16 FedX 0935 ice

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 160931-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	5/5/2016 9:25:00 AM
Sample Point ID:	MF Source Water	**Check-in Temp. (0-20C)**	2.2C
Sample Collection Date:	5/3/2016	**Container Type:**	10 L
Sample Time:	1:40:00 PM		

Comments: Turbidity = 1.85 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), 0.3 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	05/12/16-1613	Filter Type	Envirochek HV
Filter Serial #	600346	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.5 mL
Elution date	05/06/16	Elution Time	0940
Resample	No	Original Sample Date	
Analyst	DL		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	3

Sample Q. C

OPR Crypto Results	74 %
OPR Giardia Results	73 %
Method Blank Results	0

5/24/2016

Report Date

Richard E Danielson

Signature

Quality Checked ElbaM

160931-2

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY: 5-5-16
LIMS #: 160244
Client #: CAR010K
Date Rec'd: 5-5-16
Time Rec'd: 0925
Temp Rec'd: 2.2°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District, 401 E. 24th St., Big Spring, TX 79720 Contact Name: John Burch Tel: 432-267-6341	SAMPLE DATE: 5-3-16 SAMPLE TIME: 13:40 Water Temp (C): N/A Turbidity (NTU): 1.85
NAME OF SAMPLER: Robert Hildreth	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other: ______
SAMPLE SOURCE: MF Source Water	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☒ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Source Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature]	DATE / TIME: 5-4-16 16:00
RECEIVED BY: [signature]	DATE / TIME: 5-5-16 0925 FedEx

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 160931-003

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	MF Filtrate Water
Matrix:	Waste Water, treated	**Date/Time Received:**	5/5/2016 9:25:00 AM
Sample Point ID:	MF Filtrate Water	**Check-in Temp. (0-20C)**	2.2C
Sample Collection Date:	5/3/2016	**Container Type:**	10 L
Sample Time:	2:00:00 PM		
Comments:	Turbidity = 0.018 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	05/12/16-1620	Filter Type	Envirochek HV
Filter Serial #	591987	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	05/06/16	Elution Time	0940
Resample	No	Original Sample Date	
Analyst	DL		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	74 %
OPR Giardia Results	73 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

5/24/2016

Report Date

Richard E Danil

Signature

Quality Checked ElbaM

160931-3

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY: 5-5-16
LIMS #: 160244
Client #: CAR010K
Date Rec'd: 5-5-16
Time Rec'd: 0925
Temp Rec'd: 2.2°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water Distric 401 E. 24th St., Big Spring, Tx 79720

Contact Name: John Burch Tel: 432-267-6341

NAME OF SAMPLER: Robert Hildreth

SAMPLE SOURCE: MF Filtrate Water

SAMPLE LOCATION: RWPF

SAMPLE DATE: 5-3-16

SAMPLE TIME: 14:00

Water Temp (C): N/A

Turbidity (NTU): .018

TREATMENT CHARACTERISTICS (Check One):

Raw Surface Water ☐ Treated Drinking Water ☐

Treated Wastewater ☒ Wastewater ☐

Ground Water ☐ Other: ______

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)

SAMPLE VOLUME: (Meter #)

Meter Start: Meter Stop:

Total Volume: ______Gallons ______Liters

SAMPLE DESCRIPTION (G/C)

Regular Grab Sample ☐ Matrix Spike Grab ☐

Regular Filtered Sample ☒

Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐

Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF Filtrate Water

P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: [signature] DATE / TIME: 5-4-16 16:00

RECEIVED BY: [signature] DATE / TIME: 5-5-16 0925 FedX Ice

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

F:\WP\FORMS\Datasheets\G&C and MPA Data Sheet Rev 09-11-09.d

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 160931-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	Product Water
Matrix:	Waste Water, treated	**Date/Time Received:**	5/5/2016 9:25:00 AM
Sample Point ID:	Product Water	**Check-in Temp. (0-20C)**	2.2C
Sample Collection Date:	5/3/2016	**Container Type:**	10 L
Sample Time:	1:30:00 PM		

Comments: Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	05/12/16-1552	Filter Type	Envirochek HV
Filter Serial #	566433	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	05/06/16	Elution Time	0940
Resample	No	Original Sample Date	
Analyst	DL		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	74 %
OPR Giardia Results	73 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

5/24/2016
Report Date

Richard E Danil
Signature

Quality Checked ElbaM

160931-1

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY: 5-5-16
LIMS #: ~~160245~~
Client #: CAR010K
Date Rec'd: 5-5-16
Time Rec'd: 0925
Temp Rec'd: 2.2°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS:
Colorado River Municipal Water Distric
401 E. 24th St., Big Spring, TX 79720
Contact Name: John Burch Tel: 432-267-6341

NAME OF SAMPLER: Robert Hildreth

SAMPLE SOURCE: Product Water

SAMPLE LOCATION: RWPF

SAMPLE DATE: 5-3-16
SAMPLE TIME: 13:30
Water Temp (C): N/A
Turbidity (NTU): N/A

TREATMENT CHARACTERISTICS (Check One):
- ☐ Raw Surface Water
- ☐ Treated Drinking Water
- ☐ Treated Wastewater
- ☐ Wastewater
- ☒ Ground Water
- Other: Reclaimed Water

DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water):
Yes No

SAMPLE DESCRIPTION (MPA)

SAMPLE VOLUME: (Meter #)
Meter Start: Meter Stop:
Total Volume: ______ Gallons ______ Liters

SAMPLE DESCRIPTION (G/C)

- ☐ Regular Grab Sample
- ☐ Matrix Spike Grab
- ☒ Regular Filtered Sample
- ☐ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample)

Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: Product Water
P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: Greg Burn DATE / TIME: 5-4-16 16:00
RECEIVED BY: Lori Allen DATE / TIME: 5-5-16 0925 FedX

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140923-003

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF filtrate-R1
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	N/A
Matrix:	Waste Water, treated	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	Blue tap by turbidimeter, RWPF	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/8/2014	**Container Type:**	HV Envirochek
Sample Time:	9:15:00 AM		
Comments:	Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	7/17/14-1035	Filter Type	Envirochek HV
Filter Serial #	266060	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

8/13/2014

Report Date

Richard E Danielson

Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY
SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-3
Client #: Carollo K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 / SAMPLE TIME: 9:15
	Water Temp (C): / Turbidity (NTU):
Contact Name: John Burch Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Robert Hildreth	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: MF filtrate (R1)	Treated Wastewater ☑ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: blue tap by turbidimeter, RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes ☐ No ☐
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: ____ Gallons ____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)		
✓	REGULAR SAMPLE	☐
	MATRIX SPIKE SAMPLE	☐
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)		
	REGULAR SAMPLE	☐
	MATRIX SPIKE SAMPLE	☐
MICROSCOPIC PARTICULATE ANALYSIS (MPA)		
	MPA <u>WITH</u> GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)	☐
	MPA <u>WITHOUT</u> FLUORESCENCE ASSAY (EPA 910/9-92-029)	☐

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140923-004

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF filtrate-R2
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	N/A
Matrix:	Waste Water, treated	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	Blue tap by turbidimeter, RWPF	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/8/2014	**Container Type:**	HV Envirochek
Sample Time:	9:15:00 AM		
Comments:	Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	7/17/14-1039	Filter Type	Envirochek HV
Filter Serial #	266068	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

8/13/2014
Report Date

Richard E Danielson
Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY
SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-4
Client #: Carollo K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 9:15
	Water Temp (C): — Turbidity (NTU):
Contact Name: John Burch — Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Robert Hildreth	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: MF Filtrate (R2)	Treated Wastewater ☑ Wastewater ☐ Ground Water ☐ Other:
SAMPLE LOCATION: blue tap by turbidimeter, RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes ☐ No ☐
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: — Meter Stop:	Regular Filtered Sample ☑
Total Volume: ____ Gallons ____ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters — Grab Volume: ____ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)		
✓	REGULAR SAMPLE	☐
	MATRIX SPIKE SAMPLE	☐
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)		
	REGULAR SAMPLE	☐
	MATRIX SPIKE SAMPLE	☐
MICROSCOPIC PARTICULATE ANALYSIS (MPA)		
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)	☐
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)	☐

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	Im DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140923-007

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** RWPF influent (WW effluent)-R1
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Eva Steinle-Darling **Customer Sample No.:** N/A
Matrix: Waste Water, treated **Date/Time Received:** 7/9/2014 9:25:00 AM
Sample Point ID: Tap by turbidimeter **Check-in Temp. (0-20C)** 7.2 C
Sample Collection Date: 7/8/2014 **Container Type:** HV Envirochek
Sample Time: 1:10:00 PM
Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	7/17/14-1131	Filter Type	Envirochek HV
Filter Serial #	266057	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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8/13/2014

Report Date

Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-7
Client #: CAR010K
Date Rec'd: 9/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 13:10
	Water Temp (C): — Turbidity (NTU): 1.0
Contact Name: John Burch — Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: RWPF influent (WW effluent) – R1	Treated Wastewater ☑ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: tap by turbidimeter	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 9/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 140923-008

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** RWPF influent (WW effluent)-R2
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Eva Steinle-Darling **Customer Sample No.:** N/A
Matrix: Waste Water, treated **Date/Time Received:** 7/9/2014 9:25:00 AM
Sample Point ID: Tap by turbidimeter **Check-in Temp. (0-20C)** 7.2 C
Sample Collection Date: 7/8/2014 **Container Type:** HV Envirochek
Sample Time: 1:10:00 PM
Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	7/17/14-1136	Filter Type	Envirochek HV
Filter Serial #	266052	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

8/13/2014 — Richard E Danielson

Report Date **Signature** **Quality Checked** LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-8
Client #: CAR010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014	SAMPLE TIME: 13:10
	Water Temp (C):	Turbidity (NTU): 1.0
Contact Name: John Burch Tel:	TREATMENT CHARACTERISTICS (Check One):	
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☐ Treated Drinking Water ☐	
SAMPLE SOURCE: RWPF influent (WW effluent) - R2	Treated Wastewater ☑ Wastewater ☐	
	Ground Water ☐ Other:	
SAMPLE LOCATION: tap by turbidimeter	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No	
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)	
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐	
Meter Start: Meter Stop:	Regular Filtered Sample ☑	
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐	
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters	

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 140923-009

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759

Client No: CAR010K **Purchase Order No:** N/A

PWS ID: N/A **Facility ID:** Product Water

Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Robert Hildreth	**Customer Sample No.:**	N/A
Matrix:	Water, Treated	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/7/2014	**Container Type:**	HV Envirochek
Sample Time:	4:25:00 PM		

Comments: Groundwater Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	7/17/14-1141	Filter Type	Envirochek HV
Filter Serial #	266048	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	7/10/14	Elution Time	1016
Resample	No	Original Sample Date	
Analyst	SM		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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8/13/2014

Report Date

Richard E Danil

Signature

Quality Checked LBarriga

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-9
Client #: CAR010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District PO Box 869 Big Spring, TX, 79721	SAMPLE DATE: 7-7-2014 SAMPLE TIME: 16:25
	Water Temp (C): Turbidity (NTU):
Contact Name: John Burch Tel: 432-267-6341	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Robert Hildreth	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: Product Water	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☒ Other: Reclaimed water
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: Gallons Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: Liters

Client Sample ID: Product Water	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
X	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: Jmc	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 140923-001

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Moss Creek Lake PS
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Eva Steinle-Darling **Customer Sample No.:** N/A
Matrix: Raw Water **Date/Time Received:** 7/9/2014 9:25:00 AM
Sample Point ID: Pump No. 2-R1 **Check-in Temp. (0-20C)** 7.2 C
Sample Collection Date: 7/8/2014 **Container Type:** HV Envirochek
Sample Time: 11:00:00 AM
Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	266056
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	7/10/14
Elution Time	0915	Pellet Volume	0.8 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	SM	Analysis Date / Time	7/17/14-1006

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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9/12/2014
Report Date

Richard E Danil
Signature

Quality Checked LBarriga

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)

Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-1
Client #: CAB010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 11:00
	Water Temp (C): / — Turbidity (NTU): /
Contact Name: John Busch — Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☑ Treated Drinking Water ☐
SAMPLE SOURCE: Moss Creek Lake PS	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☐ Other:
SAMPLE LOCATION: Pump No. 2 -R1	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
Total Volume: ______ Gallons ~~10.75~~ Liters	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 140923-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Moss Creek Lake PS
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Eva Steinle-Darling	**Customer Sample No.:**	N/A
Matrix:	Raw Water	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	Pump No. 2-R2	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/8/2014	**Container Type:**	HV Envirochek
Sample Time:	11:00:00 AM		

Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	266058
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	7/10/14
Elution Time	1016	Pellet Volume	0.9 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	SM	Analysis Date / Time	7/17/14-1028

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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9/12/2014 Richard E Danil

Report Date **Signature**

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LAB USE ONLY:
LIMS #: 923-2
Client #: CAR010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 11:00
	Water Temp (C): / — Turbidity (NTU): /
Contact Name: John Burch Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☑ Treated Drinking Water ☐
SAMPLE SOURCE: Moss Creek Lake PS	Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ Other:
SAMPLE LOCATION: Pump No. 2 - R2	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: Mc	DATE / TIME: 7/9/14 09:25

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LAB Sample ID: 140923-005

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** RO Permeate-R1
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Eva Steinle-Darling **Customer Sample No.:** N/A
Matrix: Raw Water **Date/Time Received:** 7/9/2014 9:25:00 AM
Sample Point ID: Skid A **Check-in Temp. (0-20C)** 7.2 C
Sample Collection Date: 7/8/2014 **Container Type:** HV Envirochek
Sample Time: 9:00:00 AM
Comments: Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	266054
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	7/10/14
Elution Time	1016	Pellet Volume	<0.1 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	SM	Analysis Date / Time	7/17/14-1044

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

9/12/2014 Richard E Danielson

Report Date **Signature**

Quality Checked LBarriga

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

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LAB USE ONLY:
LIMS #: 923-5
Client #: CAR010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 9:00
	Water Temp (C): 84°F — Turbidity (NTU): <1
Contact Name: John Burch Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: RO Permeate - R1	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☑ Other: RO permeate
SAMPLE LOCATION: Skid A	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 7/9/14 09:25

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LAB Sample ID: 140923-006

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RO Permeate-R2
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Eva Steinle-Darling	**Customer Sample No.:**	N/A
Matrix:	Raw Water	**Date/Time Received:**	7/9/2014 9:25:00 AM
Sample Point ID:	Skid A	**Check-in Temp. (0-20C)**	7.2 C
Sample Collection Date:	7/8/2014	**Container Type:**	HV Envirochek
Sample Time:	9:00:00 AM		
Comments:	Calculated Results: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	266067
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	7/10/14
Elution Time	1016	Pellet Volume	<0.1 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	SM	Analysis Date / Time	7/17/14-1126

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	67 %
OPR Giardia Results	52 %
Method Blank Results	0

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9/12/2014
Report Date

Richard E Danielson
Signature

Quality Checked LBarriga

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GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 923-6
Client #: CAB010K
Date Rec'd: 7/9/14
Time Rec'd: 09:25
Temp Rec'd: 7.2

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: Colorado River Municipal Water District	SAMPLE DATE: 8 Jul 2014 — SAMPLE TIME: 9:00
	Water Temp (C): 84°F — Turbidity (NTU): <1
Contact Name: Tel:	TREATMENT CHARACTERISTICS (Check One):
NAME OF SAMPLER: Eva Steinle-Darling	Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: RO Permeate – R2	Treated Wastewater ☐ Wastewater ☐
	Ground Water ☑ Other: RO permeate
SAMPLE LOCATION: (Skid A)	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☑
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: Mc	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

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LAB Sample ID: 150175-007

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	MF Source Water #1
Matrix:	Waste Water, treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	MF Source Water #1	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	5:30:00 PM		

Comments: Turbidity = 2.62 Calculated Result: <0.1 Oocysts / Liter (Crypto), 0.6 Cysts / Liter (Crypto)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/16/15-1507	Filter Type	Envirochek HV
Filter Serial #	552470	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	2/12/15	Elution Time	0730
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	6

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/25/2015
Report Date

Richard E Danil
Signature

Quality Checked LBarriga

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 150175-008

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Sutherland	**Customer Sample No.:**	MF Source Water #2
Matrix:	Waste Water, treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	MF Source Water #2	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	5:30:00 PM		

Comments: Turbidity = 2.62 Calculated Result: 0.1 Oocysts / Liter (Crypto), 0.8 Cysts / Liter (Crypto)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/16/15-1525	Filter Type	Envirochek HV
Filter Serial #	551867	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	2/12/15	Elution Time	0738
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	1
Analyte 2	Giardia
No. of Giardia	8

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

3/25/2015

Report Date

Richard E Danielson

Signature

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LAB Sample ID: 150175-009

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	none given	**Customer Sample No.:**	RO Feed #1
Matrix:	Waste Water, treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	RO Feed #1	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	5:15:00 PM		
Comments:	Calculated Result: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Crypto)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/16/15-1533	Filter Type	Envirochek HV
Filter Serial #	552475	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	2/12/15	Elution Time	0738
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

3/25/2015

Report Date

Richard E Danil

Signature

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LAB Sample ID: 150175-010

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	none given	**Customer Sample No.:**	RO Feed #2
Matrix:	Waste Water, treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	RO Feed #2	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	5:15:00 PM		
Comments:	Calculated Result: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Crypto)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	2/16/15-1539	Filter Type	Envirochek HV
Filter Serial #	552483	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	2/12/15	Elution Time	0738
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

3/25/2015

Report Date

Richard E Danielson

Signature

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LAB Sample ID: 150175-011

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Not Given
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: Eva Steinle-Darling **Customer Sample No.:** Moss Creek Lake A
Matrix: Raw Water **Date/Time Received:** 2/11/2015 9:30:00 AM
Sample Point ID: Moss Creek Lake A **Check-in Temp. (0-20C)** 3.0 C
Sample Collection Date: 2/10/2015 **Container Type:** HV Envirochek
Sample Time: 10:35:00 AM
Comments: Calculated Result: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Crypto)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	551858
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	2/12/15
Elution Time	0738	Pellet Volume	0.4 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	2/16/15-1544

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

3/25/2015

Report Date

Richard E Danielson

Signature

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LAB Sample ID: 150175-012

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Not Given
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	Eva Steinle-Darling	**Customer Sample No.:**	Moss Creek Lake B
Matrix:	Raw Water	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	Moss Creek Lake B	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/10/2015	**Container Type:**	HV Envirochek
Sample Time:	10:35:00 AM		
Comments:	Calculated Result: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Crypto)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	552487
Number of Filters	1	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Elution date	2/12/15
Elution Time	0738	Pellet Volume	0.4 mL
Resuspended Conc. Vol.	5 mL	No. of Slides Examined	1
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	2/16/15-1549

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/25/2015

Report Date

Richard E Danielson

Signature

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150175-015

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RWPF
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	none given	**Customer Sample No.:**	RWPF Product Water
Matrix:	Water, Treated	**Date/Time Received:**	2/11/2015 9:30:00 AM
Sample Point ID:	Product Water	**Check-in Temp. (0-20C)**	3.0 C
Sample Collection Date:	2/9/2015	**Container Type:**	HV Envirochek
Sample Time:	4:45:00 PM		
Comments:	Calculated Result: <0.1 Oocysts / Liter (Crypto), <0.1 Cysts / Liter (Crypto)		

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	2/16/15-1555	Filter Type	Envirochek HV
Filter Serial #	552474	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	2/12/15	Elution Time	0738
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	82 %
OPR Giardia Results	57 %
Method Blank Results	0

3/25/2015

Report Date

Richard E Danil

Signature

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EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150942-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	RO Feed
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	RO Feed
Matrix:	Water, not otherwise specified	**Date/Time Received:**	6/3/2015 7:40:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4 C
Sample Collection Date:	6/2/2015	**Container Type:**	HV Envirochek
Sample Time:	8:46:00 AM		
Comments:	Turbidity = Not Given. Calculated Results: <0.1 Oocysts/Liter (Crypto) <0.1 Cysts/Liter (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	566554
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	6/3/15	Elution Time	0852
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	6/9/15-1331

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	54 %
OPR Giardia Results	84 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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6/27/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 942-1
Client #: CARO10K
Date Rec'd: 6/3/15
Time Rec'd: 07:40
Temp Rec'd: 3.4°C ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DIST. P.O. BOX 869 BIG SPRING, TX 79721	SAMPLE DATE: 02 ~~01~~ JUN 2015 — SAMPLE TIME: 08:46
Contact Name: JOHN BURCH — Tel: 4322676341	Water Temp (C): — Turbidity (NTU):
NAME OF SAMPLER: LAIRD	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐
SAMPLE SOURCE: RO FEED	Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ Other: RECLAIMED WATER
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: RO FEED	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME: 6/3/15 07:40
RECEIVED BY:	DATE / TIME:

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

early am fedex first O.N.

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

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LAB Sample ID: 150942-002

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	MF Source Water
Matrix:	Waste Water, treated	**Date/Time Received:**	6/3/2015 7:40:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4 C
Sample Collection Date:	6/1/2015	**Container Type:**	HV Envirochek
Sample Time:	5:06:00 PM		

Comments: Turbidity = 6.2 NTU Calculated Results: <0.1 Oocysts/Liter (Crypto) <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	6/9/15-1343	Filter Type	Envirochek HV
Filter Serial #	563051	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	1.0 mL
Elution date	6/3/15	Elution Time	0852
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	54 %
OPR Giardia Results	84 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.

MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

6/27/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 942-2
Client #: CARO10K
Date Rec'd: 6/3/15
Time Rec'd: 07:40
Temp Rec'd: 3.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT P.O. BOX 869 BIG SPRING, TX 79721	SAMPLE DATE: 02 JUN 2015 (JDB) — SAMPLE TIME: 17:06
Contact Name: JOHN BURCH Tel: 432 2676341	Water Temp (C): — Turbidity (NTU): 6.2
NAME OF SAMPLER: LAIRD	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other:
SAMPLE SOURCE: MF SOURCE WATER	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	SAMPLE DESCRIPTION (G/C)
SAMPLE VOLUME: (Meter #)	Regular Grab Sample ☐ Matrix Spike Grab ☐
Meter Start: Meter Stop:	Regular Filtered Sample ☒
Total Volume: ______ Gallons ______ Liters	Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐
	Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: MF SOURCE WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA <u>WITH</u> GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA <u>WITHOUT</u> FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: JMC	DATE / TIME: 6/3/15 07:40
RECEIVED BY:	DATE / TIME:

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

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LAB Sample ID: 150942-003

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	J. Laird	**Customer Sample No.:**	Product Water
Matrix:	Water, not otherwise specified	**Date/Time Received:**	6/3/2015 7:40:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	3.4 C
Sample Collection Date:	6/1/2015	**Container Type:**	HV Envirochek
Sample Time:	4:35:00 PM		

Comments: Turbidity = Not Given. Calculated Results: <0.1 Oocysts/Liter (Crypto) <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Filter Type	Envirochek HV	Filter Serial #	563045
Sample Vol Filtered	10.75 L	Sample Vol Examined	10.75 L
Number of Filters	1	No. of Slides Examined	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	6/3/15	Elution Time	0852
Resample	No	Original Sample Date	
Analyst	kw	Analysis Date / Time	6/9/15-1330

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C

OPR Crypto Results	54 %
OPR Giardia Results	84 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

6/27/2015

Report Date

Richard E Danil

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 942-3
Client #: CARO10K
Date Rec'd: 6/3/15
Time Rec'd: 07:40
Temp Rec'd: 3.4°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DIST. P.O. BOX 869 BIG SPRING TX ~~79720~~ 79721		SAMPLE DATE: 01 JUN 2015	SAMPLE TIME: 16:35
Contact Name: JOHN BURCH	Tel: 432 2676341	Water Temp (C): —	Turbidity (NTU): —
NAME OF SAMPLER: LAIRA		TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐	
SAMPLE SOURCE: PRODUCT WATER		Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ ☒ Other: RECLAIMED WATER	
SAMPLE LOCATION: RWPF		DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No	
SAMPLE DESCRIPTION (MPA)		SAMPLE DESCRIPTION (G/C)	
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______Gallons ______ Liters		Regular Grab Sample ☒ NO Matrix Spike Grab ☐ Regular Filtered Sample ☒ YES Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☐ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters	

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following	
METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
✓	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY:	DATE / TIME: 6/3/15 07:40
RECEIVED BY:	DATE / TIME:

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #1795

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

LAB Sample ID: 151671-001

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	Product Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	G. Bruce / J. Laird	**Customer Sample No.:**	Product Water HVF
Matrix:	Water, Treated	**Date/Time Received:**	9/17/2015 9:30:00 AM
Sample Point ID:	RWPF	**Check-in Temp. (0-20C)**	8.6
Sample Collection Date:	9/16/2015	**Container Type:**	HV Envirochek
Sample Time:	9:39:00 AM		

Comments: Turbidity not given. Calculated Results: <0.1 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	9/24/15-1625	Filter Type	Envirochek HV
Filter Serial #	560551	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	<0.1 mL
Elution date	9/18/15	Elution Time	0708
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	0
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	80 %
Method Blank Results	0

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

11/10/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir Laboratories

EPA ID# 01401, CA-ELAP #1795

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LAB Sample ID: 151671-002

Client / Address: Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759
Client No: CAR010K **Purchase Order No:** N/A
PWS ID: N/A **Facility ID:** Product Water
Client Contact: Eva Steinle-Darling, ESD@carollo.com **Client Phone:** 650-796-4823

SAMPLE INFORMATION:

Name of Sampler: G. Bruce / J. Laird
Customer Sample No.: Product Water M.S.
Matrix: Water, Treated
Date/Time Received: 9/17/2015 9:30:00 AM
Sample Point ID: RWPF
Check-in Temp. (0-20C) 8.6
Sample Collection Date: 9/16/2015
Container Type: 10 Liter Cubitainer
Sample Time: 9:42:00 AM
Comments: Matrix Spike Recovery = 44% (Crypto), 87% (Giardia)

ASSAY RESULTS: 1623 - Non-LT2 Crypto & Giardia EPA 1623

Sample Preparation

Analysis Date / Time	9/25/15-1328	Filter Type	Envirochek HV
Filter Serial #		Sample Vol Filtered	10.50 L
Sample Vol Examined	10.50 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.1 mL
Elution date	9/18/15	Elution Time	0708
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	44
Analyte 2	Giardia
No. of Giardia	87
Sample Volume Spiked (Matrix Spike)	10.50
No. of Crypto Spiked	99
No. of Giardia Spiked	100

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	80 %
Method Blank Results	0

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LAB Sample ID: 151671-002

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.

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11/10/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 1671 1-2
Client #: CMR010K
Date Rec'd: 9/17/15
Time Rec'd: 09:30
Temp Rec'd: 8.6°C

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO MUNICIPAL WATER DISTRICT 401 E. 24TH STREET BIG SPRING, TX 79720	SAMPLE DATE: 16 SEPT 2015 / SAMPLE TIME: 9:39 FILTER
Contact Name: JOHN O. BURCH Tel: 432 2676341	Water Temp (C): NA / Turbidity (NTU): NA 9:42 MS SPIKE GRAB
NAME OF SAMPLER: G. BRUCE / J. LAZCO	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☐ Wastewater ☐ Ground Water ☐ Other: RECLAIMED WATER
SAMPLE SOURCE: PRODUCT WATER	
SAMPLE LOCATION: RWPF	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ______ Gallons ______ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☐ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☒ Filtered Volume: 10.75 Liters Grab Volume: ______ Liters

Client Sample ID: PRODUCT WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
1 X	REGULAR SAMPLE
2 X	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-026)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John O. Burch	DATE / TIME: 16 SEPT 2015 - 14:00
RECEIVED BY:	DATE / TIME: 9/17/15 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

no Chlorine need in this catch ... day

BioVir Laboratories

EPA ID# 01401, CA-ELAP #1795

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LAB Sample ID: 151671-004

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	G. Bruce / J. Laird	**Customer Sample No.:**	MF Source Water HVF
Matrix:	Waste Water, treated	**Date/Time Received:**	9/17/2015 9:30:00 AM
Sample Point ID:		**Check-in Temp. (0-20C)**	2.8
Sample Collection Date:	9/16/2015	**Container Type:**	HV Envirochek
Sample Time:	10:00:00 AM		

Comments: Turbidity = 1.4 NTU Calculated Results: 1.9 Oocysts/Liter (Crypto), <0.1 Cysts/Liter (Giardia)

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	9/25/15-1433	Filter Type	Envirochek HV
Filter Serial #	560568	Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	9/18/15	Elution Time	0708
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	20
Analyte 2	Giardia
No. of Giardia	0

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	80 %
Method Blank Results	0

11/10/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir Laboratories

EPA ID# 01401, CA-ELAP #1795

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LAB Sample ID: 151671-005

Client / Address:	Carollo Engineers, Inc,8911 Capital of Texas Hwy North, Suite 2200 , Austin TX 78759		
Client No:	CAR010K	**Purchase Order No:**	N/A
PWS ID:	N/A	**Facility ID:**	MF Source Water
Client Contact:	Eva Steinle-Darling, ESD@carollo.com	**Client Phone:**	650-796-4823

SAMPLE INFORMATION:

Name of Sampler:	G. Bruce / J. Laird	**Customer Sample No.:**	MF Source Water M.S.
Matrix:	Waste Water, treated	**Date/Time Received:**	9/17/2015 9:30:00 AM
Sample Point ID:		**Check-in Temp. (0-20C)**	2.8
Sample Collection Date:	9/16/2015	**Container Type:**	10 Liter Cubitainer
Sample Time:	10:02:00 AM		
Comments:	Matrix Spike Recovery = 58% (Crypto) 66% (Giardia)		

ASSAY RESULTS: 1623 EPA 821-R-01-025

Sample Preparation

Analysis Date / Time	9/25/15-1502	Filter Type	Envirochek HV
Filter Serial #		Sample Vol Filtered	10.75 L
Sample Vol Examined	10.75 L	Number of Filters	1
Resuspended Conc. Vol.	5 mL	Pellet Volume	0.4 mL
Elution date	9/18/15	Elution Time	0708
Resample	No	Original Sample Date	
Analyst	kw		

Sample Results

Analyte	Crypto
No. of Crypto	77
Analyte 2	Giardia
No. of Giardia	66
Sample Volume Spiked (Matrix Spike)	10.75
No. of Crypto Spiked	99
No. of Giardia Spiked	100

Sample Q. C.

OPR Crypto Results	79 %
OPR Giardia Results	80 %
Method Blank Results	0

BioVir Laboratories

EPA ID# 01401, CA-ELAP #1795

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LAB Sample ID: 151671-005

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
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11/10/2015

Report Date

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

GIARDIA / CRYPTOSPORIDIUM / MPA ASSAY SAMPLE DATA SHEET

(Please fill out applicable areas, sign and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 WEB: www.biovir.com

LAB USE ONLY:
LIMS #: 167145
Client #: CAR010K
Date Rec'd: 9/17/15
Time Rec'd: 09:30
Temp Rec'd: 2.8°C ice

Note: Please print clearly using waterproof ink

COMPANY NAME & ADDRESS: COLORADO RIVER MUNICIPAL WATER DISTRICT 401 E. 24TH STREET BIG SPRING, TX 79720 Contact Name: JOHN A. CHURCH Tel: 432.267.6341	SAMPLE DATE: 16 SEPT 2015 / SAMPLE TIME: 10:00 FILTER Water Temp (C): NA / Turbidity (NTU): 1.4
NAME OF SAMPLER: G. BRICE / J. LAZRO	TREATMENT CHARACTERISTICS (Check One): 10:02 MS GRAB Raw Surface Water ☐ Treated Drinking Water ☐ Treated Wastewater ☒ Wastewater ☐ Ground Water ☐ Other:
SAMPLE SOURCE: MF SOURCE WATER	
SAMPLE LOCATION:	DECHLORINATION/ DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No (circled)
SAMPLE DESCRIPTION (MPA)	**SAMPLE DESCRIPTION (G/C)**
SAMPLE VOLUME: (Meter #) Meter Start: Meter Stop: Total Volume: ____ Gallons ____ Liters	Regular Grab Sample ☐ Matrix Spike Grab ☐ Regular Filtered Sample ☐ Matrix Spike Grab / Matrix Spike Filter Pair (>10 L Sample) ☒ Filtered Volume: 10.75 Liters Grab Volume: ____ Liters

Client Sample ID: MF SOURCE WATER	P.O. #:

ASSAY REQUESTED: Please check one of the following

METHOD 1623: Cryptosporidium and Giardia (EPA 821-R-01-025)	
4 X	REGULAR SAMPLE
5 X	MATRIX SPIKE SAMPLE
METHOD 1622: Cryptosporidium Only (EPA 821-R-01-025)	
	REGULAR SAMPLE
	MATRIX SPIKE SAMPLE
MICROSCOPIC PARTICULATE ANALYSIS (MPA)	
	MPA WITH GIARDIA/CRYPTO BY FLUORESCENCE ASSAY (FA) (EPA 910/9-92-029 & 821-R-01-025)
	MPA WITHOUT FLUORESCENCE ASSAY (EPA 910/9-92-029)

COMMENTS:

RELINQUISHED BY: John A. Church	DATE / TIME: 16 SEPT 2015 - 14:00
RECEIVED BY: [signature]	DATE / TIME: 9/17/15 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #179

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REPORT NO.: 140923

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 Culture **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-010	**Skid A - R1**	**RO Permeate-R1**	**Total Culturable Virus**	**<0.0046**	**MPN/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 719.2 L Analysis Start Date: 7/9/2014 Analysis Start Time: 1235
Analyst: ValentinaL Analysis End: 8/12/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-011	**Skid A - R2**	**RO Permeate-R2**	**Total Culturable Virus**	**<0.0047**	**MPN/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 707.8 L Analysis Start Date: 7/9/2014 Analysis Start Time: 1247
Analyst: ValentinaL Analysis End: 8/12/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-012	**Pump No. 2 R1**	**Moss Creek Lake PS**	**Total Culturable Virus**	**<0.031**	**MPN/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:20:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 106 L Analysis Start Date: 7/9/2014 Analysis Start Time: 1340
Analyst: ValentinaL Analysis End: 8/12/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-013	**Pump No. 2 R2**	**Moss Creek Lake PS**	**Total Culturable Virus**	**<0.046**	**MPN/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:39:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 72 L Analysis Start Date: 7/9/2014 Analysis Start Time: 1358
Analyst: ValentinaL Analysis End: 8/12/2014

Comment

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 Culture **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-014	**Tap by Turbidimeter**	**RWPF influent-**	**Total Culturable Virus**	**<0.0198**	**MPN/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 2:40:00 PM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 166.5 L Analysis Start Date: 7/9/2014 Analysis Start Time: 1625
Analyst: ValentinaL Analysis End: 8/12/2014

Comment

Test: EPA 1615 PCR **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-010	**Skid A - R1**	**RO Permeate-R1**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 719.2 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-010	**Skid A - R1**	**RO Permeate-R1**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 719.2 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-010	**Skid A - R1**	**RO Permeate-R1**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 719.2 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

REPORT NO.: 140923

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **EPA 1615 PCR** **Method:** **EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-010	**Skid A - R1**	**RO Permeate-R1**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 719.2 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-011	**Skid A - R2**	**RO Permeate-R2**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 707.8 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-011	**Skid A - R2**	**RO Permeate-R2**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 707.8 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-011	**Skid A - R2**	**RO Permeate-R2**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 707.8 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-011	**Skid A - R2**	**RO Permeate-R2**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector Sungwoo Bae CollectDate 7/8/2014 CollectTime: 9:30:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 707.8 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

REPORT NO.: 140923

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 PCR **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-012	**Pump No. 2 R1**	**Moss Creek Lake PS**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:20:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 106 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-012	**Pump No. 2 R1**	**Moss Creek Lake PS**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:20:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 106 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-012	**Pump No. 2 R1**	**Moss Creek Lake PS**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:20:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 106 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-012	**Pump No. 2 R1**	**Moss Creek Lake PS**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:20:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 106 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-013	**Pump No. 2 R2**	**Moss Creek Lake PS**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:39:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 72 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 PCR **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-013	**Pump No. 2 R2**	**Moss Creek Lake PS**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:39:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 72 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-013	**Pump No. 2 R2**	**Moss Creek Lake PS**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:39:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 72 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-013	**Pump No. 2 R2**	**Moss Creek Lake PS**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 11:39:00 AM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Raw Water Temp 7.2 C
Volume: 72 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-014	**Tap by Turbidimeter**	**RWPF influent-**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 2:40:00 PM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 166.5 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-014	**Tap by Turbidimeter**	**RWPF influent-**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 2:40:00 PM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 166.5 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759

CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **EPA 1615 PCR** **Method:** **EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-014	**Tap by Turbidimeter**	**RWPF influent-**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 2:40:00 PM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 166.5 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
140923-014	**Tap by Turbidimeter**	**RWPF influent-**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector Eva Steinle-Darling CollectDate 7/8/2014 CollectTime: 2:40:00 PM
ReceiveDate 7/9/2014 9:25:00 AM Matrix: Waste Water, treated Temp 7.2 C
Volume: 166.5 L Analysis Start Date: 7/10/2014 Analysis Start Time: 0958
Analyst: JHamer Analysis End: 9/4/2014

Comment

9/25/2014 Richard E Danil

Date: Signature

Quality Checked LBarriga

0923-10

7.2

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR

SAMPLE DATA SHEET

CAR010K

(Please fill out completely and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal WD	SAMPLE DATE: 8 Jul 2014	
	SAMPLE TIME: ~~8:45~~ 9:30 – 16:00	
NAME OF SAMPLER: Sungwoo Bae	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): 88°F Temp. meter model and serial no.:
SAMPLE SOURCE: RO permeate	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Surface or Groundwater ~~☑~~ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☐ Other: RO treated WW ☑
SAMPLE LOCATION: Skid A – (R1)	DECHLORINATION / DISINFECTANT NEUTRALIZATION: (If Treated Water): Yes No Free Chlorine (mg / L):	
	Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter #) TURBIDITY (NTU): Meter Start: 5981 Meter Stop: 6171 Turbidity (NTU): <1	Total Volume: 190 Gallons ______ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only.

COMMENTS:

- Water pressure limited. Sample cut off when had to leave. No clogging observed.
- Dosed 6 mL/min pre-set sodium thiosulfate to quench chloramines

(I BUTTON Returned No insulation between samples + wet ice MDP 7.9.14)

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: MC	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

0923-11

7.2

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR
SAMPLE DATA SHEET

BioVir LABORATORIES

(Please fill out completely and return to BioVir with the sample.) CAR010K
Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal WD	SAMPLE DATE: 8 Jul 2014	
	SAMPLE TIME: ~~[illegible]~~ 9:30 – 16:00	
NAME OF SAMPLER: Sungwoo Bae	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): 88°F Temp. meter model and serial no.:
SAMPLE SOURCE: ~~Skid~~ A Ro Permeate	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Surface or Groundwater ☑ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☐ Other: Ro treated WW ☑
SAMPLE LOCATION: Skid A – R2	DECHLORINATION / DISINFECTANT NEUTRALIZATION: (If Treated Water): Yes No Free Chlorine (mg / L):	
	Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter #) TURBIDITY (NTU): Meter Start: 26857 Meter Stop: 27044 Turbidity (NTU): <1	Total Volume: 187 Gallons ______ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only.

COMMENTS:

- Water pressure limited. Sample cut off when had to leave. No clogging observed.
- Dosed 6mL/min preset sodiumthiosulfate to quench chloramines.

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: MC	DATE / TIME: 7/9/14 0925

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

8923-12
7.2

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR
SAMPLE DATA SHEET

CAR010 K

(Please fill out completely and return to BioVir with the sample.)

Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal WD	SAMPLE DATE: 8 Jul 2014 SAMPLE TIME: 11:20 - 12:09	
NAME OF SAMPLER: Eva Steinle-Darling	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): Temp. meter model and serial no.:
SAMPLE SOURCE: Moss Creek Lake PS	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☑ Treated Surface or Groundwater ☐ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☐ Other: ☐
SAMPLE LOCATION: Pump No. 2 (R1)	DECHLORINATION / DISINFECTANT NEUTRALIZATION: (If Treated Water): Yes No Free Chlorine (mg / L): Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter #) TURBIDITY (NTU): Meter Start: 10777 Meter Stop: 10805 Turbidity (NTU):	Total Volume: 28 Gallons ________ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only.

COMMENTS:

- Meter readings

start	10min	20min	30min
10777	10790	10799	10805

- Significant clogging. Sample pressure maintained 35-40psi

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY: JML	DATE / TIME: 7/9/14 09:25

0923-13

7.2

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR

SAMPLE DATA SHEET

(Please fill out completely and return to BioVir with the sample.) CAR010K

Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal WD	SAMPLE DATE: 8 Jul 2014	
	SAMPLE TIME: 11:39 - 12:09	
NAME OF SAMPLER: Eva Steinle-Darling	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): Temp. meter model and serial no.:
SAMPLE SOURCE: Moss Creek Lake PS	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☑ Treated Surface or Groundwater ☐ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☐ Other: ☐
SAMPLE LOCATION: Pump No. 2 (R2)	DECHLORINATION / DISINFECTANT NEUTRALIZATION: (If Treated Water): Yes No Free Chlorine (mg / L):	
	Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter #) TURBIDITY (NTU): Meter Start: 21108 Meter Stop: 21127* Turbidity (NTU):	Total Volume: 19* Gallons ____ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only.

COMMENTS:

* Meter (totalizer) stopped during 3rd 10-minute totalizer interval:

start	10 min	20 min	30 min
21108	21118	21126	21127

Other concurrent sample had similar flow rate and 6 gallons in last 10 minutes

- Significant clogging. Pressure maintained 35-40psi.

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	DATE / TIME: 7/9/14 09:25

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

0923-14 7.2

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR

SAMPLE DATA SHEET

(Please fill out completely and return to BioVir with the sample.) CAR010K

Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal Water District Raw Water Production Facility	SAMPLE DATE: 8 Jul 2014	
	SAMPLE TIME: 14:40 – 16:00	
NAME OF SAMPLER: Eva Steinle-Darling	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): Temp. meter model and serial no.:
SAMPLE SOURCE: RWPF influent	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Surface or Groundwater ☐ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☐ Other: ☐
SAMPLE LOCATION: tap by turbidimeter	DECHLORINATION / DISINFECTANT NEUTRALIZATION: (If Treated Water): Yes No Free Chlorine (mg / L):	
	Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter #) TURBIDITY (NTU): Meter Start: 10826 Meter Stop: 10870 Turbidity (NTU): 1.0	Total Volume: 44 Gallons ______ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only.

COMMENTS:

Assay as discussed via email & phone.

RELINQUISHED BY:	DATE / TIME:
RECEIVED BY:	JMC DATE / TIME: 7/9/14 0925

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

REPORT NO.: 151671
PAGE NO.: 1 of 4
CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 Culture — Method: EPA 1615

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-003	**None Given**	**RWPF MF Source Water**	**Total Culturable Virus**	**<0.01**	**MPN/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 11:15:00 AM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 8.6
Volume: 321.7 L Analysis Start Date: 9/17/2015 Analysis Start Time: 12:54
Analyst: ValentinaL Analysis End: 9/21/2015

Comment: NO i-botton ret'd. with samples per supplies req. 5/28/15

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-006	**RO Permeate A**	**RWPF RO Permeate**	**Total Culturable Virus**	**<0.002**	**MPN/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 3:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2180.2 L Analysis Start Date: 9/17/2015 Analysis Start Time: 13:00
Analyst: ValentinaL Analysis End: 9/21/2015

Comment:

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-007	**RO Permeate B**	**RWPF RO Permeate**	**Total Culturable Virus**	**<0.002**	**MPN/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 1:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2271 L Analysis Start Date: 9/17/2015 Analysis Start Time: 13:52
Analyst: ValentinaL Analysis End: 9/21/2015

Comment:

Test: EPA 1615 PCR — Method: EPA 1615

BioVir #	Sample ID	Site	Analyte	Result	Units

REPORT NO.: 151671

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 PCR **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-003	**None Given**	**RWPF MF Source Water**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 11:15:00 AM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 8.6
Volume: 321.7 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment: NO i-botton ret'd. with samples per supplies req. 5/28/15

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-003	**None Given**	**RWPF MF Source Water**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 11:15:00 AM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 8.6
Volume: 321.7 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment: NO i-botton ret'd. with samples per supplies req. 5/28/15

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-003	**None Given**	**RWPF MF Source Water**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 11:15:00 AM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 8.6
Volume: 321.7 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment: NO i-botton ret'd. with samples per supplies req. 5/28/15

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-003	**None Given**	**RWPF MF Source Water**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 11:15:00 AM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 8.6
Volume: 321.7 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment: NO i-botton ret'd. with samples per supplies req. 5/28/15

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-006	**RO Permeate A**	**RWPF RO Permeate**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 3:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2180.2 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

REPORT NO.: 151671

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: EPA 1615 PCR **Method: EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-006	**RO Permeate A**	**RWPF RO Permeate**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 3:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2180.2 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-006	**RO Permeate A**	**RWPF RO Permeate**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 3:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2180.2 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-006	**RO Permeate A**	**RWPF RO Permeate**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 3:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2180.2 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-007	**RO Permeate B**	**RWPF RO Permeate**	**Enterovirus (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 1:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2271 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-007	**RO Permeate B**	**RWPF RO Permeate**	**Norovirus GIA (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 1:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2271 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

REPORT NO.: 151671

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **EPA 1615 PCR** **Method:** **EPA 1615**

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-007	**RO Permeate B**	**RWPF RO Permeate**	**Norovirus GIB (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 1:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2271 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

BioVir #	Sample ID	Site	Analyte	Result	Units
151671-007	**RO Permeate B**	**RWPF RO Permeate**	**Norovirus GII (PCR)**	**0**	**GC/L**

Collector: Eva Steinle-Darling CollectDate: 9/16/2015 CollectTime: 1:14:00 PM
ReceiveDate 9/17/2015 9:30:00 AM Matrix: Waste Water, treated Temp 2.8
Volume: 2271 L Analysis Start Date: 09/18/2015 Analysis Start Time: 1512
Analyst: JHamer Analysis End: 10/15/2015

Comment:

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

11/10/2015
Date:

Richard E Danielson
Signature

Quality Checked EMoran

CRC10K

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR

SAMPLE DATA SHEET

1671-3

(Please fill out completely and return to BioVir with the sample.)

Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

ice 8.6 °C

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal Water District Raw Water Production Facility	SAMPLE DATE: 9/16/15	
	SAMPLE TIME: 13:20 (started 11:15)	
NAME OF SAMPLER: Eva Steinle-Darling	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): Temp. meter model and serial no.:
SAMPLE SOURCE: RWPF MF Source Water	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Surface or Groundwater ☐ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☑ (tertiary) Other: ☐
SAMPLE LOCATION: MF Source Water Tap	DECHLORINATION / DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No Free Chlorine (mg/L):	
	Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter # 1358 3774) TURBIDITY (NTU): Meter Start: 10888 Meter Stop: 10973 Turbidity (NTU): 2.82	Total Volume: 85 Gallons ______ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following

✓	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only

COMMENTS:

vol = 321.7 L [illegible]

RELINQUISHED BY: [signature] to Fed Ex	DATE / TIME: 9/16/15 14:15
RECEIVED BY: [signature]	DATE / TIME: 9/17/15 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510 [illegible]

[illegible]

No [illegible] in this cooler - [illegible]

OAR010K

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR SAMPLE DATA SHEET

1671-
1671-6
2.8°C

(Please fill out completely and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal Water District Raw Water Production Facility	SAMPLE DATE: 9/15/15 to 9/16/15 SAMPLE TIME: 15:14 to 13:45
NAME OF SAMPLER: Eva Steinle-Darling	pH: 5.6 pH (adjusted): pH meter model and serial no.: Water Temp (C): 27.5°C Temp. meter model and serial no.:
SAMPLE SOURCE: RWPF RO permeate	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Raw Wastewater ☐ Treated Surface or Groundwater ☐ Treated Wastewater ☐ Untreated Ground water ☐ Other: RO permeate ☑
SAMPLE LOCATION: RO permeate A 20007627	DECHLORINATION / DISINFECTANT NEUTRALIZATION: (If Treated Water): Yes No Free Chlorine (mg / L): Metering pump model and serial no.: Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter # ~~80007951~~) TURBIDITY (NTU): Meter Start: 7377 Meter Stop: 7953 Turbidity (NTU):	Total Volume: 576 Gallons ______ Liters

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following	
✓	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only

COMMENTS:

Vol chk: 2180.2 L

RELINQUISHED BY: [signature] FedEx		DATE / TIME:	9/16/15 14:15
RECEIVED BY:		DATE / TIME:	9/17/15 0930

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

no i.bottom rec'd

CHRO1CK

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR
SAMPLE DATA SHEET

(Please fill out completely and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax: 707-747-1751 www.biovir.com

1671-4
1671-7
2.8°C

Note: Please use waterproof ink

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal Water District Raw Water Production Facility	SAMPLE DATE: 9/15/15 to 9/16/15 SAMPLE TIME: 15:14 to 13:40
NAME OF SAMPLER: Eva Steinle-Darling	pH: 5.6 pH (adjusted): pH meter model and serial no.: Water Temp (C): 27.5°C Temp meter model and serial no.:
SAMPLE SOURCE: RWPF RO permeate	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Raw Wastewater ☐ Treated Surface or Groundwater ☐ Treated Wastewater ☐ Untreated Ground water ☐ Other: ☐
SAMPLE LOCATION: RO permeate B	DECHLORINATION / DISINFECTANT NEUTRALIZATION (If Treated Water): Yes (circled) No Free Chlorine (mg / L): Metering pump model and serial no.: Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter # 97901143) TURBIDITY (NTU): Meter Start: 28182 (~~28182~~) Meter Stop: 28782 Turbidity (NTU):	Total Volume: 600 Gallons ______ Liters

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following

✓	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only

COMMENTS:

vol cks = 2,271 L

to FedEx

RELINQUISHED BY: Eva Steinle-Darling	DATE / TIME: 9/16/15 14:15
RECEIVED BY:	DATE / TIME: 9/17/15 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510

no 1 bottle recd

CRC10K

BioVir LABORATORIES

EPA Method 1615: Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR SAMPLE DATA SHEET

1671-3

(Please fill out completely and return to BioVir with the sample.)
Phone: 1-800-GIARDIA Fax. 707-747-1751 www.biovir.com

Note: Please use waterproof ink

ice 8.6°C

NAME AND ADDRESS OF WATER COMPANY OR UTILITY: Colorado River Municipal Water District Raw Water Production Facility	SAMPLE DATE: 9/16/15	
	SAMPLE TIME: 13:20 (started 11:15)	
NAME OF SAMPLER: Eva Steinle-Darling	pH: pH (adjusted): pH meter model and serial no.:	Water Temp (C): Temp. meter model and serial no.:
SAMPLE SOURCE: RWPF MF Source Water	TREATMENT CHARACTERISTICS (Check One): Raw Surface Water ☐ Treated Surface or Groundwater ☐ Untreated Ground water ☐	Raw Wastewater ☐ Treated Wastewater ☑ (tertiary) Other: ☐
SAMPLE LOCATION: MF Source Water Tap	DECHLORINATION / DISINFECTANT NEUTRALIZATION (If Treated Water): Yes No Free Chlorine (mg/L):	
	Metering pump model and serial no.:	Chlorine meter model and serial no.:
SAMPLE VOLUME: (Meter # 13583774) TURBIDITY (NTU): Meter Start: 10888 Meter Stop: 10973 Turbidity (NTU): 2.82	Total Volume: 85 Gallons ______ Liters	

Client ID #:	P.O. #:

ASSAY REQUESTED: Please check one of the following

✓	Method 1615 Complete: Culturable Virus and RT-qPCR (EPA 600/R-10/181)
	Method 1615 Culturable Virus Only

COMMENTS:

vol = 321.7 L [illegible]

RELINQUISHED BY: [signature] to Fed Ex	DATE / TIME: 9/16/15 14:15
RECEIVED BY: [signature]	DATE / TIME: 9/17/15 09:30

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA, CALIFORNIA 94510 [illegible]

[illegible]

No [illegible] in this cooler - [illegible]

CITY OF ODESSA LABORATORY SERVICES
TEST RESULTS

Certificate No. T104704363-13-8

Laboratory Address: 817 W. 42nd Street
Mailing Address: 817 W. 42nd Street
Odessa, TX 79764
Contact: Jason Wells
Phone: 432-368-3536
Email: jwells@odessa-tx.gov

Customer: CRMWD
Address: PO Box 869, Big Spring, TX, 79720
Date of Collection 7/8/2014
Collected by: Burch
Sample receipt date: 7/8/2014
Report Number: **070914REP06**

Laboratory ID Code	Time of Collection	Sample Location	Parameter	Method Number	Date of Analysis	Time of Analysis	Analyst(s)	Results	Units	MQL	Batch	Flag
070814801	2:20 PM	RO Feed A	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814802	2:20 PM	RO Feed B	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814803	2:20 PM	RO Feed C	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814804	2:20 PM	RO Feed D	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814805	2:20 PM	RO Feed E	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814806	2:20 PM	RO Feed F	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814807	2:20 PM	RO Feed G	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814808	2:20 PM	RO Feed H	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	1	
070814809	2:20 PM	RO Feed I	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814810	2:20 PM	RO Feed J	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814811	2:30 PM	RWPF Source Water A	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814812	2:30 PM	RWPF Source Water B	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814813	2:30 PM	RWPF Source Water C	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814814	2:30 PM	RWPF Source Water D	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814815	2:30 PM	RWPF Source Water E	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814816	2:30 PM	RWPF Source Water F	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	

Notes:

1. The data for precision and accuracy are generated on a sample analyzed in the same batch as the customer's sample. These values may or may not have been based on the customer's sample.
2. A blank space indicates that it is either not applicable or not performed.
3. These results relate only to the samples listed.
4. This report cannot be reproduced except in full without written approval of the laboratory.
5. The results contained in this report meet all the requirements of the TNI standards for accreditation.
6. MQL = Minimum Quantitation Level, LCS = Laboratory Control Sample, MD = Matrix Duplicate, MS = Matrix Spike MSD = Matrix Spike Duplicate.
7. Samples will be disposed of at the end of the method holding time or 30 days from the date the report is mailed to the customer, whichever is shorter.

8 Analysis performed by City of Odessa's Contract Lab.

9. Explanation of Flags used in this report:

Jason Wells
Laboratory Management

7/9/2014
Date

Debbie McReynolds
Quality Assurance Officer

7/14/2014
Date

CITY OF ODESSA LABORATORY SERVICES
TEST RESULTS

Certificate No. T104704363-13-8

Laboratory Address: 817 W. 42nd Street
Mailing Address: 817 W. 42nd Street
Odessa, TX 79764
Contact: Jason Wells
Phone: 432-368-3536
Email: jwells@odessa-tx.gov

Customer: CRMWD
Address: PO Box 869, Big Spring, TX, 79720
Date of Collection 7/8/2014
Collected by: Burch
Sample receipt date: 7/8/2014
Report Number: **070914REP06**

Laboratory ID Code	Time of Collection	Sample Location	Parameter	Method Number	Date of Analysis	Time of Analysis	Analyst(s)	Results	Units	MQL	Batch	Flag
070814817	2:30 PM	RWPF Source Water G	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814818	2:30 PM	RWPF Source Water H	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	2	
070814819	2:30 PM	RWPF Source Water I	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814820	2:30 PM	RWPF Source Water J	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814821	12:15 PM	Moss Creek A	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814822	12:15 PM	Moss Creek B	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	1.0	MPN	1	3	
070814823	12:15 PM	Moss Creek C	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814824	2:03 PM	Finished A	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814825	2:03 PM	Finished B	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814826	2:03 PM	Finished C	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814827	2:07 PM	AOP Feed A	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814828	2:07 PM	AOP Feed B	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	3	
070814829	2:07 PM	AOP Feed C	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	4	
070814830	2:43 PM	RO Concen A	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	4	
070814831	2:43 PM	RO Concen B	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	4	
070814832	2:43 PM	RO Concen C	E. Coli	Colilert SM 9223B	7/8/2014	4:24 PM	MJ	< 1	MPN	1	4	

Notes:
1. The data for precision and accuracy are generated on a sample analyzed in the same batch as the customer's sample. These values may or may not have been based on the customer's sample.
2. A blank space indicates that it is either not applicable or not performed.
3. These results relate only to the samples listed.
4. This report cannot be reproduced except in full without written approval of the laboratory.
5. The results contained in this report meet all the requirements of the TNI standards for accreditation.
6. MQL = Minimum Quantitation Level, LCS = Laboratory Control Sample, MD = Matrix Duplicate, MS = Matrix Spike MSD = Matrix Spike Duplicate.
7. Samples will be disposed of at the end of the method holding time or 30 days from the date the report is mailed to the customer, whichever is shorter.

8 Analysis performed by City of Odessa's Contract Lab.

9. Explanation of Flags used in this report:

Jason Wells
Laboratory Management

7/9/2014
Date

Debbie McReynolds
Quality Assurance Officer

7/14/2014
Date

QUALITY CONTROL RESULTS
for Report No.
070914REP06

E. coli, MPN

Batch: 1

MD Precision $M \leq 0.9423$			
Sample Reading	MD Reading	M	Flag
48.7	42.8	0.0561	

Batch: 2

MD Precision $M \leq 0.9423$			
Sample Reading	MD Reading	M	Flag
< 1	< 1	NC	

Batch: 3

MD Precision $M \leq 0.9423$			
Sample Reading	MD Reading	M	Flag
< 1	< 1	NC	

Batch: 4

MD Precision $M \leq 0.9423$			
Sample Reading	MD Reading	M	Flag
< 1	< 1	NC	

City of Odessa Laboratory Services | **Chain of Custody Record** | **Colorado River Municipal Water District**

COC ID #: Pg. 2 OF 2 — 070814COC11

Field Identification		Collection Date	Collection Time	Sample Collector	pH Check **	Sample Type	# of Containers	Preservation Type	E. coli (P)	TSS (P)	Chloride (P)	TDS (P)	CBOD (P)	NH_3-N (P)	SO_4 (P)	TOC (P)
MOSS CREEK	A	08 JUL 2014	12:15	BURCH		G	1	RS	✓							
	B					G	1	RS	✓							
	C					G	1	RS	✓							
						G										
FINISHED WATER	A	08 JUL 2014	14:03	BURCH		G	1	RS	✓							
	B					G	1	RS	✓							
	C					G	1	RS	✓							
						G										
AOP FEED	A	08 JUL 2014	14:07	BURCH		G	1	RS	✓							
	B					G	1	RS	✓							
	C					G	1	RS	✓							
						G										
RO CONCEN	A	08 JUL 2014	14:43	BURCH		G	1	RS	✓							
	B					G	1	RS	✓							
	C					G	1	RS	✓							
						G										
						G										
						G										
						G										
						G										
						G										
						G										
						G										
						G										

Relinquished By	Date	Time	Received By	Date	Time
[signature]	7-8-14	4:04	Olivia [signature]	7.8.14	4:04pm

Legend:
R = Cool
A = Acid to pH <2.0 SU
S = Sterile, Sodium Thiosulfate
F = Filtered on site
**Check mark = pH < 2.0 SU

G = Grab
C = Composite
(P) = Plastic
(G) = Glass

Sample Receipt Conditions:
☐ Thermal preservation not required
☑ Collected same day Received on ice
☐ Collected previous day Received on ice
Temperature:____________°C
☐ If checked, see attached Sample Rejection & Comment Form

City of Odessa Laboratory Services | **Chain of Custody Record** | **Colorado River Municipal Water District**

COC ID #: 070814COC11 Pg. 1 OF 2

Field Identification	Collection Date	Collection Time	Sample Collector	pH Check **	Sample Type	# of Containers	Preservation Type	E. coli (P)	TSS (P)	Chloride (P)	TDS (P)	CBOD (P)	NH_3-N (P)	SO_4 (P)	TOC (P)
RO FEED A	08 JUL 2014	1420	BURCH		G	1	RS	✓							
B					G	1	RS	✓							
C					G	1	RS	✓							
D					G	1	RS	✓							
E					G	1	RS	✓							
F					G	1	RS	✓							
G					G	1	RS	✓							
H					G	1	RS	✓							
I					G	1	RS	✓							
J					G	1	RS	✓							
					~~G~~										
					~~G~~										
RWRF SOURCE WATER	08 JUL 2014	1430	BURCH		G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					G	1	RS	✓							
					~~G~~										
					~~G~~										

Relinquished By	Date	Time	Received By	Date	Time
Jacob Lovid	7-8-14	4:04	Olivia [illegible]	7.8.14	4:04pm.

Legend:
- R = Cool
- A = Acid to pH <2.0 SU
- S = Sterile, Sodium Thiosulfate
- F = Filtered on site
- **Check mark = pH < 2.0 SU
- G = Grab
- C = Composite
- (P) = Plastic
- (G) = Glass

Sample Receipt Conditions:
- ☐ Thermal preservation not required
- ☑ Collected same day Received on ice
- ☐ Collected previous day Received on ice
- Temperature:______________ °C
- ☐ If checked, see attached Sample Rejection & Comment Form

CITY OF ODESSA LABORATORY SERVICES
TEST RESULTS

Laboratory Address: 817 W. 42nd Street
Mailing Address: 817 W. 42nd Street
Odessa, TX 79764
Contact: Jason Wells
Phone: 432-368-3536
Email: jwells@odessa-tx.gov

Customer: CRMWD
Address: PO Box 869
Big Spring, TX 79720
Collected by: Burch
Sample receipt date: 2/10/2015
Report Number: **021415REP01**

Certificate No. T104704363-15-11

Sample Location	Date of Collection	Time of Collection	Laboratory ID Code	Parameter	Method Number	Date of Analysis	Time of Analysis	Analyst(s)	Results	Units	MQL	Batch	Flag
Finished A	2/10/2015	11:15 AM	021015701	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	< 1	MPN	1	1	
Finished B	2/10/2015	11:15 AM	021015702	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	< 1	MPN	1	1	
Finished C	2/10/2015	11:15 AM	021015703	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	< 1	MPN	1	1	
Raw Inf A	2/10/2015	11:20 AM	021015704	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	5.2	MPN	1	1	
Raw Inf B	2/10/2015	11:20 AM	021015705	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	4.1	MPN	1	1	
Raw Inf C	2/10/2015	11:20 AM	021015706	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	11.8	MPN	1	1	
Moss Creek A	2/10/2015	10:40 AM	021015707	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	6.3	MPN	1	1	
Moss Creek B	2/10/2015	10:40 AM	021015708	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	8.6	MPN	1	1	
Moss Creek C	2/10/2015	10:40 AM	021015709	E. Coli	Colilert SM 9223B	2/10/2015	4:22 PM	MJ/AC	14.6	MPN	1	2	

Quality Control

MD Precision $M \leq 0.9974$				
Sample Reading	MD Reading	M	Flag	Batch
1.0	1.0	0.0000		1
14.6	6.3	0.6350		2

Notes:

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5. The results contained in this report meet all the requirements of the TNI standards for accreditation.
6. MQL = Minimum Quantitation Level, LCS = Laboratory Control Sample, MD = Matrix Duplicate, MS = Matrix Spike MSD = Matrix Spike Duplicate.
7. Samples will be disposed of at the end of the method holding time or 30 days from the date the report is mailed to the customer, whichever is shorter.
8. Explanation of Flags used in this report:

Jason Wells
Laboratory Management

2/17/2015
Date

Melissa Pipes
Quality Assurance Officer

2/17/2015
Date

CITY OF ODESSA LABORATORY SERVICES
TEST RESULTS

Certificate No. T104704363-15-11

Laboratory Address: 817 W. 42nd Street
Mailing Address: 817 W. 42nd Street
Odessa, TX 79764
Contact: Jason Wells
Phone: 432-368-3536
Email: jwells@odessa-tx.gov

Customer: CRMWD
Address: PO Box 869
Big Spring, TX 79720
Collected by: Burch/Laird
Sample receipt date: 6/2/2015
Report Number: **060315REP02**

Sample Location	Date of Collection	Time of Collection	Laboratory ID Code	Parameter	Method Number	Date of Analysis	Time of Analysis	Analyst(s)	Results	Units	MQL	Batch	Flag
Product Water A	6/2/2015	10:25 AM	060215701	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	< 1	MPN	1	1	
Product Water B	6/2/2015	10:25 AM	060215702	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	< 1	MPN	1	1	
Product Water C	6/2/2015	10:25 AM	060215703	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	< 1	MPN	1	1	
MF Source Water A	6/2/2015	10:30 AM	060215704	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	1.0	MPN	1	1	
MF Source Water B	6/2/2015	10:30 AM	060215705	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	2.0	MPN	1	1	
MF Source Water C	6/2/2015	10:30 AM	060215706	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	< 1	MPN	1	1	
Moss Creek A	6/2/2015	9:50 AM	060215707	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	2.0	MPN	1	1	
Moss Creek B	6/2/2015	9:50 AM	060215708	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	3.1	MPN	1	1	
Moss Creek C	6/2/2015	9:50 AM	060215709	E. Coli	Colilert SM 9223B	6/2/2015	2:00 PM	MJ	1.0	MPN	1	2	

Quality Control

MD Precision $M \leq 0.9974$				
Sample Reading	MD Reading	M	Flag	Batch
3.1	7.5	0.3837		1
1.0	5.2	0.7160		2

Notes:

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6. MQL = Minimum Quantitation Level, LCS = Laboratory Control Sample, MD = Matrix Duplicate, MS = Matrix Spike MSD = Matrix Spike Duplicate.
7. Samples will be disposed of at the end of the method holding time or 30 days from the date the report is mailed to the customer, whichever is shorter.
8. Explanation of Flags used in this report:

Jason Wells
Laboratory Management

6/3/2015
Date

Melissa Pipes
Quality Assurance Officer

6/9/2015
Date

City of Odessa Laboratory Services — Chain of Custody Record — Colorado River Municipal Water District

COC ID #: 060215COC08

Field Identification	Collection Date	Collection Time	Sample Collector	pH Check **	Sample Type	# of Containers	Preservation Type	E. coli (P)	~~TSS (P)~~	~~Chloride (P)~~	~~TDS (P)~~	~~CBOD (P)~~	~~NH_3-N (P)~~	~~SO_4 (P)~~	~~TOC (P)~~
* PRODUCT WATER A	02 JUNE 2015	10:25	BURL LAIRD		G	1	RS	✓							
PRODUCT WATER B					G	1	RS	✓							
PRODUCT WATER C					G	1	RS	✓							
MF SOURCE WATER A		10:30			G	1	RS	✓							
MF SOURCE WATER B					G	1	RS	✓							
MF SOURCE WATER C					G	1	RS	✓							
MOSS CREEK A		09:50			G	1	RS	✓							
MOSS CREEK B					G	1	RS	✓							
MOSS CREEK C					G	1	RS	✓							
					G										
					G										
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Relinquished By	Date	Time	Received By	Date	Time
Jacob Laird	6-2-15	1:26 PM	Olivia [illegible]	6.2.15	1:26pm.

Legend:
- R = Cool
- A = Acid to pH <2.0 SU
- S = Sterile, Sodium Thiosulfate
- F = Filtered on site
- **Check mark = pH < 2.0 SU
- G = Grab
- C = Composite
- (P) = Plastic
- (G) = Glass

Sample Receipt Conditions:
- ☐ Thermal preservation not required
- ☑ Collected same day Received on ice
- ☐ Collected previous day Received on ice

Temperature: 8.2+1.1=9.3 °C

☐ If checked, see attached Sample Rejection & Comment Form

CITY OF ODESSA LABORATORY SERVICES
TEST RESULTS

Laboratory Address: 817 W. 42nd Street
Mailing Address: 817 W. 42nd Street
Odessa, TX 79764
Contact: Jason Wells
Phone: 432-368-3536
Email: jwells@odessa-tx.gov

Customer: CRMWD
Address: PO Box 869
Big Spring, TX 79720
Collected by: Burch
Sample receipt date: 9/16/2015
Report Number: **091715REP01**

Certificate No. T104704363-15-12

Sample Location	Date of Collection	Time of Collection	Laboratory ID Code	Parameter	Method Number	Date of Analysis	Time of Analysis	Analyst(s)	Results	Units	MQL	Batch	Flag
Moss Creek A	9/16/2015	10:14 AM	091615804	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	
Moss Creek B	9/16/2015	10:14 AM	091615805	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	2.0	MPN	1	1	
Moss Creek C	9/16/2015	10:14 AM	091615806	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	1.0	MPN	1	1	
Product Water A	9/16/2015	11:00 AM	091615801	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	
Product Water B	9/16/2015	11:00 AM	091615802	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	
Product Water C	9/16/2015	11:00 AM	091615803	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	
MF Source Water A	9/16/2015	11:05 AM	091615807	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	
MF Source Water B	9/16/2015	11:05 AM	091615808	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	
MF Source Water C	9/16/2015	11:05 AM	091615809	E. Coli	Colilert SM 9223B	9/16/2015	2:11 PM	CP:AC/CP	< 1	MPN	1	1	

Quality Control

MD Precision $M \leq 0.9974$			
Sample Reading	MD Reading	M	Flag
1.0	1.0	0.0000	

Notes:
1. The data for precision and accuracy are generated on a sample analyzed in the same batch as the customer's sample. These values may or may not have been based on the customer's sample.
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7. Samples will be disposed of at the end of the method holding time or 30 days from the date the report is mailed to the customer, whichever is shorter.
8. Explanation of Flags used in this report:

Jason Wells
Laboratory Management

9/17/2015
Date

Melissa Pipes
Quality Assurance Officer

9/18/2015
Date

City of Odessa Laboratory Services — **Chain of Custody Record** — **Colorado River Municipal Water District**

COC ID #: 091615COC11

Field Identification	Collection Date	Collection Time	Sample Collector	pH Check **	Sample Type	# of Containers	Preservation Type	E. coli (P)	TSS (P)	Chloride (P)	TDS (P)	CBOD (P)	NH_3-N (P)	SO_4 (P)	TOC (P)
MOSS CREEK A	16 SEPT 2015	10:14	[illegible]		G	1	RS	✓							
MOSS CREEK B					G	1	RS	✓							
MOSS CREEK C					G	1	RS	✓							
PRODUCT WATER A	16 SEPT 2015	11:00	[illegible]		G	1	RS	✓							
PRODUCT WATER B					G	1	RS	✓							
PRODUCT WATER C					G	1	RS	✓							
IF SOURCE WATER A	16 SEPT 2015	11:05	[illegible]		G	1	RS	✓							
nF SOURCE WATER B					G	1	RS	✓							
mF SOURCE WATER C					G	1	RS	✓							
					G										
					G										
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					G										
					G										

Relinquished By	Date	Time	Received By	Date	Time
[illegible]	16 SEPT 2015	1:06pm	[illegible]	9.16.15	1:06 pm.

Legend:
- R = Cool
- A = Acid to pH <2.0 SU
- S = Sterile, Sodium Thiosulfate
- F = Filtered on site
- **Check mark = pH < 2.0 SU

- G = Grab
- C = Composite
- (P) = Plastic
- (G) = Glass

Sample Receipt Conditions:
- ☐ Thermal preservation not required
- ☑ Collected same day Received on ice
- ☐ Collected previous day Received on ice

Temperature:________ °C *

☐ If checked, see attached Sample Rejection & Comment Form

Eurofins Eaton Analytical
750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY
AT-1807

Laboratory Report

for

Carollo Engineers, Inc.
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
Attention: Eva Steinle-Darling

Date of Issue
05/04/2016
EUROFINS EATON ANALYTICAL

DEB: Debbie.L.Frank

Project Manager

NELAP ACCREDITED TNI LABORATORY
ORELAP 4034

Report: 585389
Project: BIG-SPRING-TX
Group: CRMWD - Big Spring
PO#: DPR JOB# 9360A00

* Accredited in accordance with TNI 2009 and ISO/IEC 17025:2005.
* Laboratory certifies that the test results meet all **TNI 2009 and ISO/IEC 17025:2005** requirements unless noted under the individual analysis.
* Following the cover page are State Certification List, ISO 17025 Accredited Method List, Acknowledgement of Samples Received, Comments, Hits Report, Data Report, QC Summary, QC Report and Regulatory Forms, as applicable.
* Test results relate only to the sample(s) tested.
* This report shall not be reproduced except in full, without the written approval of the laboratory.

eurofins | Eaton Analytical

STATE CERTIFICATION LIST

State	Certification Number	State	Certification Number
Alabama	41060	**Mississippi**	Certified
----------	--------	**Montana**	Cert 0035
Arizona	AZ0778	**Nebraska**	Certified
Arkansas	Certified	**Nevada**	CA00006-2016
California-Monrovia-ELAP	2813	**New Hampshire ***	2959
California-Colton- ELAP	2812	**New Jersey ***	CA 008
California-Folsom- ELAP	2820	**New Mexico**	Certified
California-Fresno- ELAP	2966	**New York ***	11320
Colorado	Certified	**North Carolina**	06701
Connecticut	PH-0107	**North Dakota**	R-009
Delaware	CA 006	**Oregon (Primary AB) ***	**ORELAP 4034**
Florida *	E871024	**Pennsylvania ***	68-565
Georgia	947	**Rhode Island**	LAO00326
Guam	15-003r	**South Carolina**	87016
Hawaii	Certified	**South Dakota**	Certified
Idaho	Certified	**Tennessee**	TN02839
Illinois *	200033	**Texas ***	T104704230-14-7
Indiana	C-CA-01	**Utah ***	CA000062015-8
Kansas *	E-10268	**Vermont**	VT0114
Kentucky	90107	**Virginia ***	460260
Louisiana *	LA16003	**Washington**	C838
Maine	CA0006	**West Virginia**	9943 C
Maryland	224	----------	----------
Commonwealth of Northern Marianas Is.	MP0004	**Wyoming**	8TMS-L
Massachusetts	M-CA006	**EPA Region 5**	Certified
Michigan	9906	**Los Angeles County Sanitation Districts**	10264

* NELAP/TNI Recognized Accreditation Bodies

Eurofins Eaton Analytical, Inc.
750 Royal Oaks Drive, Suite 100
Monrovia, CA 91016-3629
T | 626-386-1100
F | 626-386-1101
www.EatonAnalytical.com

ISO 17025 Accredited Method List

The tests listed below are accredited and meet the requirements of ISO 17025 as verified by the ANSI-ASQ National Accreditation Board/ANAB.

Refer to Certificate and scope of accreditation (AT 1807) found at: http://www.eatonanalytical.com

SPECIFIC TESTS	METHOD OR TECHNIQUE USED	Environ-mental (Drinking Water)	Environ-mental (Waste Water)	Water as a Component of Food and Bev/Bev/ Bottled Water
1,4-Dioxane	EPA 522	x		x
2,3,7,8-TCDD	Modified EPA 1613B	x		x
Acrylamide	In House Method (2440)	x		x
Alkalinity	SM 2320B	x	x	x
Ammonia	EPA 350.1		x	x
Ammonia	SM 4500-NH3 H		x	x
Anions and DBPs by IC	EPA 300.0	x	x	x
Anions and DBPs by IC	EPA 300.1	x		x
Asbestos	EPA 100.2	x	x	
Bicarbonate Alkalinity as HCO3	SM 2320B	x	x	x
BOD / CBOD	SM 5210B		x	x
Bromate	In House Method (2447)	x		x
Carbamates	EPA 531.2	x		x
Carbonate as CO3	SM 2330B	x	x	x
Carbonyls	EPA 556	x		x
COD	EPA 410.4 / SM 5220D		x	
Chloramines	SM 4500-CL G	x	x	x
Chlorinated Acids	EPA 515.4	x		x
Chlorinated Acids	EPA 555	x		x
Chlorine Dioxide	SM 4500-CLO2 D	x		x
Chlorine -Total/Free/ Combined Residua	SM 4500-Cl G	x	x	x
Conductivity	EPA 120.1		x	
Conductivity	SM 2510B	x	x	x
Corrosivity (Langelier Index)	SM 2330B	x		x
Cryptosporidium	EPA 1622, 1623	x		x
Cyanide, Amenable	SM 4500-CN G	x	x	
Cyanide, Free	SM 4500CN F	x	x	x
Cyanide, Total	EPA 335.4	x	x	x
Cyanogen Chloride (screen)	In House Method (2470)	x		x
Diquat and Paraquat	EPA 549.2	x		x
DBP/HAA	SM 6251B	x		x
Dissolved Oxygen	SM 4500-O G		x	x
DOC	SM 5310C	x		x
E. Coli	(MTF/EC+MUG)	x		x
E. Coli	CFR 141.21(f)(6)(i)	x		x
E. Coli	SM 9223		x	
E. Coli (Enumeration)	SM 9221B.1/ SM 9221F	x		x
E. Coli (Enumeration)	SM 9223B	x		x
EDB/DCBP	EPA 504.1	x		
EDB/DBCP and DBP	EPA 551.1	x		x
EDTA and NTA	In House Method (2454)	x		x
Endothall	EPA 548.1	x		x
Endothall	In-house Method (2445)	x		x
Enterococci	SM 9230B	x	x	
Fecal Coliform	SM 9221 E (MTF/EC)	x		
Fecal Coliform	SM 9221C, E (MTF/EC)		x	
Fecal Coliform (Enumeration)	SM 9221E (MTF/EC)	x		x
Fecal Coliform with Chlorine Present	SM 9221E		x	
Fecal Streptococci	SM 9230B	x	x	
Fluoride	SM 4500-F C	x	x	x
Giardia	EPA 1623	x		x
Glyphosate	EPA 547	x		x
Gross Alpha/Beta	EPA 900.0	x	x	x
Gross Alpha Coprecipitation	SM 7110 C	x	x	x
Hardness	SM 2340B	x	x	x
Heterotrophic Bacteria	In House Method (2439)	x		x
Heterotrophic Bacteria	SM 9215 B	x		x
Hexavalent Chromium	EPA 218.6	x	x	x
Hexavalent Chromium	EPA 218.7	x		x
Hexavalent Chromium	SM 3500-Cr B		x	
Hormones	EPA 539	x		x
Hydroxide as OH Calc.	SM 2330B	x		x
Kjeldahl Nitrogen	EPA 351.2		x	
Legionella	CDC Legionella	x		x
Mercury	EPA 245.1	x	x	x
Metals	EPA 200.7 / 200.8	x	x	x
Microcystin LR	ELISA (2360)	x		x
NDMA	EPA 521	x		x
Nitrate/Nitrite Nitrogen	EPA 353.2	x	x	x
OCL, Pesticides/PCB	EPA 505	x		x
Ortho Phosphate	EPA 365.1	x	x	x
Ortho Phosphate	SM 4500P E			x
Ortho Phosphorous	SM 4500P E	x		
Oxyhalides Disinfection Byproducts	EPA 317.0	x		x
Perchlorate	EPA 331.0	x		x
Perchlorate (low and high)	EPA 314.0	x		x
Perfluorinated Alkyl Acids	EPA 537	x		x
pH	EPA 150.1	x		
pH	SM 4500-H+B	x	x	x
Phenylurea Pesticides/ Herbicides	In House Method, based on EPA 532 (2448)	x		x
Pseudomonas	IDEXX Pseudalert (2461)	x		x
Radium-226	GA Institute of Tech	x		x
Radium-228	GA Institute of Tech	x		x
Radon-222	SM 7500RN	x		x
Residue, Filterable	SM 2540C	x	x	x
Residue, Non-filterable	SM 2540D		x	
Residue, Total	SM 2540B		x	x
Residue, Volatile	EPA 160.4		x	
Semi-VOC	EPA 525.2	x		x
Semi-VOC	EPA 625		x	x
Silica	SM 4500-Si D	x	x	
Silica	SM 4500-SiO2 C	x	x	
Sulfide	SM 4500-$S^=$ D		x	
Sulfite	SM 4500-SO^3B	x	x	x
Surfactants	SM 5540C	x	x	x
Taste and Odor Analytes	SM 6040E	x		x
Total Coliform (P/A)	SM 9221 A, B	x		x
Total Coliform (Enumeration)	SM 9221 A, B, C	x		x
Total Coliform / E. coli	Colisure (2346)	x		x
Total Coliform	SM 9221B		x	
Total Coliform with Chlorine Present	SM 9221B		x	
Total Coliform / E.coli (P/A and Enumeration)	SM 9223	x		x
TOC	SM 5310C	x	x	x
TOX	SM 5320B		x	
Total Phenols	EPA 420.1		x	
Total Phenols	EPA 420.4	x	x	x
Total Phosphorous	SM 4500 P E		x	
Turbidity	EPA 180.1	x	x	x
Turbidity	SM 2130B	x	x	
Uranium by ICP/MS	EPA 200.8	x		x
UV 254	SM 5910B	x		
VOC	EPA 524.2/EPA 524.3	x		x
VOC	EPA 624		x	x
VOC	EPA SW 846 8260	x		x
VOC	In House Method (2411)	x		x
Yeast and Mold	SM 9610	x		x

eurofins Eaton Analytical

Acknowledgement of Samples Received

Addr: **Carollo Engineers, Inc.**
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

Attn: Eva Steinle-Darling
Phone: 512-427-8118

Client ID: CAROLLO
Folder #: 585389
Project: BIG-SPRING-TX
Sample Group: CRMWD - Big Spring DPR JOB# 9360A00 Task 200 (AOP)
Project Manager: Debbie.L.Frank
Phone: (626) 386-1149
PO #: 9360A.00 TO 200

The following samples were received from you on **April 14, 2016** at **1052**. They have been scheduled for the tests listed below each sample. If this information is incorrect, please contact your service representative. Thank you for using Eurofins Eaton Analytical.

Sample #	Sample ID	Sample Date
201604140395	Product Water	04/13/2016 1000
	@UCMR3 522 C	
201604140396	Influent	04/13/2016 1015
	@UCMR3 522 C	

Test Description

@UCMR3 522 C -- UCMR3 1,4-Dioxane by EPA 522

eurofins | Eaton Analytical

CHAIN OF CUSTODY RECORD

585389

750 Royal Oaks Drive, Suite 100
Monrovia, CA 91016-3629

Phone: 626 386 1100
Fax: 626 386 1101

800 566 LABS (800 566 5227)

Website:

EUROFINS EATON ANALYTICAL USE ONLY:

LOGIN COMMENTS: ____________

SAMPLES CHECKED AGAINST COC BY: VP

SAMPLES LOGGED IN BY: RD

SAMPLE TEMP RECEIVED AT:

SAMPLES REC'D DAY OF COLLECTION? [ ] (check for yes)

[ ] ______ (Other) IR Gun ID = ______ (Observation= ______ °C) (Corr.Factor ______ °C) (Final = ______ °C)

[✓] Monrovia IR Gun ID = 4644 (Observation= 2.8 °C) (Corr.Factor -0.3 °C) (Final = 2.5 °C)

Compliance Acceptance Criteria: (Chemistry: 4 ± 2 °C) (Microbiology: < 10°C)

TYPE OF ICE: Real ✓ Synthetic ____ No Ice ____ **CONDITION OF ICE:** Frozen ✓ Partially Frozen ____ Thawed ____ N/A ____

METHOD OF SHIPMENT: Pick-Up / Walk-In / FedEx (circled) / UPS / DHL / Area Fast / Top Line / Other: ________

TO BE COMPLETED BY SAMPLER:

COMPANY/AGENCY NAME: CAROLLO ENGINEERS

PROJECT CODE: BIG SPRING TX

EEA CLIENT CODE: ?

COC ID: ?

SAMPLE GROUP: ?

TAT requested: rush by adv notice only STD ✓ 1 wk ___ 3 day ___ 2 day ___ 1 day ___

COMPLIANCE SAMPLES [ ] (check for yes) - Requires state forms [ ]

NON-COMPLIANCE SAMPLES [✓] (check for yes)

?

Type of samples (circle one): ROUTINE SPECIAL CONFIRMATION

REGULATION INVOLVED: ________ (eg. SDWA, NPDES, etc.)

SEE ATTACHED KIT ORDER FOR ANALYSES [✓] (check for yes), OR

List ALL ANALYSES REQUIRED (enter number of bottles sent for each test for each sample)

SAMPLE DATE	SAMPLE TIME	SAMPLE ID	CLIENT LAB ID	MATRIX *	FIELD DATA	FIELD DATA	ANALYSES	SAMPLER COMMENTS
		JDB 12 APR 2016 17:00h						
13 APR 2016	10:00	IN PRODUCT WATER		CFW			WB 13 APR 2016 09:26	3 BOTTLES
		~~DUPLICATE PRODUCT WATER~~		~~CFW~~				~~"~~
13 APR 2016	10:15	INFLUENT		WW				TREATED, "
		~~DUPLICATE INFLUENT~~		~~WW~~				~~TREATED, "~~
							JDB 13 APR 2016 09:27	

FedEx TRK# 0221 6632 2413 8950

*** MATRIX TYPES: RSW** = Raw Surface Water **RGW** = Raw Ground Water **CFW** = Chlor(am)inated Finished Water **FW** = Other Finished Water **SEAW** = Sea Water **WW** = Waste Water **BW** = Bottled Water **SW** = Storm Water **SO** = Soil **SL** = Sludge **O** = Other - Please Identify

	SIGNATURE	PRINT NAME	COMPANY/TITLE	DATE	TIME
SAMPLED BY:	John D. Burch	JOHN D. BURCH	CRMWD/WATER QUALITY SUPER.	13 APR 2016	ABOVE
RELINQUISHED BY:	John D. Burch	JOHN D. BURCH.	"	"	14:00
RECEIVED BY:	[signature]	VICTOR PLASCENCIA	EEA	4/14/16	1052
RELINQUISHED BY:					
RECEIVED BY:					

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Kit Order for Carollo Engineers

Debbie.L.Frank is your Eurofins Eaton Analytical Service Manager

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
(626) 386-1100 FAX (626) 386-1101

Note: Sampler Please return this paper with your samples

Kit #: 135935

Created By: Debbie.L.Frank - [DEB]
Deliver By: 04/12/2016
STG: Bottle Orders
Ice Type: W
Pre Registered

Client ID: CAROLLO
Project Code: BIG-SPRING-TX Bottle Orders
Group Name: CRMWD - Big Spring DPR JOB# 9360A00 Task 200 (AOP)
PO#/JOB#: 9360A.00 TO 200

Ship Sample Kits to
Colorado River Municipal Water District
401 East 24th Street
Big Spring, TX 79721-0869

Attn: John Burch, CRMWD
Phone: 432-213-1346 m

Send Report to
Carollo Engineers, Inc.
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

Attn: Eva Steinle-Darling
Phone: 512-427-8118

Billing Address
Carollo Engineers
4600 East Washington Street, Suite 500
Phoenix, AZ 85034

Attn: Accounts Payable

# of Samples	Tests	Bottle Qty - Type [preservative information]	UN DOT #
2	@UCMR3 522	3 - 125ml amber glass [~~6.25 Sulfite~~ +125 mg Bisulfite]	
2	@UCMR3 522 C	3 - 125ml amber glass [6.25 Sulfite +125 mg Bisulfite]	

SEE COC + EVA STEINLE - DARLING EMAIL

Comments

RUSH KO, Deliver by 0800 Tuesday 4/12/16
Include sampling instructions
Include pre-paid sample return AB__________

Sampler:
Product water has Residual Chlorine - Please follow 2-stage field preservation procedure. Sampling instrcutions sent via EMail to John Burch.

Influent - Containers have all preservative needed. Fill to the base of the neck for each container, do not overflow.

Code	Status	Date Shipped	Via	Tracking #	# of Coolers	Prepared By

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

Laboratory Comments
Report: 585389

Carollo Engineers, Inc.
Eva Steinle-Darling
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

The Comments Report may be blank if there are no comments for this report.

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750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

Laboratory Hits
Report: 585389

Carollo Engineers, Inc.
Eva Steinle-Darling
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

Samples Received on:
04/14/2016 1052

Analyzed	Analyte	Sample ID	Result	Federal MCL	Units	MRL
	201604140396	**Influent**				
04/23/2016 11:12	1,4-Dioxane		0.36		ug/L	0.07

SUMMARY OF POSITIVE DATA ONLY

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Eaton Analytical

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

Laboratory Data
Report: 585389

Carollo Engineers, Inc.
Eva Steinle-Darling
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

Samples Received on:
04/14/2016 1052

Prepared	Analyzed		QC Ref #	Method	Analyte	Result	Units	MRL	Dilution
Product Water (201604140395)							**Sampled on 04/13/2016 1000**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
4/18/2016	04/23/2016	10:57	906506	(EPA 522)	1,4-Dioxane	ND	ug/L	0.07	1
4/18/2016	04/23/2016	10:57	906506	(EPA 522)	Dioxane-d8	93	%		1
4/18/2016	04/23/2016	10:57	906506	(EPA 522)	THF-d8	116	%		1
Influent (201604140396)							**Sampled on 04/13/2016 1015**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
4/18/2016	04/23/2016	11:12	906506	(EPA 522)	1,4-Dioxane	0.36	ug/L	0.07	1
4/18/2016	04/23/2016	11:12	906506	(EPA 522)	Dioxane-d8	86	%		1
4/18/2016	04/23/2016	11:12	906506	(EPA 522)	THF-d8	115	%		1

Rounding on totals after summation.
(c) - indicates calculated results

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750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

Laboratory
QC Summary: 585389

Carollo Engineers, Inc.

QC Ref # 906506 - UCMR3 1,4-Dioxane by EPA 522 **Analysis Date: 04/23/2016**

201604140395	Product Water	Analyzed by: JYH
201604140396	Influent	Analyzed by: JYH

eurofins Eaton Analytical

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

Laboratory QC Report: 585389

Carollo Engineers, Inc.

QC Type	Analyte	Native	Spiked	Recovered	Units	Yield (%)	Limits (%)	RPDLimit (%)	RPD%
QC Ref# 906506 - UCMR3 1,4-Dioxane by EPA 522 by EPA 522						**Analysis Date: 04/23/2016**			
CCCL	1,4-Dioxane		0.07	0.0760	ug/L	109	(50-150)		
CCCM	1,4-Dioxane		20	20.6	ug/L	103	(70-130)		
LCS1	1,4-Dioxane		20	15.8	ug/L	79	(70-130)		
MBLK	1,4-Dioxane			<0.023	ug/L				
MRL_CHK	1,4-Dioxane		0.07	0.0640	ug/L	91	(50-150)		
MS_201604010153	1,4-Dioxane	1.4	20	17.2	ug/L	79	(70-130)		
MSD_201604010153	1,4-Dioxane	1.4	20	14.0	ug/L	**63**	(70-130)	20	**21**
CCCL	Dioxane-d8			104	%	104	(70-130)		
CCCM	Dioxane-d8			102	%	102	(70-130)		
LCS1	Dioxane-d8			80.5	%	80	(70-130)		
MBLK	Dioxane-d8			87.3	%				
MRL_CHK	Dioxane-d8			85.5	%	85	(70-130)		
MS_201604010153	Dioxane-d8	92		83.1	%	83	(70-130)		
MSD_201604010153	Dioxane-d8	92		60.7	%	**61**	(70-130)		
CCCL	THF-d8			96.6	%	97	(50-150)		
CCCM	THF-d8			100	%	100	(50-150)		
LCS1	THF-d8			106	%	106	(50-150)		
MBLK	THF-d8			109	%				
MRL_CHK	THF-d8			120	%	120	(50-150)		
MS_201604010153	THF-d8	112		116	%	116	(50-150)		
MSD_201604010153	THF-d8	112		114	%	114	(50-150)		

Spike recovery is already corrected for native results.
Spikes which exceed Limits and Method Blanks with positive results are highlighted by Underlining.
Criteria for MS and Dup are advisory only, batch control is based on LCS. Criteria for duplicates are advisory only, unless otherwise specified in the method.
RPD not calculated for LCS2 when different a concentration than LCS1 is used.
RPD not calculated for Duplicates when the result is not five times the MRL (Minimum Reporting Level).
(S) - Indicates surrogate compound.
(I) - Indicates internal standard compound.

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

AT-1807

Laboratory Report

for

Carollo Engineers, Inc.
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
Attention: Eva Steinle-Darling

Date of Issue
05/31/2016
EUROFINS EATON ANALYTICAL

DEB: Debbie.L.Frank

Project Manager

ORELAP 4034

Report: 588854
Project: BIG-SPRING-TX
Group: CRMWD - Big Spring
PO#: DPR JOB# 9360A00

* Accredited in accordance with TNI 2009 and ISO/IEC 17025:2005.
* Laboratory certifies that the test results meet all **TNI 2009 and ISO/IEC 17025:2005** requirements unless noted under the individual analysis.
* Following the cover page are State Certification List, ISO 17025 Accredited Method List, Acknowledgement of Samples Received, Comments, Hits Report, Data Report, QC Summary, QC Report and Regulatory Forms, as applicable.
* Test results relate only to the sample(s) tested.
* This report shall not be reproduced except in full, without the written approval of the laboratory.

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STATE CERTIFICATION LIST

State	Certification Number	State	Certification Number
Alabama	41060	**Mississippi**	Certified
----------	--------	**Montana**	Cert 0035
Arizona	AZ0778	**Nebraska**	Certified
Arkansas	Certified	**Nevada**	CA00006-2016
California-Monrovia-ELAP	2813	**New Hampshire ***	2959
California-Colton- ELAP	2812	**New Jersey ***	CA 008
California-Folsom- ELAP	2820	**New Mexico**	Certified
California-Fresno- ELAP	2966	**New York ***	11320
Colorado	Certified	**North Carolina**	06701
Connecticut	PH-0107	**North Dakota**	R-009
Delaware	CA 006	**Oregon (Primary AB) ***	**ORELAP 4034**
Florida *	E871024	**Pennsylvania ***	68-565
Georgia	947	**Rhode Island**	LAO00326
Guam	15-003r	**South Carolina**	87016
Hawaii	Certified	**South Dakota**	Certified
Idaho	Certified	**Tennessee**	TN02839
Illinois *	200033	**Texas ***	T104704230-14-7
Indiana	C-CA-01	**Utah ***	CA000062015-8
Kansas *	E-10268	**Vermont**	VT0114
Kentucky	90107	**Virginia ***	460260
Louisiana *	LA16003	**Washington**	C838
Maine	CA0006	**West Virginia**	9943 C
Maryland	224	----------	----------
Commonwealth of Northern Marianas Is.	MP0004	**Wyoming**	8TMS-L
Massachusetts	M-CA006	**EPA Region 5**	Certified
Michigan	9906	**Los Angeles County Sanitation Districts**	10264

* NELAP/TNI Recognized Accreditation Bodies

ISO 17025 Accredited Method List

The tests listed below are accredited and meet the requirements of ISO 17025 as verified by the ANSI-ASQ National Accreditation Board/ANAB.
Refer to Certificate and scope of accreditation (AT 1807) found at: http://www.eatonanalytical.com

SPECIFIC TESTS	METHOD OR TECHNIQUE USED	Environ-mental (Drinking Water)	Environ-mental (Waste Water)	Water as a Component of Food and Bev/Bev/ Bottled Water
1,4-Dioxane	EPA 522	x		x
2,3,7,8-TCDD	Modified EPA 1613B	x		x
Acrylamide	In House Method (2440)	x		x
Alkalinity	SM 2320B	x	x	x
Ammonia	EPA 350.1		x	x
Ammonia	SM 4500-NH3 H		x	x
Anions and DBPs by IC	EPA 300.0	x	x	x
Anions and DBPs by IC	EPA 300.1	x		x
Asbestos	EPA 100.2	x	x	
Bicarbonate Alkalinity as HCO3	SM 2320B	x	x	x
BOD / CBOD	SM 5210B		x	x
Bromate	In House Method (2447)	x		x
Carbamates	EPA 531.2	x		x
Carbonate as CO3	SM 2330B	x	x	x
Carbonyls	EPA 556	x		x
COD	EPA 410.4 / SM 5220D		x	
Chloramines	SM 4500-CL G	x	x	x
Chlorinated Acids	EPA 515.4	x		x
Chlorinated Acids	EPA 555	x		x
Chlorine Dioxide	SM 4500-CLO2 D	x		x
Chlorine -Total/Free/ Combined Residua	SM 4500-Cl G	x	x	x
Conductivity	EPA 120.1		x	
Conductivity	SM 2510B	x	x	x
Corrosivity (Langelier Index)	SM 2330B	x		x
Cryptosporidium	EPA 1622, 1623	x		x
Cyanide, Amenable	SM 4500-CN G	x	x	
Cyanide, Free	SM 4500CN F	x	x	x
Cyanide, Total	EPA 335.4	x	x	x
Cyanogen Chloride (screen)	In House Method (2470)	x		x
Diquat and Paraquat	EPA 549.2	x		x
DBP/HAA	SM 6251B	x		x
Dissolved Oxygen	SM 4500-O G		x	x
DOC	SM 5310C	x		x
E. Coli	(MTF/EC+MUG)	x		x
E. Coli	CFR 141.21(f)(6)(i)	x		x
E. Coli	SM 9223		x	
E. Coli (Enumeration)	SM 9221B.1/ SM 9221F	x		x
E. Coli (Enumeration)	SM 9223B	x		x
EDB/DCBP	EPA 504.1	x		
EDB/DBCP and DBP	EPA 551.1	x		x
EDTA and NTA	In House Method (2454)	x		x
Endothall	EPA 548.1	x		x
Endothall	In-house Method (2445)	x		x
Enterococci	SM 9230B	x	x	
Fecal Coliform	SM 9221 E (MTF/EC)	x		
Fecal Coliform	SM 9221C, E (MTF/EC)		x	
Fecal Coliform (Enumeration)	SM 9221E (MTF/EC)	x		x
Fecal Coliform with Chlorine Present	SM 9221E		x	
Fecal Streptococci	SM 9230B	x	x	
Fluoride	SM 4500-F C	x	x	x
Giardia	EPA 1623	x		x
Glyphosate	EPA 547	x		x
Gross Alpha/Beta	EPA 900.0	x	x	x
Gross Alpha Coprecipitation	SM 7110 C	x	x	x
Hardness	SM 2340B	x	x	x
Heterotrophic Bacteria	In House Method (2439)	x		x
Heterotrophic Bacteria	SM 9215 B	x		x
Hexavalent Chromium	EPA 218.6	x	x	x

SPECIFIC TESTS	METHOD OR TECHNIQUE USED	Environ-mental (Drinking Water)	Environ-mental (Waste Water)	Water as a Component of Food and Bev/Bev/ Bottled Water
Hexavalent Chromium	EPA 218.7	x		x
Hexavalent Chromium	SM 3500-Cr B		x	
Hormones	EPA 539	x		x
Hydroxide as OH Calc.	SM 2330B	x		x
Kjeldahl Nitrogen	EPA 351.2		x	
Legionella	CDC Legionella	x		x
Mercury	EPA 245.1	x	x	x
Metals	EPA 200.7 / 200.8	x	x	x
Microcystin LR	ELISA (2360)	x		x
NDMA	EPA 521	x		x
Nitrate/Nitrite Nitrogen	EPA 353.2	x	x	x
OCL, Pesticides/PCB	EPA 505	x		x
Ortho Phosphate	EPA 365.1	x	x	x
Ortho Phosphate	SM 4500P E			x
Ortho Phosphorous	SM 4500P E	x		
Oxyhalides Disinfection Byproducts	EPA 317.0	x		x
Perchlorate	EPA 331.0	x		x
Perchlorate (low and high)	EPA 314.0	x		x
Perfluorinated Alkyl Acids	EPA 537	x		x
pH	EPA 150.1	x		
pH	SM 4500-H+B	x	x	x
Phenylurea Pesticides/ Herbicides	In House Method, based on EPA 532 (2448)	x		x
Pseudomonas	IDEXX Pseudalert (2461)	x		x
Radium-226	GA Institute of Tech	x		x
Radium-228	GA Institute of Tech	x		x
Radon-222	SM 7500RN	x		x
Residue, Filterable	SM 2540C	x	x	x
Residue, Non-filterable	SM 2540D		x	
Residue, Total	SM 2540B		x	x
Residue, Volatile	EPA 160.4		x	
Semi-VOC	EPA 525.2	x		x
Semi-VOC	EPA 625		x	x
Silica	SM 4500-Si D	x	x	
Silica	SM 4500-SiO2 C	x	x	
Sulfide	SM 4500-$S^{=}$ D		x	
Sulfite	SM 4500-SO^{3}B	x	x	x
Surfactants	SM 5540C	x	x	x
Taste and Odor Analytes	SM 6040E	x		x
Total Coliform (P/A)	SM 9221 A, B	x		x
Total Coliform (Enumeration)	SM 9221 A, B, C	x		x
Total Coliform / E. coli	Colisure (2346)	x		x
Total Coliform	SM 9221B		x	
Total Coliform with Chlorine Present	SM 9221B		x	
Total Coliform / E.coli (P/A and Enumeration)	SM 9223	x		x
TOC	SM 5310C	x	x	x
TOX	SM 5320B		x	
Total Phenols	EPA 420.1		x	
Total Phenols	EPA 420.4	x	x	x
Total Phosphorous	SM 4500 P E		x	
Turbidity	EPA 180.1	x	x	x
Turbidity	SM 2130B	x	x	
Uranium by ICP/MS	EPA 200.8	x		x
UV 254	SM 5910B	x		
VOC	EPA 524.2/EPA 524.3	x		x
VOC	EPA 624		x	x
VOC	EPA SW 846 8260	x		x
VOC	In House Method (2411)	x		x
Yeast and Mold	SM 9610	x		x

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Acknowledgement of Samples Received

Addr:	**Carollo Engineers, Inc.** 8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759	Client ID:	CAROLLO
		Folder #:	588854
		Project:	BIG-SPRING-TX
		Sample Group:	CRMWD - Big Spring DPR JOB# 9360A00 Task 200 (AOP)
Attn:	Eva Steinle-Darling	Project Manager:	Debbie.L.Frank
Phone:	512-427-8118	Phone:	(626) 386-1149
		PO #:	9360A.00 TO 200

The following samples were received from you on **May 20, 2016** at **1130**. They have been scheduled for the tests listed below each sample. If this information is incorrect, please contact your service representative. Thank you for using Eurofins Eaton Analytical.

Sample #	Sample ID	Sample Date
201605050667	Product Water	05/19/2016 0930
	@UCMR3 522 C	
201605050671	AOP Feed	05/19/2016 0940
	@UCMR3 522 C	
201605050673	RO Feed	05/19/2016 0950
	@UCMR3 522 C	
201605050669	Influent	05/19/2016 1000
	@UCMR3 522 C	
201605050675	Moss Creek Lake	05/19/2016 1100
	@UCMR3 522 C	
201605250063	Freight Sample Return	05/19/2016 1100
	Freight - Return	

Test Description

@UCMR3 522 C -- UCMR3 1,4-Dioxane by EPA 522

750 Royal Oaks Drive, Suite 100, Monrovia, CA 91016 Tel (626) 386-1100 Fax (626) 386-1101 www.EurofinsUS.com/Eaton

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CHAIN OF CUSTODY RECORD

508854

750 Royal Oaks Drive, Suite 100
Monrovia, CA 91016-3629
Phone: 626 386 1100
Fax: 626 386 1101
800 566 LABS (800 566 5227)
Website: www.EatonAnalytical.com

EUROFINS EATON ANALYTICAL USE ONLY:

LOGIN COMMENTS: ____________

SAMPLES CHECKED AGAINST COC BY: Weena
SAMPLES LOGGED IN BY: Re

SAMPLE TEMP RECEIVED AT:
SAMPLES REC'D DAY OF COLLECTION? ☐ (check for yes)

☐ ______ (Other) IR Gun ID = ______ (Observation= ______ °C) (Corr.Factor ______ °C) (Final = ______ °C)
☑ Monrovia IR Gun ID = 464 A (Observation= 2.3 °C) (Corr.Factor -0.4 °C) (Final = 1.9 °C)

Compliance Acceptance Criteria: (Chemistry: 4 ± 2 °C) (Microbiology: < 10°C)

TYPE OF ICE: Real ✓ Synthetic ____ No Ice ____ **CONDITION OF ICE:** Frozen ✓ Partially Frozen ____ Thawed ____ N/A ____

METHOD OF SHIPMENT: Pick-Up / Walk-In / FedEx / UPS / DHL / Area Fast / Top Line / Other: ______

TO BE COMPLETED BY SAMPLER:

COMPANY/AGENCY NAME: CAROLLO ENGINEERS
PROJECT CODE: BIG-SPRING-TX
EEA CLIENT CODE: ?
COC ID: ?
SAMPLE GROUP: ?

TAT requested: rush by adv notice only STD ✓ 1 wk ___ 3 day ___ 2 day ___ 1 day ___

(check for yes) **COMPLIANCE SAMPLES** ☐ - Requires state forms ☐
(check for yes) **NON-COMPLIANCE SAMPLES** ☑
REGULATION INVOLVED: ______ (eg. SDWA, NPDES, etc.)
Type of samples (circle one): **ROUTINE SPECIAL CONFIRMATION** ?

SEE ATTACHED KIT ORDER FOR ANALYSES ☑ **(check for yes), *OR***
List ALL ANALYSES REQUIRED (enter number of bottles sent for each test for each sample)

SAMPLE DATE	SAMPLE TIME	SAMPLE ID	CLIENT LAB ID	MATRIX *	FIELD DATA	FIELD DATA															SAMPLER COMMENTS
19 MAY 2016	0930	PRODUCT WATER		CFW																	
	0940	AOP FEED		?																	
	0950	RO FEED		?																	
	1000	INFLUENT		WW																	
	1100	MOSS CREEK LAKE		RSW																	

FedEx TRK# 0221 6632 2415 3592

*** MATRIX TYPES:** **RSW** = Raw Surface Water **RGW** = Raw Ground Water **CFW** = Chlor(am)inated Finished Water **FW** = Other Finished Water **SEAW** = Sea Water **WW** = Waste Water **BW** = Bottled Water **SW** = Storm Water **SO** = Soil **SL** = Sludge **O** = Other - Please Identify

	SIGNATURE	PRINT NAME	COMPANY/TITLE	DATE	TIME
SAMPLED BY:	John D. Burch	JOHN D. BURCH	CRMWD/WATER QUALITY SUPER	19 MAY 2016	15:00
RELINQUISHED BY:	John D. Burch	JOHN D. BURCH	"	19 MAY 2016	16:00
RECEIVED BY:	[illegible]	Weena Tanawarawid	EEA	5·20·16	1130
RELINQUISHED BY:					
RECEIVED BY:					

QA FO 0029.2 (Version 2) (08/28/2014)

PAGE 1 OF 1

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Kit Order for Carollo Engineers

Debbie.L.Frank is your Eurofins Eaton Analytical Service Manager

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
(626) 386-1100 FAX (626) 386-1101

Note: Sampler Please return this paper with your samples

Kit #: 137581

Created By: Debbie.L.Frank - [DEB]
Deliver By: 05/12/2016
STG: Bottle Orders
Ice Type: W
Pre Registered

Client ID: CAROLLO
Project Code: BIG-SPRING-TX Bottle Orders
Group Name: CRMWD - Big Spring DPR JOB# 9360A00 Task 200 (AOP)
PO#/JOB#: 9360A.00 TO 200

Ship Sample Kits to
Colorado River Municipal Water District
401 East 24th Street
Big Spring, TX 79721-0869

Attn: John Burch, CRMWD
Phone: 432-213-1346 m

Send Report to
Carollo Engineers, Inc.
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

Attn: Eva Steinle-Darling
Phone: 512-427-8118

Billing Address
Carollo Engineers
4600 East Washington Street, Suite 500
Phoenix, AZ 85034

Attn: Accounts Payable

# of Sample	Tests	Bottle Qty - Type [preservative information]	UN DOT #
10	@UCMR3 522 C	3 - 125ml amber glass [6.25 Sulfite +125 mg Bisulfite]	

Comments

SEE C.O.C

Include sampling instructions
Shipping
Include pre-paid sample return AB__________

Sampler:
Please follow 2-stage field preservation procedure for all sites regardless of presence of Chlorine residual. Sampling instructions were sent via EMail to John Burch.

Code	Status	Date Shipped	Via	Tracking #	# of Coolers	Prepared By

Eurofins Eaton Analytical
750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (626) 386-1101
1 800 566 LABS (1 800 566 5227)

Laboratory Comments
Report: 588854

Carollo Engineers, Inc.
Eva Steinle-Darling
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

The Comments Report may be blank if there are no comments for this report.

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Laboratory Hits
Report: 588854

Carollo Engineers, Inc.
Eva Steinle-Darling
8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759

Samples Received on:
05/20/2016 1130

Analyzed	Analyte	Sample ID	Result	Federal MCL	Units	MRL
	201605050669	**Influent**				
05/25/2016 17:41	1,4-Dioxane		0.29		ug/L	0.07
	201605050673	**RO Feed**				
05/25/2016 18:12	1,4-Dioxane		0.26		ug/L	0.07

SUMMARY OF POSITIVE DATA ONLY

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Austin, TX 78759

Samples Received on:
05/20/2016 1130

Prepared	Analyzed		QC Ref #	Method	Analyte	Result	Units	MRL	Dilution
Product Water (201605050667)							**Sampled on 05/19/2016 0930**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
5/24/2016	05/25/2016	17:27	913178	(EPA 522)	1,4-Dioxane	ND	ug/L	0.07	1
5/24/2016	05/25/2016	17:27	913178	(EPA 522)	Dioxane-d8	116	%		1
5/24/2016	05/25/2016	17:27	913178	(EPA 522)	THF-d8	77	%		1
Influent (201605050669)							**Sampled on 05/19/2016 1000**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
5/24/2016	05/25/2016	17:41	913178	(EPA 522)	1,4-Dioxane	0.29	ug/L	0.07	1
5/24/2016	05/25/2016	17:41	913178	(EPA 522)	Dioxane-d8	90	%		1
5/24/2016	05/25/2016	17:41	913178	(EPA 522)	THF-d8	88	%		1
AOP Feed (201605050671)							**Sampled on 05/19/2016 0940**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
5/24/2016	05/25/2016	17:57	913178	(EPA 522)	1,4-Dioxane	ND	ug/L	0.07	1
5/24/2016	05/25/2016	17:57	913178	(EPA 522)	Dioxane-d8	95	%		1
5/24/2016	05/25/2016	17:57	913178	(EPA 522)	THF-d8	87	%		1
RO Feed (201605050673)							**Sampled on 05/19/2016 0950**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
5/24/2016	05/25/2016	18:12	913178	(EPA 522)	1,4-Dioxane	0.26	ug/L	0.07	1
5/24/2016	05/25/2016	18:12	913178	(EPA 522)	Dioxane-d8	92	%		1
5/24/2016	05/25/2016	18:12	913178	(EPA 522)	THF-d8	96	%		1
Moss Creek Lake (201605050675)							**Sampled on 05/19/2016 1100**		
		EPA 522 - UCMR3 1,4-Dioxane by EPA 522							
5/24/2016	05/25/2016	18:27	913178	(EPA 522)	1,4-Dioxane	ND	ug/L	0.07	1
5/24/2016	05/25/2016	18:27	913178	(EPA 522)	Dioxane-d8	94	%		1
5/24/2016	05/25/2016	18:27	913178	(EPA 522)	THF-d8	85	%		1

Rounding on totals after summation.
(c) - indicates calculated results

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Laboratory
QC Summary: 588854

Carollo Engineers, Inc.

QC Ref # 913178 - UCMR3 1,4-Dioxane by EPA 522 **Analysis Date: 05/25/2016**

201605050667	Product Water	Analyzed by: JYH
201605050669	Influent	Analyzed by: JYH
201605050671	AOP Feed	Analyzed by: JYH
201605050673	RO Feed	Analyzed by: JYH
201605050675	Moss Creek Lake	Analyzed by: JYH

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Laboratory QC
Report: 588854

Carollo Engineers, Inc.

QC Type	Analyte	Native	Spiked	Recovered	Units	Yield (%)	Limits (%)	RPDLimit (%)	RPD%
QC Ref# 913178 - UCMR3 1,4-Dioxane by EPA 522 by EPA 522						**Analysis Date: 05/25/2016**			
CCCL	1,4-Dioxane		0.07	0.0720	ug/L	103	(50-150)		
CCCM	1,4-Dioxane		20	20.2	ug/L	101	(70-130)		
LCS1	1,4-Dioxane		20	20.9	ug/L	105	(70-130)		
MBLK	1,4-Dioxane			<0.023	ug/L				
MRL_CHK	1,4-Dioxane		0.07	0.0560	ug/L	80	(50-150)		
MS_201605250324	1,4-Dioxane	0.19	20	19.2	ug/L	95	(70-130)		
MSD_201605250324	1,4-Dioxane	0.19	20	20.1	ug/L	100	(70-130)	20	4.6
CCCL	Dioxane-d8			101	%	101	(70-130)		
CCCM	Dioxane-d8			100	%	100	(70-130)		
LCS1	Dioxane-d8			93.6	%	94	(70-130)		
MBLK	Dioxane-d8			95.5	%				
MRL_CHK	Dioxane-d8			100	%	100	(70-130)		
MS_201605250324	Dioxane-d8	96		92.4	%	92	(70-130)		
MSD_201605250324	Dioxane-d8	96		96.1	%	96	(70-130)		
CCCL	THF-d8			78.2	%	78	(50-150)		
CCCM	THF-d8			91.0	%	91	(50-150)		
LCS1	THF-d8			88.5	%	89	(50-150)		
MBLK	THF-d8			83.2	%				
MRL_CHK	THF-d8			83.7	%	84	(50-150)		
MS_201605250324	THF-d8	94		85.4	%	85	(50-150)		
MSD_201605250324	THF-d8	94		94.3	%	94	(50-150)		

Spike recovery is already corrected for native results.
Spikes which exceed Limits and Method Blanks with positive results are highlighted by Underlining.
Criteria for MS and Dup are advisory only, batch control is based on LCS. Criteria for duplicates are advisory only, unless otherwise specified in the method.
RPD not calculated for LCS2 when different a concentration than LCS1 is used.
RPD not calculated for Duplicates when the result is not five times the MRL (Minimum Reporting Level).
(S) - Indicates surrogate compound.
(I) - Indicates internal standard compound.

Appendix B

Test Protocol

Test Protocol for:

Testing Water Quality in a Municipal Wastewater Effluent Treating to Drinking Water Standards

FINAL

by

Eva Steinle-Darling, Ph.D., P.E.
Andrew Salveson, P.E.
Shane Trussell, Ph.D.
David Hokanson, Ph.D.

Texas Water Development Board

P.O. Box 13231, Capitol Station
Austin, Texas 78711-3231
January 2015

Texas Water Development Board

Contract # 1348321632

Testing Water Quality in a Municipal Wastewater Effluent Treating to Drinking Water Standard

Digitally signed by Eva Steinle-Darling
Contact Info: Carollo Engineers, Inc.
Date: 2017.02.09 11:26:55-06'00'

STATE OF TEXAS
EVA STEINLE-DARLING
113317
LICENSED
PROFESSIONAL ENGINEER

by:
Eva Steinle-Darling, Ph.D., P.E.
Andrew Salveson, P.E.
Carollo Engineers, Inc.

David Hokanson, Ph.D.
Shane Trussell, Ph.D.
Trussell Technologies, Inc.

FINAL
January 2015

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Appendix A	Letter from the Texas Commission on Environmental Quality with Permit Conditions for the Raw Water Production Facility
Appendix B	List of Trace Chemicals and Disinfection Byproducts for Analysis by the Southern Nevada Water Authority Laboratory
Appendix C	Sampling Protocols for Microbiological Parameters provided by BioVir Laboratories
Appendix D	Operation, Maintenance, and Handling Manual for Toray Reverse Osmosis Membranes
Appendix E	Colorado River Municipal Water District Exception Request Letter and Texas Commission on Environmental Quality Exception Approval Letter for operation outside normal operating conditions for the purpose of implementing this Protocol

1 Introduction

Across the country, successful indirect potable reuse (IPR) projects are now creating more than 100 million gallons per day of potable water; several have been doing it safely for nearly half a century with no ill effects on public health. These include the Orange County and West Basin Municipal Water Districts in California, the Upper Occoquan Service Authority in Virginia, the City of Scottsdale, Arizona, and El Paso Water Utilities in Texas.

Nationally and within Texas, in order to ensure water supply reliability, there is now a movement towards direct potable reuse (DPR). In May 2013 the Colorado River Municipal Water District (CRMWD or the District) began augmenting raw water supplies with advanced treated reclaimed water at the Raw Water Production Facility (RWPF) in Big Spring Texas. What makes DPR unique among potable reuse projects in the United States is the lack of an environmental buffer in the treatment scheme. The environmental buffer can provide a measure of treatment (e.g., filtration through the subsurface for a groundwater recharge program) and a measure of response time (e.g., monitoring wells in a groundwater basin between the point of injection and the point of extraction). In some cases, the environmental buffer has introduced additional contamination from agricultural, industrial, municipal, or natural environmental contaminants, depending upon the local conditions. For DPR, additional treatment and/or advanced monitoring and control must compensate for the environmental buffer. Elimination of the environmental buffer and subsequent treatment for drinking water can allow maximum water recovery and reduced costs (Leverenz et al. 2011).

With the implementation of the project at Big Spring, the subsequent implementation of the DPR project at Wichita Falls, DPR is now viewed as viable option to increase a community's water supply. The two main objectives of this study are (1) to increase the confidence in the safety and effectiveness of the treatment processes used at the CRMWD's RWPF at Big Spring for DPR applications through a detailed sampling campaign, and (2) to develop a rigorous framework for DPR system analysis, including new indicators and surrogates for improved DPR process monitoring at a reasonable cost. Both of these will support the further development of DPR projects as a viable water supply alternative across Texas and the nation.

1.1 Background

The CRMWD is a raw water provider serving nearly 500,000 customers in a 31-county service area in West Texas. It serves its three member cities, the Cities of Big Spring, Odessa, and Snyder, as well as other contract holders. A map of the District's service area and raw water supplies is shown in Figure 1. Historically, the District has relied heavily on surface water supplies from the three reservoirs it owns and operates on the Colorado River, Lake J.B. Thomas, E.V. Spence Reservoir, and O.H. Ivie Reservoir. These have a full combined capacity of 1,272 million acre-feet. The District also operates five well fields to supplement this source of supply. Due to periodic droughts that have (both historically and currently) reduced the stored volume of water in its reservoirs to a minimum, the District is developing additional sources of water. This includes the recently completed 50,000 acre-foot per year (AFY) capacity Ward County Well Field and the 1.7 million-gallon-per day (mgd) RWPF at Big Spring.

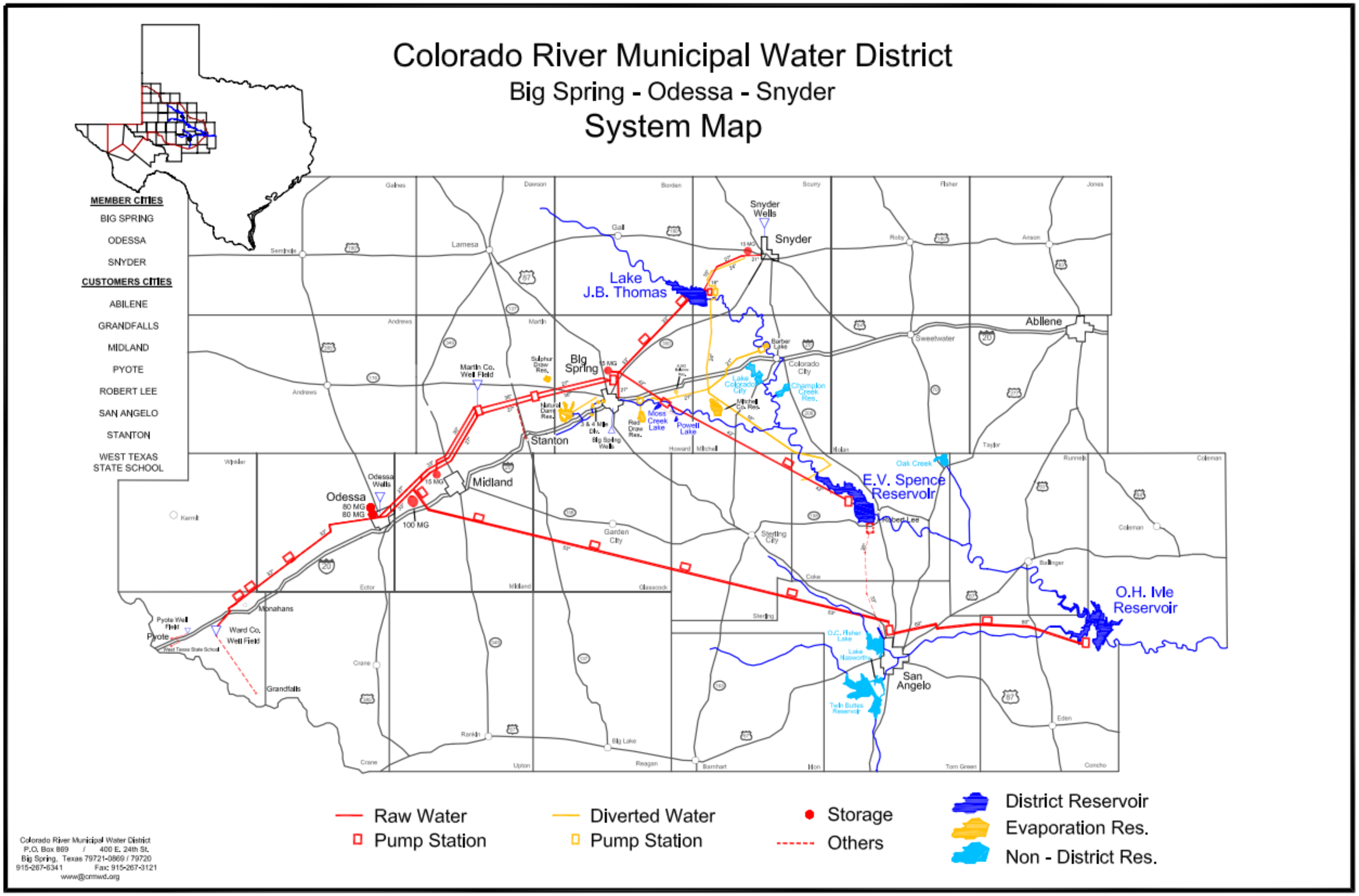

Figure 1 Colorado River Municipal Water District System Map (provided by CRMWD)

1.2 Raw Water Production Facility

The RWPF receives cloth media-filtered and chlorine-disinfected secondary effluent from the City of Big Spring's wastewater treatment plant (WWTP), This effluent is monitored for turbidity at the influent to the RWPF. Effluent that is less than 10 nephelometric turbidity units (NTU) is treated at the RWPF; if the WWTP effluent turbidity exceeds this value, it is returned to the WWTP. The treatment train for this facility includes microfiltration (MF), reverse osmosis (RO), and an advanced oxidation process (AOP) consisting of ultraviolet (UV) light with hydrogen peroxide (H_2O_2) addition. The RWPF is designed to produce slightly less than 2 mgd of raw water from a 2.5 mgd filtered secondary effluent feed flow, and was designed to be expandable to twice that capacity in the future.

1.2.1 Process Flow

A process flow diagram of the RWPF is shown in Figure 2. The facility consists of the following major pieces of equipment:

- Source water tank
- Diversion vault, where water is returned to the City of Big Spring WWTP if the influent turbidity is above 10 NTU
- 2 MF skids
- Break tank
- Low head transfer pumps to RO skids
- 2 RO skids, 2-stage (with high pressure feed pumps)
- UV with hydrogen peroxide addition, making an advanced oxidation process (AOP)
- Chemical storage and mixing tanks for chemically enhanced backwash cycles on MF and clean-in-place (CIP) procedures on the RO membranes

Backwash water from MF and CIP waste from RO is returned to the WWTP and RO concentrate is discharged to Beal's Creek. Finished water from RWPF is blended in the raw water pipeline coming from the E.V. Spence Reservoir such that the fraction of DPR water in the raw water is maximally 20%. Concentrate is discharged at the existing WWTP outfall, which flows into Beal's Creek.

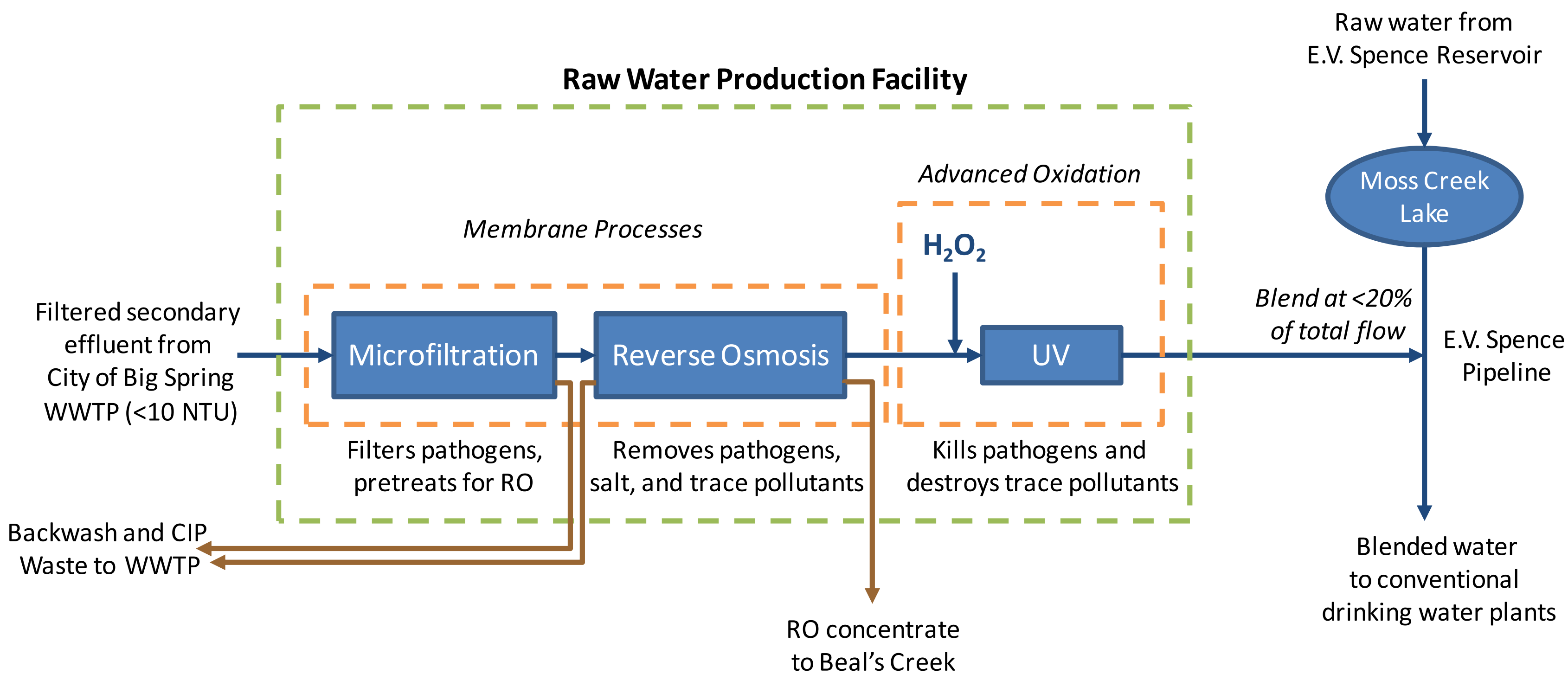

Figure 2 Simplified Process Flow Diagram of the Raw Water Production Facility

1.2.2 Microfiltration

The MF system consists of two Pall AP8 racks, each with 78 UNA-620A modules and 8 blank spaces for future expansion. It is designed for a 2.5 mgd feed flow and 2.38 mgd of net filtrate, an average flux of 29.2 gallons/square foot/day at 20^{o}C. The two racks are designed for duty operation, with no additional process redundancy. When one unit undergoes a backwash cycle, the other unit can be operated up to a maximum instantaneous flux of 38 gfd for a maximum rack flow rate of 1,107 gallons per minute (gpm), which equates to 1.6 mgd.

1.2.3 Reverse Osmosis

The RO system consists of two RO skids in a 24:12 array with 6 Toray TML20-400 elements per vessel. It is designed for a 2.38 mgd of feed flow, 10.5 gfd flux at 20^{o}C, a recovery of 75 percent (%), and a 1.782 mgd net RO permeate flow. The two RO skids are designed for continuous duty operation with no redundancy. During periodic cleaning events, the RO system production is reduced.

1.2.4 Advanced Oxidation

The advanced oxidation system is composed of two Trojan UVPhox 72AL75 UV reactors in series. Each reactor contains 72 lamps with a single UVFit intensity sensor on each reactor. This UV reactor was validated for Trojan by Carollo according to NWRI (2003) for a UV transmittance (UVT) range of 40.3% - 81.0% and a flow rate range of 0.73 to 7.39 mgd. The two UV reactors are designed for duty operation with no additional redundancy.

The validation listed above did not include testing on high UVT as would be seen at the RWPF (95%+). Thus, the dose of the system can only be estimated/extrapolated from the validated range listed above. Each reactor receives credit for 2-log virus inactivation at a design dose of 100 milli-Joule per centimeter squared (mJ/cm^2), which assumes a maximum 81% UVT. Given that the incoming UVT of RO permeate is expected to be much higher than the validated range (more than 99% based on recent measurements), the validation of the 72AL75 suggests that the actual UV fluence (delivered dose) in each reactor is much higher than 100 mJ/cm^2, which would result in a substantially higher virus inactivation potential as well.

It is our understanding that the sensors utilized for this reactor are designed for UVT values in the range of ~55% to ~75%, and may not have a working range sufficient to characterize the UV intensity of RO permeate (95%+). Testing as part of this project will determine if this is indeed the case.

1.2.5 Current Monitoring Requirements

The current required monitoring program for the RWPF is shown in Figure 3, which was obtained from the TCEQ. The monitoring program is also detailed in the Revised List of Permit Conditions (see Appendix A). The monitoring program contains a number of control points and shutdown conditions, which are described below:

1. Big Spring WWTP Effluent
   The RWPF only accepts the City of Big Spring effluent if it has turbidity of less than 10 NTU.

2. MF Units and Effluent
   The MF units must pass a daily integrity test. If they fail a test, they must be taken offline and repaired. In addition, an individual MF skid effluent turbidity higher than 0.15 NTU will trigger additional integrity tests. Turbidity is measured every 5 minutes.

3. RO Effluent
   The RO effluent (permeate) conductivity (or TDS) must be continuously monitored. If one value is 20% or 40 microSiemens higher than a previous reading, RO unit must be taken out of service.

4. UV AOP system
   The UV reactors must provide a continuous fluence of 100 mJ/cm^2 to achieve a minimum 2-log virus inactivation in each reactor. This must be measured by the internal UV sensors every five minutes. If the measured fluence falls below 100 mJ/cm^2 for more than four hours, the RWPF must be taken offline.

5. RWPF Finished Water
   Daily nitrate and nitrite samples must remain below 10.0 milligrams per liter (mg/L) and 1.0 mg/L respectively. If they exceed those thresholds, the blended water should be sampled. If the blended water exceeds the same thresholds, the RWPF is taken offline. Weekly E. *Coli* measurements must results in non-detects ("zero coliform forming units per liter (CFU/L)"), as a detection also results in facility shut-down.

Additional monitoring and reporting requirements are also included in the Revised List of Permit Conditions. In each case, any time a skid of process must be shut down, production at RWPF is either reduced by 50% (in the case of a single MF or RO skid shut-down) or stopped entirely (full MF, RO, and any UV shutdowns) until the issue is remedied.

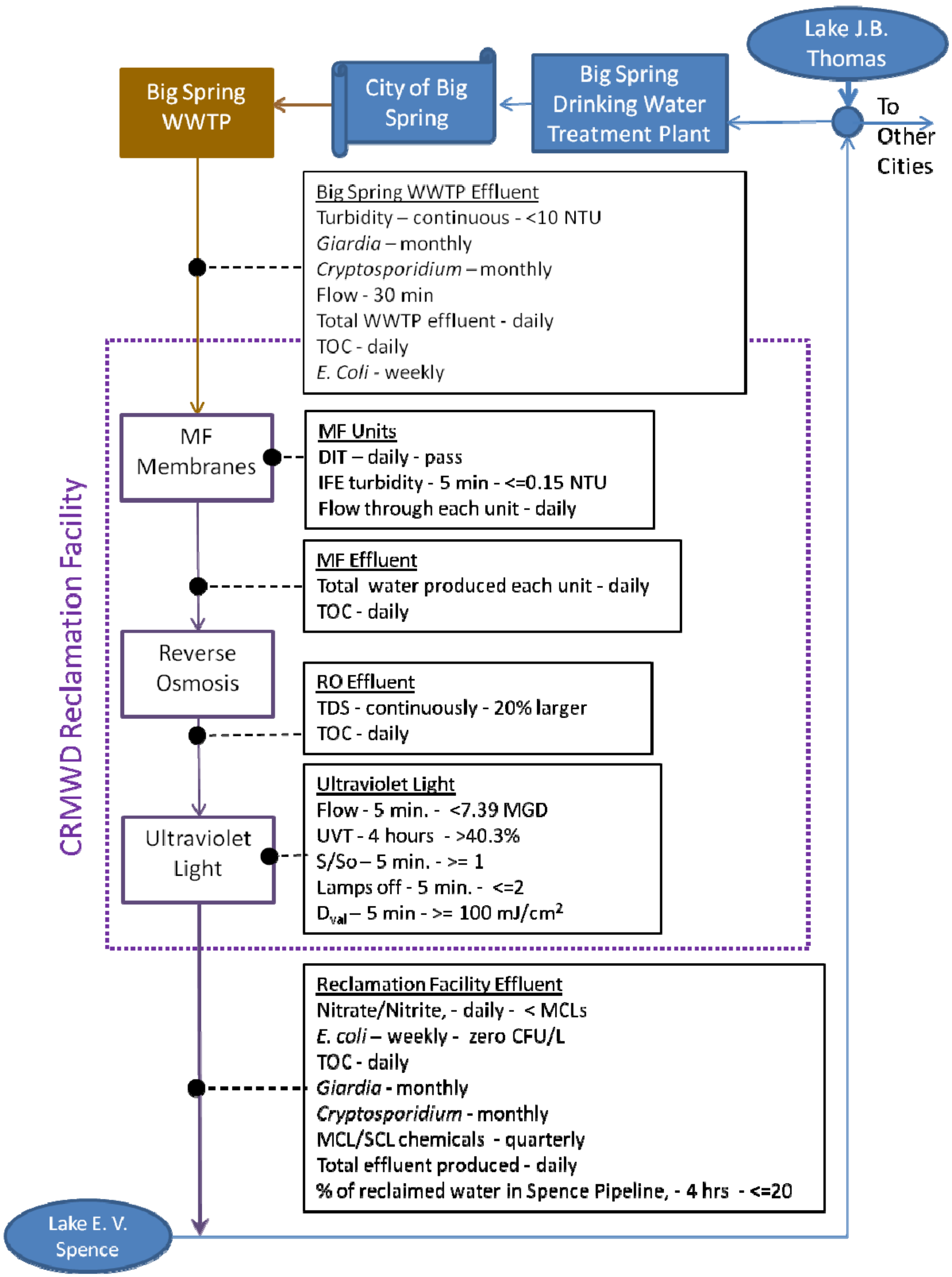

Figure 3 Required Monitoring for Raw Water Production Facility (graphic as provided by TCEQ)

1.3 Regulatory Summary

The State of Texas regulates water reuse through several methods, including the requirements for direct reuse (non-potable) described in Division 30 of the Texas Administrative Code, Chapter 210 (30 TAC 210) and 30 TAC 321 Subchapter P (satellite facilities), and indirect reuse through the Texas Water Code (TWC) Paragraph 11.042 governing bed and banks permits and TWC 11.046 governing return flows. The regulations for direct reuse include water quality requirement for Type I and Type II reclaimed water, which are both limited to non-potable uses, whereas the regulations governing indirect reuse do not include water quality requirements.

Faced with an extreme need for additional water supplies in parts of the state, TCEQ has been approving DPR projects, such as the RWPF on a case-by-case basis in accordance with the innovative / alternative treatment clause in 30 TAC 290 that allows "any treatment process that does not have specific design requirements" listed in that chapter to still be permitted. Project approval by TCEQ is based on validation data from operation of a pilot or "full scale verification." This second approval method allows treatment facilities to be approved for construction without completing a pilot study prior to design of the full-scale system. With a full-scale verification approach, which is the basis for the City of Wichita Falls DPR project, for example, the full-scale facilities are operated in "pilot mode" to collect the data necessary for final approval while finished water is sent to waste pending final approval by TCEQ to deliver water.

At Big Spring, the RWPF was permitted based on conventional pilot operation, although the UV/H_2O_2 process was not part of the pilot program. TCEQ permitted the project based on the inclusion of the three barriers now employed at RWPF (MF, RO, and UV/AOP). A log removal analysis revealed that the main pathogen of concern was virus, as the treatment for protozoa at the RWPF and the downstream WTPs together was more than adequate. Therefore, TCEQ required the UV/AOP system to achieve a minimum 4-log virus inactivation to supplement the existing 4-log credits given to each of the downstream surface water treatment plants for all three pathogen classes (see Appendix A for full permit conditions).

The most recent industry recommendations include pathogen control that achieves at minimum 12-log virus and 10-log protozoa (*Giardia* and *Cryptosporidium*), and 9-log removal or inactivation of total coliform. This was established by a panel of national experts convened by the National Water Research Institute in the context of WateReuse Research Foundation Project (WRRF) No.11-02, *Equivalency of Advanced Treatment Trains for Potable Reuse* (NWRI, 2013).

Note that unlike the requirements put forth by TCEQ, these log removal requirements include the full treatment cycle from raw wastewater to finished potable water, including primary, secondary, and tertiary wastewater treatment. Therefore, while the total log removal requirements put forth by TCEQ have lower numerical values (the 8-log virus removal required for the Big Spring, case, for example), TCEQ's approval process does not allow any treatment credits to be claimed at the wastewater treatment plant. In general, the stringency of the criteria developed for WRRF 11-02 and those applied by TCEQ appears to be similar.

2 Description of Test Parameters

2.1 Pathogens

Pathogenic microorganisms should be a particular focus for any DPR project because of their acute human health effects. Viruses require special attention because of their low infectious dose, small size, and resistance to certain types of disinfection. Small levels of pathogens in a drinking water source have the ability to cause immediate gastrointestinal illness and the potential to cause large-scale epidemics. This is in direct contrast to other contaminants such as salinity that can have a long-term detrimental impact on agriculture or industrial chemicals such as 1,4-dioxane that can have long-term human health impacts. Therefore, the primary public health concern in DPR applications should be protection from pathogens and this sampling protocol reflects this effort (National Research Council, 2012).

The following pathogens were selected for monitoring throughout the treatment train at the RWPF, representing each of the major microbial groups (viruses, bacteria, and protozoa) and they are all known to cause human health effects:

- Giardia and Cryptosporidium by EPA 1623
- Adenovirus (HAdv) by Jothikumar et al. (2005)
- *Escherichia coli* (E. *coli*) by Standard Method (SM) 9222
- Total coliform by SM 9223
- Norovirus and enterovirus by EPA 1615

The US EPA uses viruses, Giardia, and Cryptosporidium to develop regulations for drinking water[1] and have further been included in the California Department of Public Health (CDPH) Draft Regulations for Potable Reuse. E. *coli* and total coliform are found in the digestive tract of animals (including humans) and are commonly used as indicator organisms to determine the presence of other pathogenic bacteria. The combination of the monitoring of these pathogens provides for a good understanding of the effectiveness of the treatment process throughout the RWPF.

2.2 Constituents of Emerging Concern

Constituents of emerging concern (CECs), including pharmaceuticals, personal care products, and hormonally active agents, are present in secondary wastewater effluents. It is known from recent experience that the processes employed at the RWPF remove most of these constituents to below detectable levels at the nanograms per liter (ng/L)-level, though some trace pollutants have been known to pass through RO membranes. The levels of these trace pollutants in RO

---

[1] Viruses and Giardia are regulated under the 1989 Surface Water Treatment Rule (SWTR); additional requirements for *Cryptosporidium* removal were included in the 1998 Interim Enhanced Surface Water Treatment Rule (IESWTR), and both the Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rules (LT1ESWTR and LT2ESWTR).

permeate (as is the case for the RWPF), if they are detected at all, do not present a public health concern (National Research Council, 2012).

Substantial research has shown that *N*-nitrosodimethylamine (NDMA) can be formed during wastewater treatment. The primary process responsible for the formation is chloramination, which may be used during disinfection or pretreatment for RO[1]. Because RO is not as effective at removing NDMA as it is at removing most other CECs, many full advanced treatment (FAT) facilities typically apply a high dose of UV to photolyze the NDMA as a final treatment step (approximately 500 to 750 mJ/cm^2 vs. 50 mJ/cm^2 (NWRI, 2012) recommended for reclaimed water disinfection of RO effluent). The RWPF was modeled after the Groundwater Replenishment System (GWRS) at the Orange County Water District, which employs a high UV dose for NDMA reduction. The addition of hydrogen peroxide (H_2O_2) ahead of the high dose UV reactor results in advanced oxidation chemistry, as the UV light cleaves the H_2O_2, resulting in hydroxyl radical formation. These hydroxyl radicals then have the ability to destroy various trace organic compounds, such as 1,4-dioxane.

An expert panel convened by the National Water Research Institute (NWRI) for WRRF 11-02 recently issued a report that recommended a list of CECs that should be monitored in potable reuse projects based on criteria including (in order of decreasing preference, with EPA MCL the most preferred) the EPA MCL, World Health Organization Drinking Water Goal, State MCL, State provisional level (e.g., California NL), *de minimus* concentration, *de minimus* dose, medical benchmark, and *de minimus* benchmark from secondary source (NWRI, 2013).

The chemicals identified in WRRF 11-02 with these criteria include:

- disinfection byproducts (nitrosamines, including NDMA, haloacetic acids (HAAs) and total trihalomethanes (TTHMs))
- perfluorooctanoic acid (PFOA, per WRRF 11-02, transformation product of perfluorinated surfactants phased/phasing out of active use in the U.S.)
- perfluorooctane sulfonic acid (PFOS, per WRRF 11-02, transformation product of perfluorinated surfactants phased/phasing out of active use in the U.S.)
- perchlorate (naturally occurring chemical, degradation product of hypochlorite solutions, component of rocket fuel, and trace contaminant present in some fertilizers)
- 1,4-dioxane (stabilizer for chlorinated solvents);
- Steroid hormones, including ethinyl estradiol (synthetic estrogenic hormone, commonly used in oral contraceptives), and 17β-estradiol (natural estrogenic hormone);
- Pharmaceuticals in several categories:

---

[1] Chloramines are a necessary and proven method for minimizing biological fouling of the RO membranes, and are employed at similar RO treatment facilities nationally and internationally. The formation of NDMA is an unavoidable byproduct of chloramination, but can be minimized by the use of preformed chloramines and the avoidance of any dichloramine formation.

  - cotinine/primidone/dilantin (nicotine metabolite/anticonvulsant/anti-epileptic, surrogate low MW cyclics)
  - meprobamate/atenolol (mood stabilizer/beta blocker)
  - carbamazepine (anti-epileptic, unique structure)
  - estrone (estrogenic hormone, surrogate for steroids)
- Other Chemicals (chemicals of interest)
  - sucralose (ubiquitous artificial sweetener, surrogate for soluble uncharged compounds with moderate molecular weight)
  - *tris*(2-chloroethyl) phosphate (TCEP, flame retardant),
  - *N,N*-Diethyl-*meta*-toluamide (DEET, insect repellant), and
  - Triclosan (antiseptic in hand soap and toothpaste).

This testing protocol includes all but one of the recommended compounds (perchlorate), which is not a standard compound in CECs analysis lists. Including it would therefore represent a significant additional cost to the project that is not warranted given the limited information it would provide.

2.3 Indicators and Surrogates

In a general sense, both an indicator and a surrogate serve to assess the presence and removal of CECs and pathogens throughout a treatment process. An ***indicator*** is an individual compound or organism that represents a family of compounds or organisms with similar characteristics that are relevant to fate and transport during treatment. As stated by Drewes et al. (2008), an indicator "provides a conservative assessment of removal." A ***surrogate*** is a quantifiable physical or chemical property that can measure the performance of individual unit processes or operations in removing chemicals and/or pathogens and their indicators.

A number of indicators and one main surrogate are proposed for each treatment process as presented below.

2.3.1 Proposed Indicators

2.3.1.1 Total Coliform as an Indicator for Enteric Bacteria

As summarized by Trussell, *et al.* (2013), "in general, bacteria are considered less resistant pathogens compared to the viruses and protozoa [therefore] treatment that inactivates the more resistant viral and protozoan pathogens is assumed to also inactivate bacteria." Nonetheless, due to its general ubiquity of use as an indicator for (bacterial) pathogens, total coliform measurements are proposed to be included in this test plan as an indicator for enteric bacteria, such as *Salmonella* spp. In addition, *E. coli* samples will also be taken at select locations.

2.3.1.2 Cryptosporidium as an Indicator for Protozoa

Cryptosporidium will serve as an indicator for the effectiveness of protozoa removal through the MF process. As it is smaller than *Giardia*, the other protozoan of interest, the use of Cryptosporidium provides the more conservative approach.

2.3.1.3 MS-2 Bacteriophage as an Indicator for Viruses

MS-2 bacteriophage (MS2) is proposed as an indicator for virus removal. The main removal mechanism for virus is expected to occur through the RO and UV/AOP processes. The MS2 virus is smaller than most other viruses, including those of interest for DPR (enteric pathogenic viruses such as norovirus and adenovirus), which makes it a conservative indicator for RO performance. MS2 testing analysis will be performed for both indigenous and seeded organisms to best quantify removal performance.

There will be no (or extremely low) measureable virus, protozoa, or coliform in the RO permeate, so indigenous testing will not provide useful data. Seeding of MS2 ahead of the UV reactor, could be performed, but because of the high UV dose (estimated at >500 mJ/cm^2), all seeded MS2 will be destroyed. Further, the virus (and overall pathogen) reduction performance of UV as a function of dose is well quantified in the literature. For the RWPF, the remaining knowledge gap is the determination of dose delivery from the full-scale UV system. This determination and the use of a surrogate for continuous monitoring of UV dose are discussed in the surrogate section below.

2.3.1.4 NDMA and 1,4-dioxane as Indicators for Constituents of Emerging Concern

NDMA is anticipated to be found in the RO permeate at concentrations of 10 to 50 ng/L, based upon experience at other potable reuse facilities. NDMA is destroyed by UV photolysis, and has been shown to be independent of hydrogen peroxide (H_2O_2) addition (Carollo Engineers, 2013 and others). Demonstration of NDMA destruction by the full-scale UV reactor at the RWPF will allow an estimation of UV dose delivered and thus the ability to destroy other compounds by photolysis.

The addition of H_2O_2 to the UV reactor results in advanced oxidation chemistry, with the generation of hydroxyl radicals that can then destroy trace pollutants. There are two common surrogates for AOP effectiveness. Methyl-*tert*-butyl ether (MTBE), was originally investigated in the context of remediating gas station spills. The most commonly used indicator for advanced oxidation performance in reclaimed water applications is 1,4-dioxane, which is a difficult compound to oxidize and thus a conservative indicator of performance. However, its concentration in RO permeate is most likely too low to detect. Some potable reuse pilot studies have seeded 1,4-dioxane into the system for analysis, but that is not recommended here for this fully operational water production facility due to toxicity concerns with 1,4-dioxane. Because of these complications, bench-top UV AOP testing will be performed which will examine the destruction on indigenous NDMA and seeded 1,4-dioxane, as described in Section 4.4.2 of this protocol.

2.3.1.5 Fluorescence Emission Excitation Matrices as Indicators for Bulk Organic Load

Fluorescence spectroscopy can be used to generate fluorescence Emission Excitation Matrices (EEMs), colorful images that provide a tool for evaluating differences in organic matter between water sources, as well as changes resulting from treatments. These images are produced by plotting the changes in fluorescence intensity generated as an individual water sample is excited through a spectrum of light wavelengths (e.g., 240-470 nm), against the corresponding fluorescent emissions over a similar wavelength range (e.g., 280-580). EEM images are an especially useful visual metric for communicating water quality. Figure 4 gives an example of EEM images and how these evolve through a treatment process.

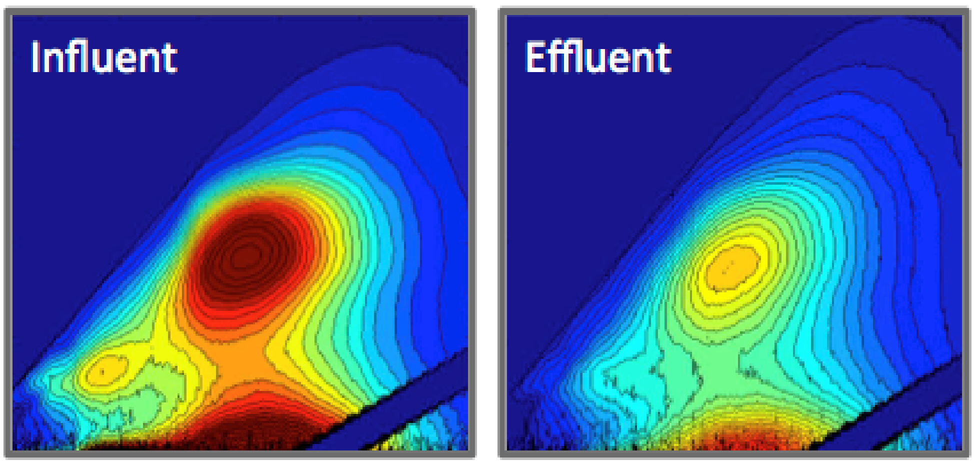

Figure 4 Emission Excitation Matrices images of wastewater before and after treatment

2.3.2 Bioassays as Indicators for Overall Biological Effects

Bioassays measure the biological impact of a sample instead of providing a list of chemicals that have been detected. These assays have the advantage of measuring the effect of what is in the water, which might be caused by unknown compounds. Three assays have been identified for inclusion in this test protocol: the Yeast Estrogen Screen (YES) or E-screen bioassay, total nitrosamine (TONO) assay and TOX assay. The YES assay serves to assess the removal of unidentified constituents that contribute to the estrogenic activity of the water as a whole. The two others will help assess the removal of unidentified nitrosamines and halogenated DBPs, respectively.

2.3.3 Proposed Surrogates

2.3.3.1 Particle Counting as a Surrogate for Protozoa Removal and Microfilter Integrity

MF does not, and should not, get credit for virus removal, as the pores in the MF membranes are too large to remove virus effectively when the membranes are not fouled. Testing of virus removal at the Dublin San Ramon Services District in 1998 and in 2006 (2006 testing documented in Linden et al., 2012) showed 2+ log removal of virus with new MF membranes in 1998 and zero log reduction of virus with older MF membranes in 2006. However, MF can and should get credit for bacteria and protozoa removal, as these pathogens are larger than the MF pores. Though appropriate for drinking water applications and currently accepted for indirect potable reuse applications, the current methods for membrane integrity monitoring, which are online turbidity and offline pressure decay tests, provide an insufficient level of accuracy and confidence for direct potable reuse applications. MF membrane effluent turbidity has not been shown to correlate with pathogen log reduction. Pressure decay tests do demonstrate membrane integrity (Reardon *et al.*, 2005, CDPH 2011), but only do so for one finite time period every day. Thus, there is no continuous and accurate online measurement of MF performance.

Tracking the reduction in particles in the appropriate size ranges allows for a better determination of true pathogen reduction performance (Linden *et al.*, 2012). Unlike a some other IPR facilities, automated online particle counters are not in use at the RWPF. However, Carollo will provide a bench-top particle counter for this project. Regarding online particle counters, our experience is that entrained air results in false positives (false detection of particles, (Sethi *et al.*, 2004)), whereas bench-top units, in which air can be allowed to leave the sample, are more accurate. A second method for daily analysis of MF performance is the documentation of total coliform removal across the MF, which is also included within this test protocol.

2.3.3.2 Trasar® Monitoring to Demonstrate Reverse Osmosis Process Integrity

TCEQ does not currently provide any log removal credits for the RO process. The CDPH will allow confirmation of direct RO integrity, and thus pathogen removal credit, with online measurements of electrical conductivity (EC) or total organic carbon (TOC), which can demonstrate between 1.5 to 2.0 log reduction of these parameters. However, these log reduction measurements can underestimate the removals achieved by the RO process because pathogens are significantly larger than the dissolved constituents that result in EC and TOC readings.

As there currently is no method used to demonstrate continuously greater than the 1.5 to 2.0 log reduction by RO, the testing plan includes investigation of the Trasar® molecule as an online surrogate for RO integrity. The Trasar® compound may be able to demonstrate 4-log or greater reduction of various pathogens by its removal and detection (due to size exclusion). Developed by the Nalco Company, the Trasar® tracer compound is an organic molecule that is an NSF-certified fluorescent dye and can be detected down to a level of 10 micrograms per liter (ug/L) with an online sensor. It is currently used as an additive in Nalco's antiscalants to allow for precise dosing in RO operations. By dosing the Trasar® compound to the RO feed at a concentration of up to 6-log higher than the detection limit and measuring its concentration in the feed, concentrate and permeate, the removal performance can be determined.

The molecular weight of the Trasar® molecule (614 grams per mole (g/mol)) is similar to trace organic compounds commonly found in wastewater and is large enough that it should not penetrate RO membranes (thus demonstrating up to 6-log removal), but is much smaller than enteric viruses (20-85 nanometer (nm) diameter) and should therefore act as a conservative surrogate for even the smallest of the pathogens of interest. A 2006 study of membrane integrity monitoring in Southern California demonstrated high removal (average log removal of 6.3) of

Trasar® using a two-stage RO system. However, these results have not been published or released to the public so there is no formal reference.

2.3.3.3 Chloramines Residual as a Surrogates for UV System Performance

Research conducted at the West Basin Municipal Water District in California has shown that chloramines are reduced through advanced oxidation in proportion to the destruction of different trace pollutants. The measured reduction in chloramines also correlates directly with dose delivery, which allows a determination of pathogen log reduction based upon a known UV dose.

As part of ongoing activities at the RWPF, chloramines addition ahead of RO is being implemented to reduce biofouling and will be completed ahead of this testing. Chloramines will pass through the RO membranes, and thus are available for measurement through the UV/H_2O_2 AOP. Therefore, the online monitoring of chloramines destruction can be used to correlate directly with pathogen and pollutant destruction. Figure 5 shows an example using chloramines as an indicator for NDMA destruction. This relationship has been shown in the presence and absence of hydrogen peroxide.

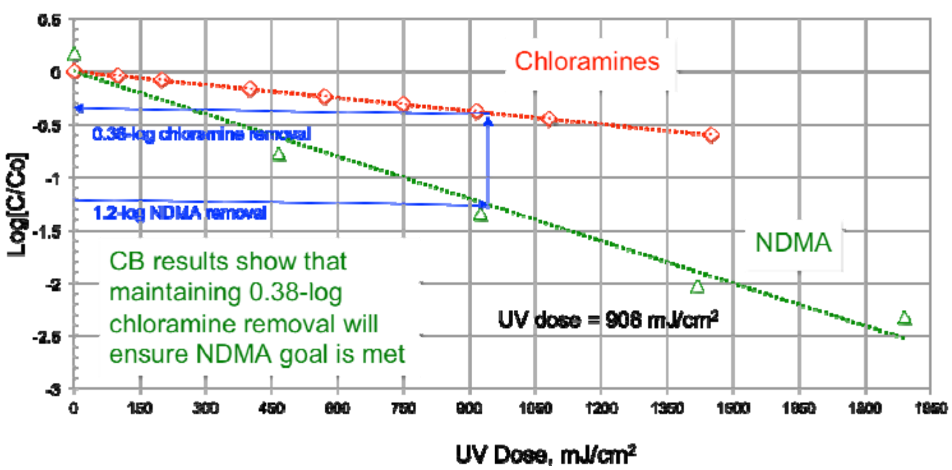

Figure 5 Using Chloramines as an Effective Surrogate for NDMA

3 Testing Plan

This section describes the proposed sampling and testing locations, as well as the testing schedule.

3.1 Testing Locations

The test locations are shown in numbered order on the process flow diagram in Figure 6 and also in the photos shown in Figure 7. The following six locations are proposed for sample collection:

1. RWPF influent - hose bib in influent sample panel
2. MF filtrate - collected directly after MF skids (2a) at the tap on the MF skid, or after the inter-process storage tank at the influent sample panel (2b)

3. RO permeate – tap on permeate collector tube
4. RO concentrate - tubing as shown in Figure 8
5. RWPF product water - hose bib after AOP
6. Raw surface water (used for blending) – Moss Creek Lake (not shown in Figure 6)

3.1.1 Raw Surface Water Sample Location

The surface water, with which RWPF product water is blended, is held in Moss Creek Lake, a small open reservoir upstream of the blending point. All water from the E.V. Spence pipeline enters this reservoir and is then pumped to Big Spring, from which is it sent to up to five different conventional surface water treatment plants operated by CRMWD customers, including the City of Big Spring. Moss Creek Lake is publicly accessible and samples of the surface water will be collected at this location. An attempt should be made to collect this sample from near the E.V. Spence pipeline intake.

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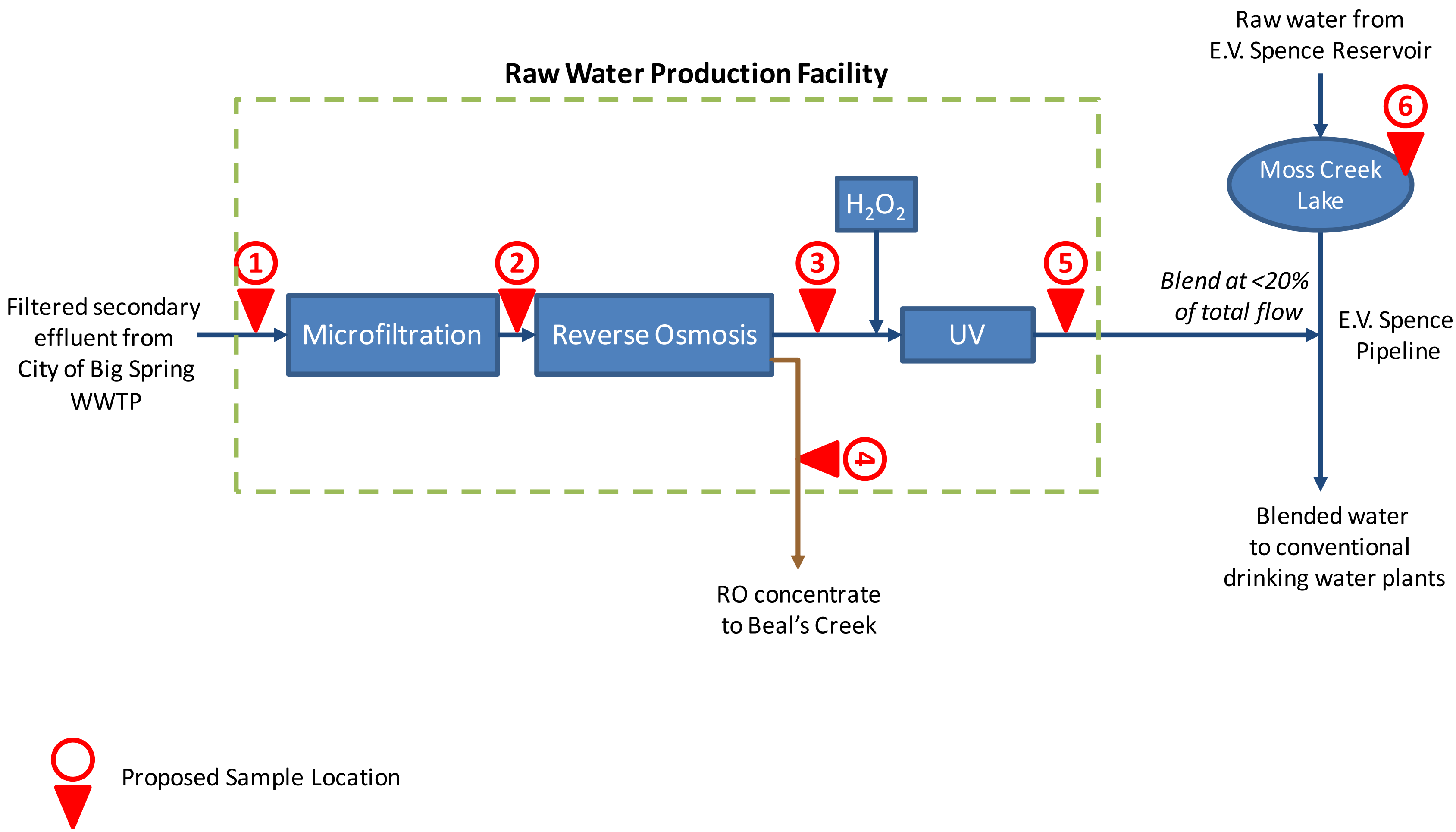

Figure 6 Proposed Sample Locations

Figure 7 Photos with numbered sample locations marked by white arrows.

3.2 Testing Schedule

The testing schedule for chemicals and microbiological constituents are summarized in Tables 1 and 2, respectively. Each table also contains the testing planned for indicators and surrogates of the respective primary parameters. Testing is planned to take place in a total of four events, with events capturing seasonal variability and spanning 2014 and 2015. As shown in Table 1, the second testing event (event #2) will include additional testing of the RO system, including seeded MS2 challenge testing, Trasar® validation and failure testing, and the collection of RO permeate for collimated beam testing as described in more detail in Sections 4.2, 4.3, and 4.4, respectively.

Note that some flexibility in the sample schedule will be needed in order to react to unforeseen operational constraints at RWPF. If certain samples or testing cannot be completed during the planned testing event, these will be made up during a subsequent quarter if possible. The project team will notify TWDB and CRMWD staff of any such changes.

Table 1 Chemical Test Plan by Sample Event

Parameter	**Sample Event**				**Locations**
	#1	**#2**	**#3**	**#4**	
Trace Chemicals[1]					
Pharmaceuticals	X				
Hormones	X				
Perfluorochemicals (PFCs)	X				All[2,3]
Nitrosamines	X	Reduced data set[2]			
Total Trihalomethanes (TTHMs)	X				
Haloacetic Acids (HAA5)	X				
Disinfection Byproduct (DBP) Formation Potentials (FPs)					
Trihalomethanes (THM) Formation Potentials (FPs)	X				
HAA FPs	X	Reduced data set[2]			All[2,3] except RO concentrate
Nitrosamine FPs	X				
Bioassays[4]					
Yeast Estrogen Screen (YES)	X				
Total Nitrosamines (TONO)	X	Reduced data set[2]			RWPF influent and product water
THM/HAA Toxicity (TOX)	X				
Chloramine Residual	X	X	X	X	MF filtrate and RO permeate
Excitation Emission Matrix (EEM)	X	Reduced data set[2]			All[2,3]
Collimated Beam	X				RO permeate
Trasar® Testing		X			MF filtrate and RO permeate

Table 1 Chemical Test Plan by Sample Event (continued)

Notes:

1. The full list of trace chemicals is provided in Table B1.
2. The sampling scope includes a full sets of samples (event #1), and a reduced set of samples (i.e., samples from fewer locations) for subsequent sample events. These will be determined based on the results of the first sampling event. For example, locations that show no detections for two consecutive quarters may not be tested again.
3. All locations include (1) RWPF influent, (2) MF filtrate, (3) RO permeate, (4) RO concentrate, (5) finished water, and (6) raw surface water.

Table 2 Microbiological Sampling Test Plan

Microbe or Surrogate	Location # / Method[1]	Number of Samples Collected in Testing Events 1/2/3/4[2]						Total Samples
		(1) RWPF Influent	(2) MF Filtrate	(3) RO Permeate	(4) RO Concentrate	(5) RWPF Product Water	(6) Raw Surface Water	
Giardia & Cryptosporidium	EPA 1623	3/1/1/3	3/3/0/0	3/3/0/0	0	1/1/1/1	3/3/0/0	30(22)[3]
PSD Analysis	Optical Particle Counter	4/4/4/4	4/4/4/4	0	0	0	0	32
MS2 (seeded)[4]	Double Agar Overlay (Adams, 1959)	0	0/4/0/0	0/12/0/0	0	0	0	16
MS2 (indigenous)	Double Agar Overlay (Adams, 1959)	0/2/0/0	0/2/0/0	0/2/0/0	0	0	0	6
Enteric virus[5]	EPA 1615	1/1/0/0	0[6]	2/0/0/0[7]	0	0	2/2/0/0	8
E. coli	SM9223	10/3/3/3	10/3/3/3	3/3/3/3	1/0/0/0	3/3/3/3	3/3/0/0	69
Total Coliform	SM9222	10/3/3/3	10/3/3/3	3/3/3/3	1/0/0/0	3/3/3/3	3/3/0/0	69

Notes:
1. All samples except Particle Size Disitribution (PSD), E. *coli*, and total coliform are anticipated to be analyzed by BioVir Laboratories. PSD samples are analyzed by Carollo. E. *coli* and total coliform samples are analyzed by City of Odessa laboratory.
2. Samples shown for the first testing event are those actually collected in July 2014. The samples for testing events 2 through 4 are anticipated and subject to revision depending on sample conditions. A fourth sample event will only be conducted if data gaps are identified that must be filled.
3. One sample from the RWPF influent and product water is collected and analyzed for *Cryptosporidium* and *Giardia* each month under a separate task of this project. The results of these additional samples will augment the matrix as shown above. This saves the research task a total of 8 sample analyses.
4. Male-specific 2 (MS2) bacteriophage samples will be seeded during challenge testing scheduled for the second testing event.
5. Virus samples are analyzed by a quantitative polymerase chain reaction (qPCR) method for genes specific norovirus and enterovirus. In addition, the EPA 1615 culture method is used to determine the total culturable virus concentrations.
6, The pressure available at the MF filtrate sample point is insufficient for field filtration for collection of virus samples, which were attempted for collection in July 2014. No additional virus samples are proposed for collection at this location.
7. Based on initial results from July 2014, which showed no detections of enteric virus in the RWPF influent or RO permeate, no additional samples of MF filtrate or RO permeate are proposed for indigenous enteric virus analysis. The absence of virus from the RWPF influent will be confirmed in the second sampling event.

4 Detailed Protocols

A large proportion of testing proposed in this test plan consists of collecting water samples at various locations throughout the RWPF for off-site analysis at the SNWA Laboratory (for the CECs listed in Table 1) and the other laboratories as listed in Table 2. General protocols for collection of the various samples are listed in Section 4.1, with reference, where needed, to the detailed instructions provided in Appendix B.

Three detailed sets of tests are proposed in this test plan:

1. MS2 challenge testing of the RO system (as listed in Table 2)
2. Trasar$^{(R)}$ validation testing (done simultaneously with MS2 challenge testing) on the RO system, and
3. Off-site collimated beam testing of RO permeate for verification of UV/AOP performance.

These sets of tests are described in Sections 4.2, 4.3 and 4.4, respectively.

4.1 Sample Collection Protocols

4.1.1 Trace Chemical Testing

Testing for trace chemicals (also called constituents of emerging concern, or CECs) can be challenging because the concentrations being measured are very small, and the parameters of interest are contained in products used by people everyday (coffee, sunscreens and lotions, antibacterial hand soap, Teflon liners, etc.). The key to collecting good samples for trace chemicals is to remember a key concept in your handling of personal protective equipment: Your goal is not only to protect yourself from the water sample ***but also to protect the water sample from you!***

General rules of thumb are summarized below:

- Wear only *new* latex or nylon gloves;
- Do not wear perfume, cologne, lotion, deodorant (yes!), sunscreen, insect repellant, or anything other than clothing.
- Label all sample containers ahead of time to avoid confusion (there will be many);
- Do not touch your face, bare skin, clothing, any food packaging (or much of anything else) with your gloves before sampling;
- Do not breathe on or near the samples;
- Collect the samples as directed in the appropriate containers (yes, both the type of lid liner and the color of the glass matter); and
- Start with the “cleanest” sample location (i.e., finished water) and progress backwards through the treatment train.

Detailed testing protocols for trace chemicals have been provided by SNWA and are enclosed in Appendix B.

4.1.2 Microbial Testing (Pathogen and Indicators)

The microbial samples and analysis methods include the following:

- *Giardia* and Cryptosporidium by EPA 1623
- *E. coli* by Standard Method 9223 as an indicator for enteric bacteria
- Total coliform by Standard Method 9222 as an indicator for enteric bacteria
- Adenovirus (HAdv) by Jothikumar *et al.* (2005)
- Norovirus and enterovirus by EPA 1615
- MS-2 bacteriophage (seeded and unseeded) by Adams (1959).

Given the low concentrations of pathogens and other microbial parameters expected during sampling at RWPF, similar general precautions are appropriate as described for trace chemical sampling, though pathogen contamination is less of a concern compared to trace chemical contamination. Detailed sample collection protocols for these parameters have been provided by BioVir Laboratories and are enclosed in Appendix C.

4.1.3 Other Testing

Particle Size Distribution Testing - Particle size distribution (PSD) samples will be used as a surrogate for *Cryptosporidium* and *Giardia* removal through MF. Samples from locations (1) and (2) will be collected in plastic bottles with a minimum volume of 500 mL and should be shipped overnight on ice to the Carollo laboratory in Sacramento, California.

Chloramines Residual - Chloramines residual will be tested as a surrogate of UV process efficacy during the collimated beam (CB) testing described in Section 4.4 and during full-scale testing. Field samples will also be collected from sample locations (3) and (5) and tested on-site for chloramines residual using simple colorimetric (e.g., HACH) test kits.

4.2 Reverse Osmosis Challenge Testing with MS-2 Bacteriophage

The purpose of RO challenge testing with MS2 is to demonstrate the ability of the membranes at RWPF to reduce virus concentrations, using MS2 as an indicator organism. The goal of this testing is to demonstrate the RO membranes capacity to remove viruses by up to 6-log. Bioassay testing will be conducted during this study by adding concentrated MS2 coliphage to the influent upstream of only one RO train.

Note that the other RO train must be valved off for the period of testing, which would reduce the production capacity of the RWPF during that time.

This testing is proposed for the second testing event, in conjunction with the Trasar® validation testing described in Section 4.3.

4.2.1 Background on MS2 Bacteriophage

The MS2 bacteriophage is virus that infects E. *coli* and other members of the *Enterobacteriaceae* family of gram negative bacteria (van Duin *et al.,* 2006). The MS2 viral particle is about 27 nm in diameter (Strauss *et al.* 1963) and has an isoelectric point of 3.9 (Dowd *et al.*, 1998) which means that it, like many other viruses, carries a negative surface charge at neutral pH.

MS2 is commonly used as an indicator species for human pathogens because it is commonly found in wastewater effluent, it is easy to measure and to seed, it its presence in water correlates with the presence of enteric viruses (Ventkatesan *et al.*, 2008) and its susceptibility to inactivation through UV and chemical disinfection relative to pathogenic viruses are known. The most critical characteristic of MS2 for use as an indicator species and treatment surrogate is that it is not a human pathogen. ***Therefore, MS2 does not represent a human health threat (Havelaar et al, 1990, Schijven et al, 1999).***

The seeding challenge test proposed for one RO train in this protocol involves seeding the MS2 at approximately 10^6 Plaque-Forming Units (PFU) per milliliter (mL). Downstream processes in place at RWPF (RO and UV) as well as the conventional surface water treatment plants are credited with 8-log virus removal (and it is generally recognized that significantly more removal or inactivation is taking place). This means the seeded MS2 (along with all background levels of MS2) will be removed to non-detectable levels well before entry of the water into the distribution system.

4.2.2 Determine MS-2 Bacteriophage Dose and Approximate Total Stock Volume Needed

In order to meet the 6-log removal goal demonstration, the upstream MS2 concentration must be at minimum 6-log higher than 1 (PFU/ml), which is the minimum sensitivity of the method for MS2 analysis. MS2 will be provided by BioVir in an 11-log stock solution (10^{11} PFU/mL), which is then placed in a large carboy, diluted sufficiently to allow better dosing control, and then dosed into the RO influent to attain an RO influent concentration of approximately 10^6 PFU/mL.

The total volume of MS2 stock needed depends on the volume within the RO skid, as proper testing requires a steady state condition. The total volume of one RO skid is estimated at approximately 1,296 gallons[1]. The amount of MS2 needed for any given test, for conservatism, is estimated based upon filling this hydraulic volume three times with the proper concentration of MS2.

For an internal volume of 1,296 gal at an influent flow rate of 0.75 mgd, the mean hydraulic residence time (HRT) would be 2.5 minutes, thus dosing of MS2 for 7.5 minutes prior to sampling should result in steady state conditions for proper analysis. Confirmation testing of the time to steady state conditions is detailed below.

4.2.3 Hydraulic Analysis to Determine Sample Timing

The final effort for determining the approximate total amount of MS2 needed for seeding will be refined on-site through the determination of exact sample timing. This refinement of the HRT will be performed using a tracer (likely food-grade table salt with monitoring of EC in the RO permeate). For the given flow rate, 0.75 mgd, the tracer plug will require a set amount of time to

[1] This is the estimated empty vessel volume in one skid, based on an approximate empty vessel volume of 6 gallons per 8" element provided in the Toray Operations and Maintenance Manual (Appendix D) multiplied by the number of elements in one skid (216).

reach the effluent sampling location. That time value, likely greater than 1 HRT, will become the minimum time between the start of MS2 seeding and the start of sampling.

4.2.4 MS-2 Bacteriophage Challenge Testing

For each bioassay test, one influent and three effluent samples will be collected from each sample location. MS2 will be introduced in the feed port using a gear pump at a feed flow rate of ~1 L/min. Sampling will begin after the passage of the appropriate amount of time (as calculated above) to ensure that the feed concentration of MS2 has equilibrated across the RO train.

Important note: Chloramines dosing must be turned off during the RO challenge testing with MS2, to minimize any disinfection resulting from chloramines addition. Total chloramines dosing system downtime will be minimal and should not affect biofouling control.

4.3 Trasar® Validation Testing

Trasar validation testing will be performed during the second testing event. The purpose of this testing is to validate the use of the Trasar technology as an appropriate surrogate for virus removal by RO membranes. A successful demonstration would result in a continuous, online confirmation of RO integrity with respect to virus removal (and thus the removal of all pathogens of concern).

This validation testing will be completed in conjunction with the MS2 challenge testing described above. Nalco will supply a custom-built Trasar$^{(R)}$ sensor unit for this testing. The Trasar$^{(R)}$ compound will be dosed upsteam of the RO train and concentrations will be measured in the feed, permeate, and concentrate of the RO train. These tests will be conducted as close to simultaneously with the MS2 challenge testing described above as possible.

An initial set of combined MS2 tests will be conducted on the existing membranes at the RWPF.

4.3.1 Failure Challenge Testing

The expectation for intact membranes is that all viruses and all Trasar$^{(R)}$ compound would be removed to non-detectable concentrations in the permeate. However, in order to validate Trasar® as a surrogate for RO membrane integrity, it must be proven to identify membrane failures. To simulate these conditions, two types of failure conditions are proposed, under which the concurrent MS2 and Trasar$^{(R)}$ challenge testing will be repeated:

1. ***Insertion of a deliberately cut o-ring in the connection between two RO membranes.*** This is likely to result in increased passage of Trasar® compound and MS2. The rapidity of the sensor unit response will provide assurance that, should such a significant breach occur, the Trasar® sensor would alarm immediately.

2. ***Temporary replacement of one existing membrane element with another that has been exposed to oxidizing conditions (provided by Orange County Water District).*** Oxidizing conditions are known to increase water flux and reduce salt rejection in RO membranes. Exposure to oxidizing conditions may result in membrane defects that will reduce virus

and Trasar® retention. The relative magnitude of this effect for MS2 and Trasar® will provide an indication of the compound's suitability as an integrity monitor.

Detailed procedures for correct handling and reassembly of membrane elements are provided in Appendix D.

4.4 Additional Testing for Advanced Oxidation Process Verification

4.4.1 UV Collimated Beam Test

In order to test the impact of UV in the treatment train, RO permeate will be collected at the same time as sampling during one of the chemical and surrogate testing days from the RWPF and shipped to the Trussell Technologies Laboratory in Pasadena, CA. Benchtop testing of UV/H_2O_2 will be conducted using a collimated beam (CB) test, and results will be correlated to full-scale NDMA and chloramines destruction to better determine the full-scale UV dose.

The sample will be exposed to a series of four low pressure (LP) UV lamps irradiating at a high fluence (dose) for a predefined amount of time. This will allow for a determination of the relative applied dose of the UV reactor, confirmation of the performance of the UV AOP, and development of the relationship between the UV AOP performance and potential surrogates. The CB exposure time is determined based on several factors, including distance from the center of the UV lamp to the base of the aperture, the petri factor, absorption coefficient, as well as the initial solution volume. The CB test apparatus at the Trussell Technologies Laboratory is depicted in Figure 8. Peroxide, at doses of 3, 5, and 10 mg/L, will be added prior to the start of UV exposure. The current peroxide dose applied at RWPF varies between 3 mg/L and 4 mg/L.

Figure 8 Collimated Beam Test for Advanced Oxidation Process testing

4.4.2 N-Nitrosodimethylamine (NDMA) and 1,4-dioxane Testing

The use of UV AOP is typically driven by the need to address recalcitrant compounds with small molecular weights that pass through RO. In order to test the removal of such compounds during benchtop CB testing, NDMA (indigenous) and 1,4-dioxane (seeded) will be used as indicator compounds. NDMA is destroyed via photolysis during UV exposure, whereas 1,4-dioxane removal is catalyzed by free radicals generated with H_2O_2 combined with the UV. Further, the bench-top destruction of NDMA will be correlated to measured UV dose values. NDMA destruction by the full-scale UV system can then be used to determine dose delivery in the full-scale UV system, and thus pathogen kill. The treatment conditions for CB testing are summarized in Table 4.

Table 4 Summary of Collimated Beam Test Plan

H_2O_2 Dose (mg/L)	**Chloramine Dose (mg/L as Cl_2)**	**UV fluence (mJ/cm^2)**	**Treatment Surrogates**
3,5, and 10	1,2, and 4	300, 650, and 1,000	Chloramines, UVA, nitrite

RO permeate samples will be tested with the CB at three UV exposures (300, 650, and 1000 mJ/cm^2) for each of the specified H_2O_2 doses (3, 5, and 10 mg/L) and UVT (ambient UVT, modified to obtain chloramine doses of 1, 2, and 4 mg/L as Cl_2). The 3 mg/L H_2O_2 dose represents the dose used by Orange County at their Groundwater Replenishment System and testing higher doses is recommended in order to evaluate an appropriate hydrogen peroxide dose to assure the demonstration of 0.5-log removal of 1,4-dioxane. Chloramine doses of 2, 4, and 6 mg/L as Cl_2 will be used to test the water with three different UVT levels, which can affect the performance of the UV AOP process. In addition, by the time this testing is started, chloramines will be added to the RWPF's RO feed to control biofouling on the membranes and this concentration may vary in future operations. Finally, chloramines can potentially be used as a treatment surrogate and understanding their relationship to the effectiveness of the UV AOP over a range of concentrations and water quality conditions is essential. Note that the use of chloramines decay as a surrogate measure of UV AOP effectiveness is predicated on sufficient passage of chloramines through the RO membranes, so this monitoring method may not be applicable in all advanced treatment systems.

Samples from the of RO permeate before and after CB testing will be collected and sent to an external laboratory, Eurofins Eaton Analytical Inc. (Eaton Analytical), to measure NDMA and 1,4-dioxane. The change in concentration from the initial and treated samples will be used to determine removal through UV AOP. The 1,4-dioxane testing will be performed on separate days form the NDMA testing. During 1,4-dioxane testing, the RO permeate will be spiked with 30 μg/L of 1,4-dioxane in order to have a sufficient concentration for demonstrating 0.5-log removal.

The CB testing apparatus can accommodate two crystallization dishes, each with a maximum test volume of 500 milliliters (mL), for simultaneous exposure to a given UV dose. Eurofins Analytical requires a minimum one liter (L) of sample for NDMA analysis and 125 mL for the analysis of 1,4-dioxane. In addition, each test will require approximately 200 mL for analysis of a suite of general water quality parameters. A summary of the testing parameters associated with UV AOP CB testing is provided in Table 5.

Table 5 Summary of Advanced Oxidation Process Water Quality Testing

Monitoring Parameter	Laboratory	Analytical Method or Instrument
NDMA (ng/L)	Eaton Analytical	EPA 521
1,4-dioxane (ng/L)	Eaton Analytical	EPA 522mod
Alkalinity (mg/L)	Trussell Tech lab	SM 2320 B
Chlorine, Total Residual (mg/L)	Trussell Tech lab	SM 4500-Cl G
Conductivity (uS/cm)	Trussell Tech lab	EPA 120.1
Hydrogen Peroxide (mg/L)	Trussell Tech lab	WRF-04-019 Titanium Oxalate Method
MS-2 Bacetriophage (PFU/mL)	Trussell Tech lab	SM 9224 C
Nitrate (mg/L)	Trussell Tech lab	SM 4500-NO_3^- E
Nitrite (mg/L)	Trussell Tech lab	SM 4500-NO_2^- B
pH	Trussell Tech lab	SM 4500-H+
Temperature (ºC)	Trussell Tech lab	SM 2550 B
Total Organic Carbon (mg/L)	Trussell Tech lab	SM 5310C
Turbidity (NTU)	Trussell Tech lab	EPA 180.1
UV Absorption (cm^{-1})	Trussell Tech lab	HACH DR 5000

NDMA and 1,4-dioxane samples from CB testing will be collected in bottles supplied by Eurofins Analytical, refrigerated, and then transported in a cooler with ice to Eurofins Analytical for analysis within the specified hold time.

4.4.3 UV Sensor Analysis

To better support the accurate operation of the UV system, sensor intensities will be collected over a range of UVT and power settings in the RO permeate. UVT may be suppressed to 95% to expand the sensor data set, pending approval to add a UVT modifier to the RO permeate. The goal of the testing is to determine if the sensors show sufficient sensitivity to changes in UVT and power. Sensor modifications, if necessary, will be recommended.

5 Quality Management

Quality management is an integral part of this study; the data collected on site will be used to verify the performance of the testing units. The analytical testing equipment will be calibrated and maintained as described in the section below. The analytical testing performed by the off-site laboratory will use the methods listed in the tables below.

5.1 Testing Quality Control

5.1.1 Calibration schedule

The calibration schedule for instruments used on-site at RWPF is presented in Table 6. Any contract laboratory used during this study will calibrate analytical laboratory equipment according to the applicable Environmental Protection Agency or Standard Method for each analysis. A quality control report will be included with the water quality data analysis.

Table 6 Instrument calibration schedule.

Instrument Frequenc	y	Method
Bench-top conductivity meters(1)	Every time sample is run	Verify with standard
Bench-top pH meters (1)	Every time sample is run	Verify with buffer
Field turbidity kits (1)	Every time sample is run	Verify with standard
Chemical feed pumps	3 per week	Check of tank volume versus hour meter on pilot plant

Notes:
1. Texas Commission on Environmental Quality 290.46 (s) indicates the frequency or verification method.

5.1.2 Water quality testing methods

A summary of basic water quality parameters and respective testing methodologies that may be used over the course of the study are presented in Table 7.

Table 7 Water quality monitoring parameters and methods.

Parameter Method	
General	
Temperature	SM 2550
pH	EPA 150.1
Alkalinity	SM 2320
Turbidity	SM 2130
Total dissolved solids	SM 2540C
Conductivity	SM 2510

5.2 Health and Safety

As discussed in Sections 4.2 and 4.3, the MS2 solutions and the Trasar® compound to be used in testing are not hazardous. Additional on-site water quality tests, as listed in Table 5.2 may require small quantities (< 5L each) of other chemicals. All chemical usage on the testing site will be in accordance with the safety policies of the RWPF. Key items related to health and safety issues are summarized as follows:

1. Carollo will provide Material Safety Data Sheets for the chemicals brought on site.
2. Carollo will provide secondary containment for chemical storage containers.
3. Adequate lighting will be provided in the proposed site area for off-hours response.
4. The project site area will require use of safety glasses; however, hard hats will not be necessary.

5.2.1 Spill Control / Clean-up

All chemical (and MS2 solution) storage and dosing tanks that may be used on-site will be double contained. All product and waste stream spills from the testing units will be directed to an appropriate waste drain. The testing units have been designed to minimize the potential for major spills. However, in the unanticipated case of a large spill of solids or chemicals, Carollo will perform clean up.

5.3 Roles and Responsibilities

The following summarizes the roles and responsibilities of the project partners involved in the testing described in this protocol. Only staff from Carollo, Nalco, and TWDB are proposed to be onsite, with the remaining parties responsible only for off-site sample analyses, as follows:

Carollo:

- Coordinate all testing and sampling with CRMWD
- Discuss with and obtain approval of testing plan from CRMWD, TWDB and TCEQ
- Perform all on-site sampling, with the exception of monthly *Cryptosporidium* and *Giardia* samples collected for compliance with TCEQ monitoring program
- Perform MS2 challenge testing (event #2 only, see Section 4.2)
- Support Nalco with Trasar$^{(R)}$ validation & failure testing (event #2 only)
- Perform off-site analysis for particle size distribution at Sacramento laboratory (see Table 2, footnote 2)

Nalco:

- Attend pre-testing site visit (with Carollo staff)
- Install Trasar$^{(R)}$ detection unit (for event #2 only)
- Perform Trasar$^{(R)}$ validation and failure testing (event #2 only, see Section 4.3)

Trussell Technologies:

- Perform off-site collimated beam testing of RO permeate (event #2 only, see Section 4.4)

SNWA Laboratories:

- Perform off-site analysis of samples collected by Carollo at all testing events for chemical constituents listed in Tables 1 and B1

<u>BioVir Laboratories:</u>

- Perform off-site analysis of samples collected by Carollo in at all testing events for microbial parameters (see Table 2, footnote 2)

<u>City of Odessa Laboratories:</u>

- Perform off-site analysis of E. *Coli* and total coliform samples collected by Carollo in at all testing events, see Table 2, footnote 2)
-

<u>CRMWD:</u>

- Review, comment, and approval of this test protocol
- Update Carollo regarding operational status of RWPF that might affect testing schedule (for example, shut-downs, changes in operating procedures, changes in operational conditions or feed water quality)
- Schedule testing with Carollo at mutually acceptable times at approximately quarterly intervals
- Discuss Trasar$^{(R)}$ detection unit installation during pre-testing site visit with Carollo and Nalco (during Q1 testing)
- Install sample taps, where necessary, at locations discussed with Carollo and Nalco during pre-testing site visit (during Q1 testing)
- Provide access to RWPF during scheduled testing periods. If possible, allow after-hours access (especially during Q2 testing) to maximize testing that can be done within a limited testing time frame
- Collect monthly *Cryptosporidium* and *Giardia* samples collected for compliance with TCEQ monitoring program and submit results to TCEQ

<u>TWDB:</u>

- Review, comment, and approval of this test protocol
- May observe on-site testing during one or more testing events

<u>TCEQ:</u>

- Review, comment, and approval of this test protocol

5.3.1 Contact Information

The contact information for the project team members that may be present on-site at RWPF for testing is presented in Table 8.

Table 8 Contact Information for Project Team Members

Name Phone	Number	E-mail Address

Colorado River Municipal Water District		
Cole Walker,	(432) 267-6341 ext 324	cwalker@crmwd.org
John Womack,	(432) 267-6341 ext 305	jwomack@crmwd.org
Carollo Engineers		
Eva Steinle-Darling	(512) 427-8118	esd@carollo.com
Justin Sutherland	(512) 453-5383	jsutherland@carollo.com
Andrew Salveson	(925) 932-1710	asalveson@carollo.com
Hutch Musallam	(972) 239-9949	hmusallam@carollo.com
Nalco		
Seong Hoon Yoon	(630) 305-1675	syoon@nalco.com
Chris Morrison	(415) 497-1772	cmorrison@nalco.com
Texas Water Development Board		
Erika Mancha	(512) 463-7932	erika.mancha@twdb.texas.gov
Sanjeev Kalaswad	(512) 936-0838	sanjeev.kalaswad@twdb.texas.gov
Texas Commission on Environmental Quality		
Marlo Berg	(512) 239-6967	Marlo.Berg@tceq.texas.gov

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Appendix A

Letter from the Texas Commission on Environmental Quality with Permit Conditions for the Raw Water Production Facility

PWS/1140038/CO
PWS/0680002/CO
PWS/1140001/CO
PWS/1590001/CO
PWS/1650001/CO
PWS/2080001/CO

Texas Commission on Environmental Quality

Protecting Texas by Reducing and Preventing Pollution

April 11, 2013

Mr. David W. Sloan, P.E., BCEE
Freese and Nichols, Inc.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109

Subject: Revision to the Previously Granted Exception to Use Membrane-Treated Reclaimed Wastewater from the Big Spring Wastewater Treatment Plant as a Raw Water Source for Public Drinking Water Systems
Colorado River Municipal Water District - PWS ID No. 1140038
Howard County, Texas

CN602515967 RN105692891

Dear Mr. Sloan:

The Texas Commission on Environmental Quality (TCEQ) received your March 1, 2013 letter requesting review and changes in some of the conditions described in the TCEQ's November 30, 2010 letter approving an innovative raw water source. The Colorado River Municipal Water District (CRMWD) Big Spring Regional Water Reclamation Project (reclamation facility) had requested an exception to the requirements for the raw water source. The exception request proposed the use of City of Big Spring Wastewater Treatment Plant (WWTP) effluent treated at the CRMWD reclamation facility by hollow fiber (HF) microfiltration (MF) membranes followed by reverse osmosis (RO) membranes to be used as a raw water source for the City of Big Spring (PWS ID 1140001), City of Snyder (PWS ID 2080001), City of Odessa (PWS ID 0680002), City of Stanton (1590001), and City of Midland (PWS ID 1650001) surface water treatment plants (SWTPs).

The CRMWD correspondence contained requests that were not specified or are not consistent with the requirements and approvals addressed in the TCEQ's November 30, 2010 letter. The TCEQ has reevaluated the conditions of the approved exception for the reclamation facility because of the CRMWD's requests to:

- Use ultraviolet light (UV) in lieu of chlorine for viral control;
- Base membrane cleaning on the volume of water treated instead of on time in service;
- Gain approval of the HF MF membrane direct integrity test (DIT) parameters;
- Increase the allowed instantaneous ratio of CRMWD reclamation effluent to EV Spence water from 15% to 20%;
- Monitor key parameters instead of recording the amount of chemicals used daily;
- Gain clarification that field sampling methods are allowed for certain analyses; and
- Modify the total dissolved solids (TDS) monitoring requirements.

TCEQ recognizes the CRMWD reclamation facility will produce source water from wastewater effluent for public water systems. This constitutes direct potable reuse of wastewater effluent without an environmental buffer. Because of the knowledge gained while approving several direct potable reuse facilities, the TCEQ has modified the conditions under which the CRMWD reclamation facility can produce water. A summary of the changes is listed below. A complete list of all the conditions, both original (from the November 30, 2010 letter) and amended to address the March 1, 2013 request, is provided as Enclosure A.

Summary of Changes

- The requirement for a 1.0 milligram per liter (mg/L) free chlorine residual in the water received from the WWTP is replaced with a requirement for the reclamation facility to provide at least 4.0-log viral inactivation through UV disinfection. The reclamation facility may only claim 4.0-log viral inactivation credit when:
  - all of the permeate from the RO units is passing through a series of two modified Trojan UVPhox™ 72AL75 UV reactors;
  - the reactors are operating at validated flow rates;
  - the calculated validated dose (D_{val}) for each reactor is greater than or equal to 100 millijoules per square centimeter (mJ/cm^2) which is the dose required (D_{req}) for 2.0 log viral inactivation; and
  - no more than 2 of the 144 lamps are inoperative.

  Conversely, the reclamation facility may not claim 4.0-log viral inactivation credit when all of the permeate is not passing through both reactors, the reactors are not operating at validated flow rates, when the D_{val} for either reactor is lower than the D_{req}, or when more than 2 of the 144 lamps are inoperative (even if the D_{val} for each reactor is exceeding D_{req}).
- The conditions under which the MF membrane modules will need an enhanced maintenance clean are amended. We have based the cleaning frequency on the volume of water processed instead of the time in use, as requested.
- The requested DIT parameters for the facility are approved.

TABLE 1: DIT PARAMETERS FOR THE TWO HF MF MEMBRANE UNITS AT THE CRMWD RECLAMATION FACILITY (1)

Initial Test Pressure (P_{test}) (psi)	**Upper Control Limit (UCL)** (psi/min)	**Log Removal Credit (LRC)** (log)
25.0	0.07	4.0

(1) Based on the data and calculations shown in Enclosures A & B.

- The ratio of CRMWD reclamation facility water to raw surface water in the Spence raw water pipeline must remain at or below 20%. That ratio must be measured and recorded once every four hours. During periods of drought, TCEQ may reevaluate the ratio based on a written request from CRMWD.
- The TCEQ has reviewed the planned automated control system showing that all key parameters are measured, recorded, and that alarms and shut-down commands are in place when the key parameters reach the required levels. The CRMWD's central operation center is staffed at all times when the facility is producing water and an operator can be summoned to the CRMWD reclamation facility when an alarm is sounded. If the plant is shut-down it can only be re-started by an operator on site at the CRMWD reclamation facility. The conditions in which an operator must be present have been clarified. Additionally, the TCEQ has amended the letter to allow measurement of key parameters instead of direct measurement of the chemicals used during automated operation.

- The TCEQ encourages the use of field sampling to assure results are received in the timeliest fashion. Therefore, the conditions to use only methods available in 30 TAC §290.119 has been changed to allow the use of any reasonable field methods if approved by the TCEQ.
- The trigger level for shut down of the RO unit has been modified to incorporate a finite value of TDS.
- The TCEQ has received sample results from samples collected on January 31, 2013 from the CRMWD reclamation facility effluent. Based on those results, the TCEQ will require three additional quarterly sampling events for regulated minerals, metals and organic compounds for a total of one year of quarterly samples. The sampling frequency will be reevaluated based on sample results after receipt of four consecutive quarterly samples.
- A DIT must be performed daily for each HF MF membrane unit instead of every seven days. This is consistent with EPA's Long Term 2 Enhanced Surface Water Treatment (LT2) Rule. The LT2 rule requires DITs every day for systems using sources with elevated pathogen levels. Wastewater has elevated pathogen levels, and thus will require daily DITs.
- The nitrate and nitrite levels in the combined CRMWD effluent and raw water pipeline must remain below 10 milligrams/liter (mg/L) and 1.0 mg/L respectively. These are the maximum contaminant levels for nitrate and nitrite in drinking water. Nitrate and nitrite have acute health effects. The nitrate and nitrite levels must be measured and recorded daily.
- The *Cryptosporidium,* and *Giardia* concentrations in the WWTP effluent and CRMWD reclamation facility's effluent must be measured once a month for 2 years. The CRMWD effluent sampling must begin when the CRMWD reclamation facility is first placed in service. The WWTP effluent monitoring must begin when CRMWD secures funding or by September 30, 2013, whichever comes first. The TCEQ will evaluate the need for continued pathogen monitoring once the two years of data have been collected and reviewed.
- The *E. coli* concentrations (enumeration) in the WWTP effluent and the CRMWD reclamation facility's effluent must be measured once every seven days for two years. The TCEQ will evaluate the need for continued pathogen monitoring once the two years of data have been collected and reviewed.
- The total organic carbon (TOC) in the WWTP effluent, RO feed water, RO permeate, and CRMWD reclamation facility effluent must be measured and recorded once per weekday for at least one month. At the end of the month, the TCEQ will review the results and determine a final monitoring schedule for TOC.
- The Texas Pollutant Discharge Elimination System (TPDES) and 30 TAC 210 permits of the Big Spring WWTP must be current.
- The TCEQ has added a recommendation that the facility inform the receiving public water systems (PWS) and the TCEQ if the CRMWD reclamation facility is shut down since this could result in less water being sent to the receiving PWSs.
- The CRMWD reclamation facility's operations and maintenance manual must contain the communications plan with local health officials and the procedures and contact information for contacting the TCEQ and the receiving PWSs. A copy must be maintained at the CRMWD reclamation facility.

- The CRMWD reclamation facility must submit monthly reports to TCEQ using the TCEQ's specified reporting formats when a customized form is made available. Since the November 10, 2010 response letter was written, the TCEQ's reporting form has been updated to include MF membrane units and UV reactors. The TCEQ will further assist CRMWD by customizing the form for its specific needs. Until TCEQ provides the customized form, a form created by CRMWD containing all the items required to be reported in Enclosure A may be used. This temporary form must be submitted to the TCEQ by the tenth day of the month following the end of the reporting period.
- The calibration, reporting, and record keeping requirements have been modified to incorporate the above changes.
- The TCEQ recommends that CRMWD monitor the untreated WWTP's effluent, and the CRMWD reclamation facility's effluent for the potential chemical and microbiological contaminants of concern on a quarterly basis.

Please see Enclosure A for a complete list of the amended conditions for the CRMWD reclamation facility. If you have any questions or need further assistance, please contact Ms. Marlo Wanielista Berg, P.E. of my staff at marlo.berg@tceq.texas.gov, or at (512) 239-6967.

Sincerely,

Marlo Wanielista Berg, P.E.,
Technical Review and Oversight Team
Plan and Technical Review Section
Water Supply Division
Texas Commission on Environmental Quality

Linda Brookins

Linda Brookins, Director
Water Supply Division
Office of Water
Texas Commission on Environmental Quality

Enclosure A: CRWMD Big Spring Reclamation Facility List of Conditions
Enclosure B: DIT Worksheet
Enclosure C: Comparison of CRMWD Reclamation Facility and Spence Reservoir Sample Results
Enclosure D: Unregulated Contaminants of Concern

LB/mew

cc: Mr. John Grant, General Manager, Colorado River Municipal Water District, PO Box 869, Big Spring, TX 79721- 0869
Mr. Jim R. Purcell, Colorado River Municipal Water District, PO Box 869, Big Spring, TX 79721- 0869
The Honorable Tommy Duncan, Mayor, City of Big Spring, 310 Nolan Street, Big Spring, TX 79720-2657
Mr. Tony Modisette, City of Big Spring, 310 Nolan Street, Big Spring, TX 79720-2657
The Honorable Terry Martin, Mayor, City of Snyder, PO Box 1341, Snyder, TX 79550-1341
Mr. Chris Woodard, City of Snyder, PO Box 1341, Snyder, TX 79550-1341
The Honorable W. Wesley Perry, Mayor, City of Midland, PO Box 1152, Midland, TX 79702-1152
Mr. Stuart T. Purvis, City of Midland, PO Box 1152, Midland, TX 79702-1152
The Honorable David Turner, Mayor, City of Odessa, PO Box 4398, Odessa, TX 79760-4398
The Honorable Justin Burch, Mayor, City of Stanton, PO Box 370, Stanton, TX 79782-0370
Mr. Jessie Montez, City of Stanton, PO Box 370, Stanton, TX 79782-0370
TCEQ Midland Regional Office – R7
Ms. Vera Poe, P.E., Team Leader, Utilities Technical Review Team – MC159
Mr. Joel Klumpp, Team Leader, Technical Review and Oversight Team – MC159
Mr. Bob Patton, Section Manager, Public Drinking Water Section - MC155
Mr. Gary Chauvin, Team Leader, Drinking Water Quality Team - MC155
Ms. Jaya Zyman-Ponebshek, Assistant Director, Water Quality Division – MC145

Enclosure A
Revised List of Conditions, April 11, 2013
CRMWD Big Spring Reclamation Facility

The following list of conditions replaces the conditions outlined in the November 30, 2010 Texas Commission on Environmental Quality (TCEQ) letter for the Colorado River Municipal Water District (CRMWD) Big Spring Regional Water Reclamation Project (reclamation facility).

The proposed project's purpose is to supplement the raw source water received for drinking water treatment at the City of Big Spring (PWS ID 1140001), City of Snyder (PWS ID 2080001), City of Odessa (PWS ID 0680002), City of Stanton (1590001), and the City of Midland (PWS ID 1650001) surface water treatment plants (SWTPs). The current raw water sources for these systems are provided by the CRMWD through a series of regional raw water pipelines from groundwater and surface water sources. At this time, raw surface water can be delivered through these interconnected raw water pipelines from several groundwater well fields, OH Ivie Reservoir, EV Spence Reservoir, and Lake JB Thomas to each of the above public water systems (PWSs).

The project would supplement the raw groundwater and surface water sources by introducing treated reclaimed wastewater effluent as an alternate raw source water. The alternate source water will be carried by the pipeline from the EV Spence Reservoir to the City of Big Spring's SWTP and other CRMWD raw water pipelines, allowing the blended alternate raw water source and raw surface water to be further distributed to the other four SWTPs for additional treatment. Up to twenty percent of the EV Spence Reservoir pipeline water will be made up of the reclaimed wastewater treatment plant effluent (WWTP). The CRMWD reclamation facility will take the effluent from the Big Spring WWTP, treat it with hollow fiber (HF) microfiltration (MF) membranes, reverse osmosis (RO) and advanced oxidation with ultraviolet light (UV) and hydrogen peroxide before the CRMWD reclamation facility's effluent is discharged into the EV Spence Reservoir raw water pipeline.

This enclosure includes the minimum site-specific requirements for the granted exception for the proposed direct potable reuse (DPR) of WWTP effluent as a raw water source for human consumption. Additionally, this enclosure sets the minimum design, operation, reporting, calibration and record keeping requirements for the CRMWD reclamation facility as an alternative source of raw water for PWSs. The requirements in this document supersede all previously stated conditions for this exception request to use an alternate raw water source other than groundwater or surface water to be treated for human consumption.

Title 30 Texas Administrative Code (30 TAC) Chapter 290, Subchapters D, E, and F rules apply to all PWSs. The CRMWD reclamation facility will produce a new alternate raw water source for other PWSs. However, requirements for treatment and distribution of drinking water found in Subchapters D, E and F are not applicable. The following conditions are TCEQ site-specific minimum operation, design, reporting, calibration, and record keeping requirements for the proposed innovative integrated membrane CRMWD reclamation facility which will produce an alternate raw water source for PWSs and are based on the pilot study data supplied.

Operational Requirements

1. The CRMWD reclamation facility may only discharge source water into the CRMWD EV Spence Reservoir raw water pipeline when all of the following conditions have been met. Except when notice is required, it is recommended that the facility inform the receiving PWSs and the TCEQ if the CRMWD reclamation facility, or a

treatment process such as a membrane unit, must be taken offline because this can result in less water being sent to the receiving PWSs. The conditions are:

a. The WWTP effluent turbidity is below 10 Nephelometric Turbidity Units (NTU). If the WWTP effluent turbidity level is above 10 NTU the water from the WWTP must not enter the CRMWD reclamation facility. As described in the Freese and Nichols, Inc. pilot study report on page 30, turbidity levels above 10 NTU may cause performance issues with the HF MF membranes.
b. The HF MF membrane units have passed the most recent direct integrity test (DIT). All DITs must be conducted using a sensitivity of 4.0-log and a resolution capable of detecting a 3.0 micron breach using the parameters approved by TCEQ and shown in Table 1 of Item No. 3 below. If a HF MF membrane unit fails a DIT, it must be taken off line, inspected and, if necessary, repaired. The HF MF membrane unit cannot be returned to service until the inspection and any needed maintenance have been performed and the unit passes a subsequent DIT. The pilot study HF MF membrane test units with a DIT sensitivity of 4.0-log removal produced water with the same levels (non-detectable) of *Cryptosporidium* oocysts and *Giardia* cysts as those found in the CRMWD EV Spence Reservoir raw water pipeline.
c. The ratio of CRMWD reclamation facility water effluent to raw EV Spence Reservoir water is at or below 20%. If at any time the ratio is found to be above 20% the facility must be taken off line until the ratio can be returned to 20% or less. During periods of drought, TCEQ may reevaluate the ratio based on a written request from CRMWD.
d. If conductivity or total dissolved solids levels of an RO unit's permeate increase by the larger of 20% or 40 microSiemens per centimeter (μS/cm) over the last reading then the RO unit must be removed from service, the problem repaired, and an acceptable conductivity or total dissolved solids achieved in the permeate before discharge to the CRMWD raw water pipeline can be resumed.
e. The nitrate and nitrite levels in the CRMWD reclamation facility effluent are below 10.0 mg/L and 1.0 mg/L respectively. If the sample results show the nitrate level to be above 10.0 mg/L or the nitrite level to be more than 1.0 mg/L then the facility must sample the blended raw and reclamation facility water in the EV Spence Reservoir raw water pipeline. If nitrate concentration of the blended water is over 10.0 mg/L for nitrate or 1.0 mg/L for nitrite, the plant must be taken off line, inspected, and, if necessary, repaired. Due to the acute health risk, CRMWD must notify the TCEQ and the receiving PWSs immediately after receipt of any results over 10.0 mg/L for nitrate and 1.0 mg/L for nitrite in the blended water.
f. The *E. coli* concentration levels in the reclamation facility effluent are zero (0) Colony Forming Units/Liter (CFU/L). If *E. coli* is present in the CRMWD reclamation facility effluent, the reclamation facility must be shut down, inspected and, if necessary, repaired. CRMWD must resample *E. coli* and receive a zero CFU/L concentration before the CRMWD reclamation facility can be returned to service.
g. All the water passes through each of the treatment units including the entire WWTP process, HF MF, RO, and advanced oxidation with UV light and hydrogen peroxide.
h. The reclamation facility must provide at least at least a 4.0-log inactivation of viruses through the use of UV light. If the CRMWD reclamation facility produces off-spec water for more than four (4) consecutive hours during a day, the facility

must be taken off line and the reactors must be inspected and, if necessary, repaired.

2. Item No. 1, above, contains the conditions under which the CRMWD reclamation facility, or a particular treatment process, must be shut down. If the CRMWD reclamation facility produces source water that does not meet the conditions in Item No. 1, the TCEQ and the receiving PWSs must be contacted within 24 hours by telephone at 1-888-777-3186 or by e-mail at pdws@tceq.state.tx.us. Within five working days, the CRMWD must submit written notification to:

TCEQ Technical Review and Oversight Team (MC 159)
P.O. Box 13087
Austin, TX 78711-3087

The written notification must include:

a. The problem that required:
    i. The WWTP Effluent to be returned to the head of the WWTP; or
    ii. The CRMWD reclamation facility, or a particular treatment process, to be taken out of service;
b. The corrective actions taken;
c. The quantity and duration of any unacceptable water discharged to the CRMWD EV Spence Reservoir raw water pipeline; and
d. A list of the PWSs using the water at that time.

3. The CRMWD must conduct a DIT on each HF MF membrane unit to verify that the integrity of the HF MF membranes has not been compromised and the approved 4.0-log removal credit for *Cryptosporidium* oocysts and *Giardia* cysts is being continuously achieved. A DIT must be conducted on a HF membrane unit :

a. Once each day;
b. Before returning a HF MF membrane unit to service after failing an initial DIT and being repaired; and
c. After each clean-in-place (CIP) procedure.

4. The DIT must be conducted using a procedure approved by the TCEQ including resolution and sensitivity requirements. The DIT must show 4.0-log removal sensitivity.

TABLE 1: DIT PARAMETERS FOR THE TWO HF MF MEMBRANE UNITS AT THE CRMWD RECLAMATION FACILITY (1)

Initial Test Pressure (P_{test}) (psi)	**Upper Control Limit (UCL)** (psi/min)	**Log Removal Credit (LRC)** (log)
25.0	0.07	4.0

(1) Based on the data and calculations shown in Enclosure B.

5. The CRMWD reclamation facility must immediately conduct a DIT on any HF MF membrane unit that produces filtered water with a turbidity level above 0.15 NTU in two consecutive 5-minute readings.

6. Continuous indirect integrity monitoring of each HF MF membrane unit's filtrate turbidity levels must be conducted using the Hach Model FilterTrak method 10133, or an alternative acceptable to the TCEQ. The results must be recorded every five minutes.

7. All of the permeate from the RO units must pass through a series of two modified Trojan UVPhox™ 72AL75 UV reactors.

   a. Because the validation study was conducted on a Trojan UVFit™ 72AL75 reactor, the sensor in each of the UVPhox 72AL75 reactors must be replaced with the sensor used in the validated UVFit reactor. With the exception of the end caps on the UVPhox reactors, the parts, construction, and design of the modified UVPhox reactors must exactly match those of the validated UVFit reactor.

   b. Following the modification, the two reactors must meet the following specifications.

Number/Type of Lamps and Sleeves	72 Low Pressure, High Output (LPHO) lamps
Lamp Model and Part Number	Trojan UVPhox , P/N 794447-ORD (Lamp, GA64T6HE ANG)
Sleeve Model and Part Number	Trojan UVPhox P/N 793024 (Sleeve, QTZ 28x25x)
Number of UV Intensity Sensors	1
Sensor Model and Part Number	Trojan UVFit, PN 015389-PX-S-480N

   c. The reactor must be operated based on the validated conditions for the UVFit™ 72AL75 reactor, which are shown in the table below.

Validated UV Transmittance (UVT) Range	40.3 to 81.0 %*
Validated Flow Rate Range	0.73 to 7.39 MGD* (507 to 5,132 gpm)
Maximum Viral Inactivation Credit Allowed and its corresponding Required Validated Dose (D_{req})	2.0-log @ 100 millijoules per square centimeter (mJ/cm^2)

* The minimum validated flow and/or maximum validated UVT must be used in the calculation of Validated Dose.

d. The calculated Validated Dose for each reactor must be determined using the following equation.

$$D_{VAL} = \frac{RED_{CALC}}{VF} = \frac{10^A \times Q^B \times UVT^C \times \left(\frac{S}{S_O}\right)^D}{1.183}$$

Where:
D_{val} = the calculated Validated Dose, mJ/cm²;
RED_{calc} = the calculated Reduction Equivalent Dose, mJ/cm²;
VF = Validation Factor, unitless;
Q = flow rate, MGD
= 0.73 if the actual flow rate is less than 0.73 MGD, the minimum validated flow rate; or
= the actual flow rate through the reactor or 0.73 MGD, the minimum validated flow rate, whichever is greater;
UVT = percent UV transmittance of the water, %
= 81 if the actual UVT exceeds 81%, the maximum validated UVT;
= the actual UVT or 81%, the maximum validated transmittance, whichever is lower;
S = the (sensor's) UV intensity measured under actual operating conditions, milliwatts per square centimeter (mW/cm²)
= S_O if actual intensity reading exceeds S_O, the maximum validated sensor reading;
= the actual measured UV intensity or S_O, the maximum validated sensor reading, whichever is lower;
S_O = the corresponding UV intensity, in mW/cm2, with new lamps and sensor and without any fouling
= $1.0536 \times 10^{-5} \times UVT^{2.7691}$ mW/cm²; and
A, B, C, and D = the regression equation coefficients shown in November 2009 Validation Report for the TrojanUVFit 72AL75 reactor.

8. The UV facilities may only claim 4.0-log viral inactivation credit when all of the permeate from the RO units is passing through both UV reactors, the reactors are operating at less than 7.39 MGD and a UVT greater than 40.3%, the D_{val} for each reactor is greater than or equal to D_{req}, and no more than 2 of the 144 lamps are inoperative. Conversely, the UV facilities will not be providing 4.0-log viral inactivation when any of the permeate bypasses either reactor, when the reactors are not operating at validated flow rates, when the D_{val} for either reactor is lower than the D_{req}, or if more than 2 of the 144 lamps are inoperative (even if the D_{val} for each reactor exceeds D_{req}). When the CRMWD reclamation facility is not meeting the 4.0-log viral inactivation requirement, it is producing "off-spec" water.

9. The status of each lamp, UV sensor reading, flow rate, and D_{val} result for each reactor must be recorded at least once every 5 minutes so that the plant can determine:

a. The volume of permeate treated each day,
b. The volume of off-spec water produced each day,
c. The duration of each off-spec event, and
d. The percentage of off-spec water each month.

10. The accuracy of the UV sensor in each reactor must be checked against a reference sensor at least once each month. If the duty sensor does not read within 20% of the reference sensor, the D_{val} result must be corrected to compensate for the discrepancy until the duty sensor is recalibrated or replaced. After submitting 12 months of data, the CRMWD may propose an alternative verification frequency.

11. The UV transmittance (UVT) of the RO permeate must be recorded at least once every 4 hours. If an online UVT monitor is used, the accuracy of the online unit must be checked against a calibrated benchtop unit at least once each week. If the on-line analyzer reads more than 2%UVT higher than the benchtop monitor, the online sensor must be replaced or recalibrated. Until the error in the online UVT analyzer is corrected, the D_{val} result must be based on the results of the 4-hour benchtop readings or the maximum validated UVT, whichever is lower. After submitting 12 months of data, the CRMWD may propose an alternative verification frequency.

12. The flow to the HF MF membrane units must be monitored continuously and the results must be recorded every 30 minutes.

13. The performance of the individual RO units shall be continuously monitored by a conductivity meter or a total dissolved solids meter. The highest confirmed reading shall be recorded each day.

14. Data collected from on-line instruments may be recorded electronically by a SCADA system or on a strip chart recorder. The recorder must be designed so that the operator can accurately determine the value of the readings at the required monitoring interval for reporting.

15. If there is a failure in the continuous monitoring equipment, grab sampling must be conducted every four hours in lieu of continuous monitoring, but for no more than five working days following the failure of the equipment.

16. The ratio of CRMWD reclamation facility effluent to raw water in the EV Spence Reservoir raw water pipeline must be determined and recorded every four hours. The highest daily ratio must be reported on the monthly operating report.

17. The nitrate and nitrite levels must be measured and recorded once per day in the CRMWD reclamation facility effluent.

18. The total organic carbon (TOC) in the WWTP effluent, RO feed water, RO permeate, and CRMWD reclamation facility effluent must be temporarily measured and recorded once per weekday for at least one month. At the end of the month, the TCEQ will review the results and determine a final monitoring schedule for TOC.

19. For two years, *E. coli* enumeration must be performed and recorded once every seven days in the WWTP effluent and the CRMWD reclamation facility effluent. The monitoring frequency will be reevaluated at the end of two years.

20. Once the CRMWD reclamation facility is discharging effluent into the EV Spence Reservoir pipeline, Long Term 2 Enhanced Surface Water Treatment Rule (LT2) raw source water sampling must be performed on the alternative blended source water for all of the PWSs that have the potential to receive this alternative blended source water as described in 30 TAC §290.111(b). *Cryptosporidium* and *Giardia* sampling must be performed once a month for 2 years. *Cryptosporidium* analysis must be performed by a laboratory approved by EPA for *Cryptosporidium* analysis. *Giardia* analysis must be performed concurrently. The monitoring frequency will be reevaluated at the end of two years.

21. CRMWD must contact each of the PWSs that can receive the alternative source water from the CRMWD reclamation facility to notify them of the new source water monitoring requirement. CRMWD must also notify the Technical Review and Oversight Team (MC-159) in writing when the reclamation facility begins producing source water at:

    TCEQ Technical Review & Oversight Team (MC 159)
    P.O. Box 13087
    Austin, Texas 78711-3087

22. For two years, CRMWD must collect monthly samples for *Cryptosporidium* and *Giardia* in the WWTP effluent. The sampling is to begin as soon as CRMWD secures funding or by September 30, 2013 whichever is sooner. The monitoring frequency will be reevaluated at the end of two years. *Cryptosporidium* analysis must be performed by a laboratory approved by EPA for *Cryptosporidium* analysis. *Giardia* analysis must be performed concurrently.

23. All monitoring required as a condition of this exception must be conducted using methods that conform to the requirements of 30 TAC §290.119. If alternative methods are preferred, reasonable field methods can be approved by the TCEQ.

24. A plant operations manual that meets the requirements of 30 TAC §290.42(l) must be kept on site and must be made available to TCEQ staff upon request. The operations manual shall include the communication plan with local health officials of all receiving PWS. The manual shall also include the procedures and contact information for the TCEQ and the receiving PWSs.

25. A Class B surface water operator must be employed by the CRMWD reclamation facility. Class C surface water operators can operate the CRMWD reclamation facility if the Class B operator is on call. Operators having both a water and wastewater license may work in the CRMWD reclamation facility and Big Spring WWTP, but not during the same shift, to prevent the introduction of contaminants.

26. The CRMWD reclamation facility must have a Class C or higher Surface Water operator on site when CIP procedures are being conducted on the HF MF and RO membrane units, lab instruments and UV sensors are calibrated, any time UV

maintenance (lamp, sensor, sleeve or other replacements) occur, and to respond to alarms and shut-downs caused by the automated control system.

27. The TCEQ has received chemical analytical results of the CRMWD reclamation facilities' treated water as shown in Enclosure C. Based on these results, the TCEQ will require quarterly sampling for one year. The January 31, 2013 sample will be considered the first of the four samples. TCEQ will reevaluate the sample schedule after the end of one year. If during future sampling events, the chemical sample results are higher than the MCL for any constituent, the receiving PWSs may need to increase their sampling frequency.

28. Results of pilot study sampling showed an increase in total trihalomethane (TTHM) levels above those seen in the EV Spence Reservoir raw water pipeline. The CRMWD must notify all of the PWSs that have the potential to receive the CRMWD reclamation facility effluent as an alternative source water of the levels found so that the PWSs can assess the impact to their finished drinking water compliance.

29. TCEQ recommends that CRMWD disinfect newly constructed or repaired facilities and verify the effectiveness of the disinfection procedure in accordance with American Water Works Association (AWWA) regulations as described in 30 TAC §290.46(g) as practical.

30. The CRMWD reclamation facility HF MF membrane filtrate tank and the RO membrane permeate storage tank must be inspected annually by the facility's licensed water operators or a contract inspection service as described in 30 TAC §290.26(m).

31. All electrical wiring must be securely installed in compliance with local or national electrical codes.

32. The CRMWD reclamation facility must maintain internal procedures to notify TCEQ immediately if an emergency event would negatively impact the delivery of the alternative blended source water. A list of such events is located in 30 TAC §290.46(w)

33. All backflow prevention assemblies that are required by this enclosure shall be tested upon installation and then once every 12 months as described in 30 TAC §290.44(h)(4).

34. Comprehensive Compliance Investigations of the CRMWD reclamation facility will be conducted by TCEQ staff periodically to assure the conditions of this letter and enclosures are being met. The investigations will be conducted as part of a PWS investigation, not a wastewater investigation because the effluent of the CRMWD reclamation facility is being discharged into a pipeline, not a water body.

35. The Texas Pollutant Discharge Elimination System (TPDES) and 30 TAC 210 permits of the Big Spring WWTP must be current. For assistance, please contact TCEQ's Wastewater Permitting Section (MC 148) for information at (512) 239-2369.

36. The TCEQ recommends that CRMWD monitor the untreated WWTP's effluent, and the CRMWD reclamation facility's effluent for the potential chemical and microbiological contaminants of concern contained in Enclosure D: Unregulated Contaminants of Concern on a quarterly basis.

DESIGN REQUIREMENTS

37. Engineering specifications and drawings were submitted for the TCEQ review on January 14, 2011 and approved with conditions on March 14, 2011. Additional information on the UV facilities was submitted after the plans and specification were approved.

38. In the future, the CRMWD reclamation facility must notify TCEQ prior to making any change (increase or decrease) in production, treatment, storage, disinfection (disinfectant method/type used, application points, or monitoring points), replacement of membranes (MF or RO), blending ratio, or any additional treatment processes (such as corrosion control) as described in 30 TAC §290.39(j).

39. All waste discharge must be in accordance with federal and state requirements as described in 30 TAC §290.42(i). For assistance, please contact TCEQ's Wastewater Permitting Section (MC 148) for information required for the proper disposal of generated waste (such as RO membrane reject, CIP cleaning solutions, etc.) and any required discharge permit at (512) 239-2369.

40. A full-scale HF MF membrane system with Pall Microza® Model UNA-620A HF MF membrane modules (See the HF Membrane Details section for further details.) must be installed with the following design specifications:

   a. Pre-treatment facilities consisting of a 300 micron strainer;
   b. Pall Microza® Model UNA-620A HF MF membrane modules with the following specifications:
      i. A HF MF pressure membrane module six inches in diameter, approximately 80 inches (in) in length and containing polyvinylidene fluoride (PVDF) fibers with a total feed side surface area of 538-square feet (sf);
      ii. A membrane fiber nominal pore size of 0.1 microns;
      iii. Outside-to-inside flow mode with dead-end operation;
      iv. Allowable transmembrane pressure (TMP) operating range of 1 to 43.5 pounds per square-inch (psi);
      v. Allowable operating temperature range of 0° to 40° C;
      vi. A 1,000 mg/L chlorine tolerance; and
      vii. Manufacture's allowable feed water turbidity level spike of 600 NTU.
   c. Facilities to allow a filtrate duration of 20 minutes;
   d. Facilities for a backwash cycle procedure on each HF MF membrane unit every 20 minutes using a Simultaneous Air Scrubbing and Reverse Filtration (SASRF) procedure for 60 seconds followed by Forward Flush (FF) for 20 seconds;
   e. Facilities to conduct both a sodium hypochlorite and 1% citric acid enhanced filtrate maintenance (EFM) wash procedure utilizing RO permeate as make up water as needed. One EFM will be conducted once every 2.88 million gallons (MG) for a duration of 37 minutes;

f. Facilities to conduct a HF MF membrane unit chemical CIP procedure no less than once every 30 days for a duration of approximately six hours utilizing RO permeate as makeup water;
g. Facilities to provide an average instantaneous filtrate flux rate of 37.2 gallons per square-foot per day (gfd) (temperature corrected to 20° C);

41. A full-scale RO membrane system of Toray TML 10 RO elements, or another TCEQ acceptable Toray element (see the RO Membrane Details section for further details) must be installed in pressure vessels arranged in a two-stage configuration with twice as many pressure vessels and elements in each Stage 1 as are in the corresponding Stage 2 (2:1 array) with the following specifications:

h. Toray TML 10 RO elements model with the following specifications:
   i. 4-inch diameter or if a larger Toray membrane is used, the elements must have the same leaf length as the pilot TML 10;
   ii. A leaf length of 40 inches;
   iii. An active membrane area of 75 sf;
   iv. Minimum salt rejection of 99%;
   v. Recovery rate of 75%;
   vi. Maximum operating temperature of 113° F;
   vii. Maximum allowed continuous free chlorine value of non-detectable;
   viii. An operating pH range of 2 to 11;
   ix. A pH cleaning range of 1 to 12;
   x. A maximum operating pressure of 600 psi;
   xi. A maximum pressure drop per element of 20 psi; and
   xii. A maximum silt density index (SDI) of 5.
i. Facilities for dechlorination of the water prior to the RO membrane units must be provided;
j. Facilities to assure complete dechlorination was achieved must be provided;
k. Facilities to feed sulfuric acid or another antiscalant for scale control must be provided;
l. Facilities for performing an RO membrane unit CIP procedure using both caustic and acid heated solutions; and
m. Facilities to achieve an average flux rate of 10.5 gfd.

42. Open tanks or basins at the CRMWD reclamation facility must be located at least 500 feet from any wastewater treatment units or lands irrigated with sewage effluent. The enclosed portion of the CRMWD reclamation facility must be located at least 150 feet from any wastewater treatment units or lands irrigated with sewage effluent.

43. The CRMWD reclamation facility shall be located at a site that is accessible by an all-weather road as described in 30 TAC §290.42(a)(3).

44. All water discharged to the CRMWD EV Spence Reservoir raw water pipeline must be treated by the HF MF and RO membrane units and the advanced oxidation (using UV and hydrogen peroxide) processes. This means, the CRMWD reclamation facility units must be designed to treat all of the WWTP effluent received. Blending of WWTP effluent with reclamation facility effluent is not approved.

45. No return of decanted water or solids to the beginning of the CRMWD reclamation facility is proposed. If recycle return is desired in the future, please contact the TCEQ Technical Review & Oversight Team (MC 159) at the following address:

    TCEQ Technical Review & Oversight Team (MC 159)
    P.O. Box 13087
    Austin, Texas 78711-3087

46. The CRMWD reclamation facility, including all filtrate and permeate storage tanks, shall be enclosed by an intruder-resistant fence as described in 30 TAC §290.38(37). The gates shall be locked during periods of darkness and when the plant is unattended.

47. Chemical storage facilities shall comply with the applicable requirements in 30 TAC §290.42(f)(1).

48. Chemical feed facilities shall comply with the applicable requirements in 30 TAC §290.42(f)(2).

49. Pipe galleries shall provide ample working room, good lighting, and good drainage provided by sloping floors, gutters, and sumps. Adequate ventilation to prevent condensation and to provide humidity control is also required as detailed in 30 TAC §290.42(d)(12).

50. The identification of piping shall be accomplished by the use of labels or various colors of paint as described in 30 TAC §290.42(d)(13).

51. Sanitary facilities for water works installations must be provided as described in 30 TAC §290.42(h).

52. The safety requirements of 30 TAC §290.42(k)(1) must be followed.

53. No cross-connection shall be permitted to exist between the WWTP effluent and the CRMWD reclamation facility effluent or any stage of prior treatment as described in 30 TAC §290.42(d)(2).

54. All reclaimed customer connections between the CRMWD reclamation facility and the CRMWD EV Spence Reservoir raw water pipeline shall be provided with backflow/backsiphonage protection to eliminate the possibility of chemical contamination and pathogen contamination as described in 30 TAC §290.44(h)(1)(A).

55. Separation distances between the CRMWD reclamation facility's effluent distribution/transmission piping and potable water piping shall be as specified in 30 TAC §290.44(e)(7).

56. Separation distances between the CRMWD reclamation facility's effluent distribution/transmission piping and wastewater collection mains and other potential sources of contamination shall be as described in 30 TAC §290.44(e)(7).

57. Sampling taps must be located after the CRMWD reclamation facility's source water (WWTP effluent) storage tank, on the HF MF membrane filtrate storage tanks' effluent, RO membrane permeate storage tanks' effluent and the CRMWD reclamation facility's discharge piping to the CRMWD EV Spence Reservoir raw water pipeline as described in 30 TAC §290.43(c) and §290.42(d)(14). These sample taps must be readily accessible to the plant operators and TCEQ representatives.

58. All treatment chemicals and media used in the full-scale facility must conform to American National Standard Institute/National Sanitation Foundation (ANSI/NSF) Standard 60 for direct additives and ANSI/NSF Standard 61 for indirect additives and be certified by an organization accredited by ANSI as described in 30 TAC §290.42(j). This includes dechlorination compounds, disinfectants, anti-scalants, acids, caustics and other membrane cleaning chemicals.

59. Flow measuring devices will be required on the WWTP effluent, the feed to each HF MF membrane unit, the HF MF membrane backwash supply, the combined HF MF membrane filtrate, RO concentrate, UV reactor influent stream(s), and the CRMWD reclamation facility discharge piping to the CRMWD EV Spence Reservoir raw water pipeline as described in 30 TAC §290.42(d)(5). The RO permeate flow rate may be calculated by subtracting the RO concentrate flow from the RO influent flow or by direct measurement.

60. The CRMWD reclamation facility must be designed to conduct and record continuous turbidity monitoring of the WWTP effluent.

61. The HF MF membrane system must be designed to conduct and record continuous indirect integrity monitoring on each HF MF membrane unit using the Hach FilterTrak method 10133, or an acceptable TCEQ alternative as described in 30 TAC §290.42(g)(3)(C).

62. The RO membrane system must be designed to conduct and record continuous conductivity or total dissolved solids on each RO membrane unit.

63. The HF MF and RO membrane systems must be designed so that the membrane units' feed water, filtrate, backwash supply, waste, and chemical cleaning piping shall have cross-connection protection to prevent chemicals from all chemical cleaning processes from contaminating other membrane units' filtrate and permeate in other modes of operations. This may be accomplished by the installation of a double block and bleed valving arrangement, a removable spool system, or other alternative method approved by the TCEQ.

64. The CRMWD reclamation facility's feed water must receive the same pretreatment, at a minimum, under full-scale operation as received during this pilot study. The treatment is provided at the Big Spring WWTP and is as follows: Raw wastewater is first screened and de-gritted, then flows to a primary clarifier. Primary effluent then proceeds to a single rock media trickling filter for biological stabilization and then is pumped to the aeration basin for additional biological treatment. The contents of the aeration basin flow to the final clarifier, where the active biomass is separated from the treated effluent and recycled to the aeration basin. The effluent is

chlorinated. The filtered effluent containing the chlorine residual was the source water for the pilot study.

65. The CRMWD reclamation facility must be designed to conduct and record the results of DITs as described in 30 TAC §290.42(g)(3)(B). The DIT values are calculated as described in the *DIT Resolution and LRV$_{DIT}$ Sensitivity Calculations* under the HF MF Membrane Details section.

66. An adequately equipped laboratory must be available so that daily tests such as disinfectant residual, UV transmittance, turbidity, pH, conductivity or total dissolved solids, and all other tests required by the conditions of this letter may be performed.

67. The water storage tank used to store CRMWD reclamation facility's effluent before it is sent to the CRMWD EV Spence Reservoir raw water pipeline must meet the requirements of 30 TAC §290.43(c).

CALIBRATION

68. Conductivity or dissolved solids meters used to monitor the RO membrane units' permeate shall be calibrated with solution of known concentrations at least once every 90 days.

69. Flow measuring devices and rate-of-flow controllers shall be calibrated at least once every 12 months. Magnetic flow meters shall be verified at least once every 12 months and calibrated if needed.

70. pH meters shall be properly calibrated as described in 30 TAC §290.46(s)(2)(A).

71. Turbidimeters shall be properly calibrated as described in 30 TAC §290.46(s)(2)(B).

72. Pressure monitors used for DIT measurements shall be calibrated or verified at least once every 12 months.

73. Instruments used to monitor nitrate and nitrite shall be calibrated or verified at least once every 12 months.

74. Instruments used to monitor TOC shall be calibrated or verified at least once every 12 months.

75. The accuracy of the UV sensor in each reactor must be checked against a reference sensor at least once each month for at least 12 months. If the duty sensor does not read within 20% of the reference sensor, the duty sensor must be recalibrated or replaced. After 12 months, the CRMWD may propose an alternative verification frequency.

76. If an online UVT monitor is used, the accuracy of the online unit must be checked against a calibrated benchtop unit at least once each week for at least 12 months. If the on-line analyzer reads more than 2%UVT higher than the benchtop monitor, the

online sensor must be replaced or recalibrated. After 12 months, the CRMWD may propose an alternative verification frequency.

REPORTING

77. The TCEQ will require the CRMWD reclamation facility to record the following:
   a. The highest daily confirmed turbidity in the WWTP's effluent;
   b. The daily maximum flow rates to each HF MF membrane units;
   c. Total water produced by each HF MF membrane unit each day;
   d. The total daily flow to the RO membrane units;
   e. The highest confirmed daily turbidity of each HF MF membrane unit;
   f. Any HF MF membrane unit DIT's starting test pressure and decay pressure rate in pounds per square inch per minute (psi/min);
   g. Any corrective actions taken, such as pinning, to correct a failed HF MF membrane DIT;
   h. Any CIP that has been performed on a HF MF or RO membrane unit;
   i. The daily highest confirmed conductivity or total dissolved solids for each RO membrane unit;
   j. The minimum validated UV dose (D_{val}) achieved each day in each UV reactor, the values of the parameters used to calculate the minimum D_{val}, the volume of off-spec water produced each day, the number of consecutive hours that the UV facility produced off-spec water each day, and the percentage of off-spec water produced each month;
   k. The amount of each chemical used per day, except for on weekends and holidays;
   l. The amount of WWTP effluent treated per day;
   m. The amount of water sent to the EV Spence Reservoir raw water pipeline per day;
   n. The daily maximum ratio of CRMWD reclamation facility effluent to raw water in the EV Spence Reservoir raw water pipeline;
   o. The nitrate and nitrite results found in the CRMWD reclamation facility effluent and if necessary the EV Spence Reservoir raw water pipeline each day;
   p. The weekly *E. coli* of the WWTP and CRMWD reclamation facility effluent;
   q. The daily TOC in the WWTP effluent, RO feed water, RO permeate, and CRMWD reclamation facility effluent each weekday for one month only; and
   r. Any *Cryptosporidium* or *Giardia* sample results received. .

78. The TCEQ will require the CRMWD reclamation facility to record the following:
   a. The dates that storage tanks and other facilities were cleaned and/or repaired; and
   b. The maintenance and/or replacement activities for the system equipment and facilities.

79. The CRMWD reclamation facility shall record the daily and monthly data required in the reporting section of this Enclosure using the most recent version of the Surface Water Monthly Operating Report (SWMOR-Alt, form number 00102D) and submit the form monthly to the TCEQ. The TCEQ shall customize this report for the facility. The facility can use a self-created form until the time TCEQ produces a customized report. The records must be completed in ink, typed, or computer printed and must be signed by a Class B Surface Water Operator

80. The CRMWD reclamation facility must submit the monthly operating reports and other reports listed in the reporting section of this enclosure to the TCEQ by the

tenth day of the month following the end of the reporting period. Send the reports to:

TCEQ Technical Review & Oversight Team (MC 159)
P.O. Box 13087
Austin, Texas 78711-3087

81. The TCEQ will require the reclaimed wastewater to be identified as a raw water source on the consumer confidence report (CCR) for any PWS using this water as a raw water source.

82. The CRMWD must report to TCEQ as described in Item No. 2. If the CRMWD reclamation facility produces source water that does not meet the conditions in Item No. 1, it must contact the TCEQ within 24 hours by telephone at 1-888-777-3186 or by e-mail at pdws@tceq.state.tx.us, and immediately notify all PWSs receiving the source water. Within five working days, submit written notification regarding the problem that required the CRMWD reclamation facility, or part of the facility, to be taken out of service, the corrective actions taken, quantity of any unacceptable water discharged to the CRMWD raw water pipeline, and the PWSs using the water at that time to:

TCEQ Technical Review and Oversight Team (MC 159)
P.O. Box 13087
Austin, TX 78711-3087

83. Data on system ownership and management shall be provided as detailed in 30 TAC §290.46(p)(1).

RECORD RETENTION

84. The following records must be retained for at least two years:
    a. The amount of chemicals used each day except for on weekends and holidays;
    b. The volume of water treated each day;
    c. The dates that storage tanks and other facilities were cleaned; and
    d. The maintenance records for the system equipment and facilities.

85. The following records must be retained for at least three years:
    a. Turbidity monitoring results for the individual HF MF membrane units;
    b. The online and benchtop data for all parameters used to determine the viral inactivation achieved in the UV reactors; and
    c. The calibration records for laboratory equipment, flow meters, on-line turbidimeters, on-line conductivity or total dissolved solids meters, UV sensors and disinfectant residual analyzers.

86. This letter must be retained while the exception is valid and then for at least five years after the exception is no longer valid.

87. Results of inspections of all water storage facilities must be retained for at least five years.

88. The following records must be retained for at least ten years:
    a. The daily highest confirmed turbidity in the wastewater effluent;
    b. The daily maximum flow rates to the HF MF membrane units;

c. Total water produced by each HF MF membrane unit each day;
d. The total daily flow to the RO membrane units;
e. The highest daily confirmed turbidity in the HF MF membrane effluent;
f. Any HF MF membrane unit DIT's starting test pressure, and decay pressure rate in psi/min;
g. Any corrective actions taken, such as pinning, to correct a failed DIT or to address performance problems with the UV reactors;
h. Each CIP performed on a HF MF or RO membrane unit;
i. The daily highest confirmed conductivity or total dissolved solids for each RO membrane unit;
j. The minimum validated UV dose (D_{val}) achieved each day in each UV reactor, the values of the parameters used to calculate the minimum D_{val}, the volume of off-spec water produced each day, the number of consecutive hours that the UV facility produced off-spec water each day, and the percentage of off-spec water produced each month;
k. The amount of WWTP effluent treated per day;
l. The amount of water sent to the EV Spence Reservoir raw water pipeline per day;
m. The daily maximum ratio of CRMWD reclamation facility effluent to raw water in the EV Spence Reservoir raw water pipeline;
n. The nitrate and nitrite results found in the CRMWD reclamation facility effluent and if necessary the EV Spence Reservoir raw water pipeline each day;
o. The weekly *E. coli* of the WWTP and CRMWD reclamation facility effluents;
p. Daily TOC in the WWTP effluent, RO feed water, RO permeate, and CRMWD reclamation facility effluent collected each weekday for one month only.
q. A laboratory report containing *Cryptosporidium* and *Giardia* concentrations in the WWTP and CRMWD reclamation facility effluent; and
r. The results of all chemical analyses.

89. Accurate, up-to-date, detailed plans and specification for the facility shall be maintained at the system until the facility is decommissioned.

HF MF MEMBRANE DETAILS

Pall Microza® Model UNA-620A MF Membrane Details

Based on approximately 30 days of operation (Cycle #7 of the pilot study report), from October 8, 2009 through November 10, 2009, of the Pall HF MF membrane test unit, the TCEQ finds that the following piloted operating parameters are accepted to yield a maximum of 17,959 gallons per day (GPD) of total filtrate water at 20° C per 538 sf membrane module.

1. Pre-treatment consists of a 300-micron strainer;

2. The water is not dechlorinated until after the HF MF membrane unit, thus the treatment unit has a 1 to 5 mg/L chlorine residual across the membranes;

3. The maximum recorded turbidity from the submitted turbidity data was approximately 80 NTU, but the CRMWD reclamation facility is choosing to divert the wastewater back to the WWTP if the turbidity is over 10 NTU. Based on this choice, the maximum allowable feed water turbidity for the treatment plant will be 10 NTU;

4. Pall Microza® Model UNA-620A HF MF membrane modules with the following specifications:
    a. A HF MF pressure membrane module six inches in diameter, approximately 80 inches (in) in length and containing polyvinylidene fluoride (PVDF) fibers with a total feed side surface area of 538-sf;
    b. A membrane fiber nominal pore size of 0.1 microns;
    c. Outside-to-inside flow mode with dead-end operation;
    d. Allowable TMP operating range of 1 to 43.5 psi;
    e. Allowable operating temperature range of 0° to 40° C;
    f. A 1,000 mg/L chlorine tolerance; and
    g. Manufacture's allowable feed water turbidity level spike of 600 NTU.

5. A filtrate duration of 20 minutes;

6. A backwash cycle using a SASRF frequency of once every 20 minutes at a flow rate of 8 gallons per minute (gpm) of filtrate and 3 standard cubic feet per minute (SCFM) of air for a duration of 1.0 minute, followed by a forward flush (FF) at a flow rate of 18 gpm of feed water for a duration of 20 seconds;

7. A sodium hypochlorite enhanced filtrate maintenance (EFM) wash procedure once every 2.81 MG for a duration of 37 minutes with either 500 parts per million (ppm) sodium hypochlorite solution circulated or 1% citric acid solution for 30.0 minutes followed by a SASRF and FF for a total filtrate water use of 15 gallons per module. RO permeate is used for EFM make up volume. In times of poor water quality, an EFM utilizing 1000 ppm sodium hypochlorite instead of 500 ppm sodium hypochlorite will be performed. It is not expected that the 1000 ppm sodium hypochlorite EFM will be needed in full-scale because water with over 10 NTU will be returned to the WWTP;

8. A total of 1,331.4 minutes per day in filtrate mode and 108.8 minutes per day in SASRF, FF, and EFM;

9. A minimum chemical CIP frequency of no less than once every 30 days for a duration of approximately six hours. The CIP uses a heated 1% caustic and sodium hypochlorite pH 11 solution re-circulated through the membranes and filtrate piping for 2 hours with a subsequent air scrub and feed side rinse. The process is repeated with a heated 1% citric acid pH 3 solution re-circulated for 1 hour. RO permeate is used for the CIP make up volume;

10. An average instantaneous filtrate flux rate of 37.2 gfd (temperature corrected to 20° C); and

11. A gross filtrate production of 18,499 gpd and an in-plant use of filtrate of 540 GPD to yield a net filtrate of 17,959 gpd per a 538-sf module at 20° C available for future customer use.

Based on two units with 78 Pall UNA-620A HF MF membrane modules each, the HF MF membranes can produce 2.8 MGD.

The TCEQ determines the capacity of HF MF membrane facilities based on an instantaneous filtrate flux corrected to 20° C. This amount is determined by subtracting the total in-plant use of filtrate (for backwashing membranes and maintenance cleaning such as EFMs, and any other in-plant use) from the gross potential filtrate production of a membrane unit in service for a 24-hour period of operation.

$$\text{Pall's filtrate flux}_{\text{at feed water temperature}} = \frac{(\text{filtrate flux}_{\text{at 20 C}})*0.9826}{0.0004481*T^2 - 0.03946*T + 1.5926}$$

Where T is the HF MF membranes' feed water temperature in degrees centigrade, and filtrate flux at 20°C is 37.2 gfd.

**** Please note this is a Pall specific formula. It must be used at your facility, and cannot be used with other manufactures membrane units. ****

DIT Resolution and LRV_{DIT} Sensitivity Calculations

On February 26, 2013 the TCEQ received your e-mail providing information for the DIT calculations for the membrane treatment units at the CRMWD Reclamation facility – TCEQ Plant No 21710. The TCEQ is **approving** the following DIT values. To comply with the conditions of this letter, CRMWD must conduct daily DITs to verify the removal efficiency of the membrane treatment process.

Membrane Filtration Units – Unit 1 - 2

The TCEQ evaluated the design data submitted with your February 26, 2013 e-mail and prepared Table 1 to help the CRMWD reclamation facility operators complete the monthly report for units 1-2.

TABLE A-1: DIT PARAMETERS FOR THE TWO UNITS AT THE CRMWD RECLAMATION FACILITY (1)

Initial Test Pressure (P_{test}) (psi)	**Upper Control Limit (UCL)** (psi/min)	**Log Removal Credit (LRC)** (log)
25.0	0.07	4.0

(1) Based on the data and calculations shown in Enclosure B.

Direct Integrity Test (DIT) Resolution and Sensitivity Calculations:

Removal credit awarded to the CRMWD reclamation facility membrane filtration system is based on the lower of either the log removal value (LRV) demonstrated by a direct integrity test (LRV_{DIT}) or the log removal value validated by a challenge study ($LRV_{C\text{-}Test}$). The values used in these calculations are required for the TCEQ to approve removal credits for the CRMWD reclamation facility, TCEQ Plant ID 21710 .

Pall Corporation provided detailed descriptions of the calculations methods and values for the DIT. All formulas and methods of calculation are from the US EPA *Membrane Filtration Guidance Manual* and are in accordance with the DIT requirements of 40 Code of Federal Regulations (CFR) §141.719(b)(3). **Based on our review of the submitted calculations for determining the necessary values to verify a DIT test pressure resolution of 3.0 microns and sensitivity for the log removal credit (LRC) required, the following are TCEQ accepted values:**

Approved Minimum Test Pressure for DIT

The DIT procedure must be conducted at a pressure high enough to detect a 3-micron breach in the membrane.

1. **The TCEQ accepts the use of 25.0 psi for the Minimum Test Pressure (P_{test}).**
   Equation 4.1 (for a 3.0 micron defect): $P_{test} = (0.193 * \kappa * \sigma * \cos(\theta) + BP_{max})$

   Where:

   Membrane specific pore shape correction factor (κ) = 1.0,
   Surface tension at the air-liquid interface (σ) = 74.9 dynes/centimeter (cm),
   Liquid-membrane contact angle (θ) = 0 degrees, and
   Maximum back pressure (BP_{max}) on the system = 3.0 psi.

   The TCEQ accepts the use of the most conservative values for κ, σ, and θ (as described above). This test pressure meets the required DIT resolution to detect a 3-micron defect or larger. The equation above calculates a P_{test} of 17.5 psi, but the documentation provided states that the facility utilizes a P_{test} of 25 psi. The 25 psi P_{test} is further used throughout the UCL calculations, thus a P_{test} of 25 psi has been granted as the minimum test pressure.

   Please note that the plant may conduct its DITs at any pressure that is greater than or equal to the approved minimum test pressure shown above.

Approved Log Removal Credit (LRC) for the Membrane Unit

2. **The TCEQ accepts the volume of pressurized air in the system during the test (V_{sys}) of 1,875 liters (L) for the full-scale HF MF membrane unit.**

   V_{sys} is used in equation 4.9 of the US EPA's Membrane Filtration Guidance Manual to verify that the sensitivity of the DIT conducted during the pilot study is equal to, or greater than, the required Log Removal Credit (LRC)of **4.0-log**.

   Equation 4.9: $LRV_{DIT} = \log[(Q_p \times ALCR \times P_{atm}) \div (\Delta P_{test} \times V_{sys} \times VCF)]$

   Where Q_p is the design capacity filtrate flow, ALCR is air-liquid conversion ratio, P_{atm} is atmospheric pressure, VCF is the volumetric concentration factor, and ΔP_{test} (0.06 psi per minute as given by the manufacturer) is the smallest rate of pressure decay that can be reliably measured during the integrity test.

3. **The TCEQ accepts the use of 24.32 for the ALCR;**

   Equation C.4: $ALCR = 170 \times Y \times [(P_{test} - BP) \times (P_{test} + P_{atm}) / (460 + T) \times TMP]^{1/2}$

   Using the following values:
   - P_{test} = 25 psi;
   - P_{atm} = 14.7 psia;
   - BP = 0.0 psi;
   - Temperature (T) = 90°F ;
   - TMP = 35 psi maximum allowable per Pall Corporation;
   - Net expansion factor for compressible flow through pipe to a larger area (Y) = 0.630. (from Appendix C Equation C.5 Membrane Filtration Guidance)

The above equation, Eq. C.4, is based on the Darcy Pipe Flow Model assuming turbulent flow such as from a broken hollow fiber (as defined in the US EPA Membrane Filtration Guidance Manual).

4. **The TCEQ accepts the use of 4103.65 liters per minute (L/min) as the design capacity Q_p**, based on a flow of 37.2 gallons per square foot per day (gfd) as in the TCEQ letter dated November 30, 2010, module square footage of 538 ft^2, and 78 modules per rack as verified by the water treatment plant.

5. **A VCF of 1.08 for the full scale HF MF membrane units is acceptable.**

6. Using the smallest verifiable decay rate of 0.06 psi/min (ΔP_{test}), as provided by the manufacturer, a sensitivity of 4.08-log was determined from the LRV_{DIT} calculation specified in Equation 4.9. For the purpose of validating that the response from the pressure decay test can verify **a 4.0 log removal credit (LRC), the TCEQ accepts the use of an upper control limit (UCL) of 0.07 psi/min.**

   Equation 4.17: Upper control limit (UCL) = (Q_p x ALCR x P_{atm}) / (10^{LRC} x V_{sys} x VCF)
   Where:
   - Q_p = 4103.65 L/min;
   - ALCR = 24.32;
   - P_{atm} = 14.7 psia;
   - LRC = 3.0;
   - V_{sys} = 1,875 L; and,
   - VCF = 1.08

Challenge Study
Pall Corporation has provided challenge test data for the installed Pall UNA 620A. The TCEQ has received the data and approved a Challenge Test Log Removal Value (LRV_{CT}) of 5.68. TCEQ has also approved the Non-Destructive Performance Testing (NDPT) method, corresponding Quality Control Release Value (QCRV) and method for the Direct Integrity Test Log Removal Value (LRV_{DIT}) as specified in the US EPA's LT2ESWTR and US EPA *Membrane Filtration Guidance Manual*.

Because the approved pathogen removal values are based on the lower of the LRV_{CT} and the LRV_{DIT} the 4.0 *Cryptosporidium* and *Giardia* log removal shown in the challenge study can be verified in full scale using the above DIT parameters.

RO MEMBRANE DETAILS

Toray TML 10 RO Membrane Details

Toray TML 10 RO membranes were piloted in conjunction with the HF MF membrane units in a simulated full-scale design configuration. The Toray RO test unit consisted of six pressure vessels (PV) each containing three RO test elements. Two PV were piloted in parallel with HF MF membrane filtrate water as their feed water source. Each of these two PVs' concentrate was fed to two more PVs in parallel. The concentrate from the second set of PVs was blended and used as feed water for a fifth PV. The fifth PV's concentrate was fed to the sixth and final PV. The first four PVs simulated two full-scale PVs operating in parallel with six RO elements each and the last two PVs simulated a single full-scale PV containing six RO elements. This is a commonly used pilot study arrangement achieving a 2:2:1:1 test array and simulating a full-scale 2:1 array with 6 membranes per PV.

Based on our review of Cycle #6, performed November 6, 2009 to November 24, 2009, the Toray TML 10 RO membrane elements can be installed under the following conditions:

1. Each array must achieve an average flux rate of 10.5 gfd for the Toray TML 10 RO membrane element's feed side surface area.

2. Each full-scale RO membrane unit must use a two-stage 2:1 array as simulated by the pilot study.

   a. All RO elements are to be the same model, or a larger TCEQ acceptable Toray RO element model having the same leaf length, salt rejection, removal efficiency and design (no mixing of non-piloted elements); and
   b. Twice the number of PV and RO elements in each Stage 1 as is in Stage 2.

3. The full-scale RO membranes must meet the following specifications:
   a. 8-inch diameter;
   b. An active membrane area of 400 square feet;
   c. Have a leaf length of 40 inches;
   d. Minimum salt rejection of 99%;
   e. Recovery rate of 75%;
   f. Maximum operating temperature of 113° F;
   g. Maximum allowed continuous free chlorine value of non-detectable;
   h. An operating pH range of 2 to 11;
   i. A pH cleaning range of 1 to 12;
   j. A maximum operating pressure of 600 psi;
   k. A maximum pressure drop per element of 20 psi; and
   l. A maximum silt density index (SDI) of 5.

4. The full-scale Toray membrane elements, internal surface of the PVs and associated RO membrane unit piping must be NSF 61 certified.

5. ANSI/NSF Standard 60 certified chemicals must be used. It is noted that Hypersperse MDC150 by GE Betz Inc. and sulfuric acid were used as the RO anti-scaling products.

6. ANSI/NSF Standard 60 certified sodium bisulfite must be used at a dose necessary to remove all chlorine residual before the RO membranes. During the pilot this dose was 22 mg/L.

7. A CIP must be conducted on each RO membrane unit using ANSI/NSF Standard 60 certified cleaning chemicals and the following procedure:
   a. Perform a flush of the pressure vessels using clean RO permeate or dechlorinated potable water;
   b. Start recirculation of cleaning solution through the system;
      i. Allow low pH ~ 3, 1% citric acid cleaning solution to circulate through the system for approximately one hour while maintaining the solution at approximately 95°F;
      ii. Drain the RO unit

iii. Collect waste and neutralize;

c. Perform another flush of the system to remove any traces of the cleaning solution;
d. Repeat the recirculation of the cleaning solution with 0.1% caustic soda solution at a pH of 12 for 1 hour at 95°F through the system; and
e. Flush the system with dechlorinated tap water or permeate.

GENERAL INFORMATION

The pilot study report contained data supporting the use of HF MF or HF ultrafiltration (UF) followed by RO membranes. Two treatment trains were pilot tested:

1. Pall Microza® UNA-620A HF MF followed by Toray TML 10 RO membranes; and
2. Siemens L20V HF UF membranes followed by Hydronautics BW30LE RO membranes.

The source water for the membrane pilot study was the effluent of the Big Spring WWTP. The WWTP is a hybrid plant, including both fixed film and suspended growth biological processes. Raw wastewater is first screened and de-gritted, then flows to a primary clarifier. Primary effluent then proceeds to a single rock media trickling filter for biological stabilization and then is pumped to the aeration basin for additional biological treatment. The contents of the aeration basin flow to the final clarifier where the active biomass is separated from the treated effluent and recycled to the aeration basin. The effluent is chlorinated. The filtered effluent containing the chlorine residual was the source water for the pilot study. The effluent of the WWTP is currently subject to permit number TPDES 10069-003.

Additional information on the UV facilities was submitted at later dates and included the following.

a. An e-mail from David Sloan, P.E., dated November 30, 2012, that was accompanied by one sheet of engineering drawings for the CRMWD Big Springs UV reactor installation.
b. A letter from Scott Bindner, of Trojan Technologies, dated November 21, 2012, that was accompanied by
    i. detailed calculations on viral inactivation dated November 21, 2012,
    ii. a Trojan UVFit™ 72AL75 UVDGM Equivalency Report dated October 16, 2012, and
    iii. a Trojan UVFit™ 72AL75 Validation Report dated November 2009.
c. An e-mail from Adam Festger, of Trojan Technologies, dated December 19, 2012, that was accompanied by
    i. his letter of that same date responding to some questions that had been raised during the review,
    ii. one sheet of standard drawings on the UVPhox 72AL75 reactor, and
    iii. one sheet of standard drawings on the UVFit 72AL75 reactor.
d. An e-mail from Mr. Festger dated January 8, 2013, that was accompanied by a December 12, 2012, letter from Greg Warkentin, of Trojan Technologies, regarding the equivalency of the UVFit 72AL75 and UVPhox 72AL75 reactors.
e. A letter from Neil Brown, of Trojan Technologies, dated February 5, 2013 describing the reactor control strategy for the CRMWD Big Springs UV system.
f. An e-mail from Robert Haas, of Trojan Technologies, dated February 11, 2013, that was accompanied by
    i. a parts list for the UVFit 72AL75 reactor,
    ii. a parts list for the UVPhox 72AL75 reactor, and

iii. an image of the UVFit 72AL75 reactor.

g. An e-mail from Robert Haas, dated March 1, 2013, that was accompanied by an unsigned letter of that same date regarding the control algorithm for the CRMWD Big Springs UV system.
h. An e-mail from Robert Haas, dated March 8, 2013, that was accompanied by the CFD Model Report comparing the piping configuration that existed during reactor validation with the configuration used at the CRMWD Big Springs UV reactor installation.
i. E-mails from Mr. Festger and Mr. Sloan providing some additional details about the control algorithm for the UV system.

This exception for the alternative raw water source approval is subject to periodic review and may be revoked or amended if warranted. All conditions contained are site-specific minimum operation, design, reporting, calibration and record keeping requirements for the CRMWD reclamation facility as specified in 30 TAC §290.39(l)(4). Failure by the CRMWD reclamation facility to comply with these conditions can result in the water produced no longer being able to be used as a source of raw water for public drinking water systems.

Enclosure B -1 76 modules per rack
CRMWD Big Spring Reclamation facility - PWS 1140038
WATER RECLAMATION PLANT - TCEQ ID 21710
Pall Microza UNA-620A

P_{test} (psi)	LRC_{DIT}	UCL psi/min
25.0	**4.00**	**0.07**

Q_p L/min	V_{sys} (L)
3998.43	1875.14

P_{test}	P_{test} (psi)	k Pore Shape Correction Factor	s Surface Tension	cos q liquid-- membrane contact angle	BP_{max}
Minimum Pressure Test (Equation 4.1)					
$P_{test}=(0.193 * k * s * \cos q)+ BP_{max}$	**17.5**	1	74.9	0	3

ALCR Turbulent Flow (Equation C.9)	**ALCR**	Y	P_{atm} (psia)	Ptest used (psi)	T (F)	BP_{max} (psi)	TMP (psi)
$ALCR = 170 * Y * Sqrt[((P_{test} - BP)(P_{test} + P_{atm}))/((460+T)*TMP)]$	**24.32**	0.630	14.7	25.0	90	0	35

LRV_{DIT} Sensitivity (Equation 4.9)	**LRV_{DIT}**	Q_p L/min	P_{atm} (psia)	DP_{test} (psi/min)	VCF	V_{sys} (L)
$LRV_{DIT} = \log((Q_p *ALCR * P_{atm})/(DP_{test} * V_{sys} * VCF))$	**4.07**	3998.43	14.7	0.06	1.08	1875.14

UCL (Equation 4.17)	UCL psi/min	Q_p L/min	P_{atm} (psia)	LRC	VCF	V_{sys} (L)
$UCL = (Q_p *ALCR * P_{atm})/(10^{LRC} * V_{sys} * VCF)$	**0.07**	3998.43	14.7	4	1.08	1875.14

	L/gal	**min/day**	**L/ft3**
Conversion Factors	3.78541	1440	28.3168

Flux rate (gal/sf-day)*	**sf***	**modules****	# of Units **
37.20	538	76	2

*from pilot study
** confirmed by plant

Enclosure B -2 78 modules per rack
CRMWD Big Spring Reclamation facility - PWS 1140038
WATER RECLAMATION PLANT - TCEQ ID 21710
Pall Microza UNA-620A

P_{test} (psi)	LRC_{DIT}	UCL psi/min
25.0	**4.00**	**0.07**

Q_p L/min	V_{sys} (L)
4103.65	1875.14

P_{test} Minimum Pressure Test (Equation 4.1)	**P_{test}** (psi)	k Pore Shape Correction Factor	s Surface Tension	cos q liquid--membrane contact angle	BP_{max}
P_{test}=(0.193 * k * s * cos q)+ BP_{max}	**17.5**	1	74.9	0	3

ALCR Turbulent Flow (Equation C.9)	**ALCR**	Y	P_{atm} (psia)	Ptest used (psi)	T (F)	BP_{max} (psi)	TMP (psi)
ALCR = 170 * Y * Sqrt[((P_{test} - BP)(P_{test} + P_{atm}))/((460+T)*TMP)]	**24.32**	0.630	14.7	25.0	90	0	35

LRV_{DIT} Sensitivity (Equation 4.9)	**LRV_{DIT}**	Q_p L/min	P_{atm} (psia)	DP_{test} (psi/min)	VCF	V_{sys} (L)
LRV_{DIT} = log((Q_p *ALCR * P_{atm})/(DP_{test} * V_{sys} * VCF))	**4.08**	4103.65	14.7	0.06	1.08	1875.14

UCL (Equation 4.17)	UCL psi/min	Q_p L/min	P_{atm} (psia)	LRC	VCF	V_{sys} (L)
UCL = (Q_p *ALCR * P_{atm})/(10^{LRC} * V_{sys} * VCF)	**0.07**	4103.65	14.7	4	1.08	1875.14

	L/gal	**min/day**	**L/ft3**
Conversion Factors	3.78541	1440	28.3168

Flux rate (gal/sf-day)*	**sf***	**modules****	# of Units **
37.20	538	78	2

*from pilot study
** confirmed by plant

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-1: Inorganics with Maximum Contaminant Levels (MCL)			
Contaminant	**CRMWD Reclamation Facility Effluent January 31, 2013 (mg/L)**	**MCL (mg/L)**	**EV Spence Raw Water Pipeline 2009 (mg/L)**
Antimony, Total	<0.001	0.006	<0.002
Arsenic	<0.002	0.01	<0.00695
Asbestos	<0.1987 million fiber/liter (MFL)	7 MFL	0 MFL
Barium	<0.001	2	0.264
Beryllium, Total	<0.0008	0.004	<0.001
Cadmium	<0.001	0.005	<0.001
Chromium	<0.01	0.1	<0.001
Cyanide	<0.01	0.2	Not provided
Fluoride	<0.1	4	0.558
Mercury	<0.0004	0.002	<0.000150
Nitrate (as Nitrogen)	0.26	10	<0.05
Nitrite (as Nitrogen)	0.02	1	<0.05
Nitrate & Nitrite (Total)	0.28	10	<0.100
Selenium	<0.003	0.05	0.00794
Thallium	<0.0004	0.002	<0.001

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-2: Volatile Organic Compounds with MCLs			
	CRMWD Reclamation Facility Effluent January 31, 2013	MCL	EV Spence Raw Water Pipeline 2009
Contaminant	**(mg/L)**	**(mg/L)**	**(mg/L)**
1,1-Dichloroethylene	<0.0005	0.007	<0.001
1,1,1-Trichloroethane	<0.0005	0.2	<0.001
1,1,2-Trichloroethane	<0.0005	0.005	<0.001
1,2-Dichloroethane	<0.0005	0.005	<0.001
1,2-Dichloropropane	<0.0005	0.005	<0.001
1,2,4-Trichlorobenzene	<0.0005	0.07	<0.001
Benzene	<0.0005	0.005	<0.001
Carbon tetrachloride	<0.0005	0.005	<0.001
cis-1,2-Dichloroethylene	<0.0005	0.07	not provided
Dichloromethane	<0.0005	0.005	not provided
Ethylbenzene	<0.0005	0.7	<0.001
Monochlorobenzene	<0.0005	0.1	not provided
o-Dichlorobenzene	<0.0005	0.6	not provided
para-Dichlorobenzene	<0.0005	0.075	not provided
Styrene	<0.0005	0.1	<0.001
Tetrachloroethylene	<0.0005	0.005	<0.001
Toluene	<0.0005	1	<0.001
trans-1,2-Dichloroethylene	<0.0005	0.1	not provided
Trichloerothylene	<0.0005	0.005	<0.001
Vinyl Chloride	<0.0005	0.002	<0.001
Xylenes (total)	<0.0005	10	<0.001

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-3: Synthetic Organic Compounds with MCLs			
	CRMWD Reclamation Facility Effluent January 31, 2013	MCL	EV Spence Raw Water Pipeline 2009
Contaminant	(mg/L)	(mg/L)	(mg/L)
Alachlor	<0.0002	0.002	<0.000111
Atrazine	<0.0001	0.003	<0.000111
Benzopyrene	<0.00002	0.0002	<0.000111
Carbofuran	<0.0009	0.04	<0.01
Chlordane	<0.0002	0.002	<0.000111
Dalapon	<0.001	0.2	<0.00206
Di(2-ethylhexyl)adipate	<0.0006	0.4	not provided
Di(2-ethylhexyl)phthalate	<0.0006	0.006	not provided
Dinoseb	<0.0002	0.007	<0.000515
Endrin	<0.00001	0.002	<0.000111
Ethylene Dibromide	<0.00001	0.00005	not provided
Heptachlor	<0.00004	0.0004	<0.000111
Haptachlor epoxide	<0.00002	0.0002	<0.000111
Hexachlorobenzene	<0.0001	0.001	<0.000111
Hexachlorocyclopentadiene	<0.0001	0.05	<0.000111
Lindane	<0.00002	0.0002	<0.000111
Methoxychlor	<0.0001	0.04	<0.000111
Oxamyl (Bydate)	<0.002	0.2	<0.01
Pentachlorophenol	<0.00004	0.001	<0.000111
Picloram	<0.0001	0.5	<0.000515
Polychlorinated biphenyls(PCB)	Not Detected	0.0005	<0.000111
Simazine	<0.00007	0.004	<0.000111
Toxaphene	<0.001	0.003	<0.000111
2,4,5-TP	<0.0002	0.05	<0.000515
2,4-D	<0.0001	0.07	<0.000515

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-4: Radionuclides with MCLs		
Contaminant	**CRMWD Reclamation Facility Effluent January 31, 2013**	**MCL**
Combined radium-226 and radium-228	<1 pCi/L	5 pCi/L
Gross alpha particle activity	<2 pCi/L	15 pCi/L
Gross beta particle activity	<4 pCi/L	50 pCi/L
38-Strontium-90	<2 pCi/L	8 pCi/L
Tritium	<500 pCi/L	20000 pCi/L
Uranium	<1 µg/L	30 µg/L

Table C-5: Disinfectant By-Products with MCLs		
Contaminant	**CRMWD Reclamation Facility Effluent January 31, 2013 (mg/L)**	**MCL (mg/L)**
Total Trihalomethane (TTHMs)	<0.004	0.080
Haloacetic acids (HAA_5)	<0.006	0.060

Table C-6: Contaminants with Secondary Contaminant Levels (SCL)			
Contaminant	**CRMWD Reclamation Facility Effluent January 31, 2013 (mg/L)**	**SCL (mg/L)**	**EV Spence Raw Water December, 2012 (mg/L)**
Aluminum	<0.02	0.05-0.2	not provided
Chloride	7	300	391-414
Copper	0.0027	1	not provided
Fluoride	<0.1	2	not provided
Iron	<0.01	0.3	not provided
Manganese	0.0032	0.05	not provided
Silver	<0.01	0.1	not provided
Sulfate	<1	300	231-236
Total Dissolved Solids	18	1,000	1,222-1,248
Zinc	0.0826	5	not provided

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-7: Other Sampled Inorganic Contaminants			
Contaminant	**CRMWD Reclamation Facility Effluent January 31, 2013 (mg/L)**	**MCL (mg/L)**	**EV Spence Raw Water December, 2012 (mg/L)**
Alkalinity, Bicarbonate	7	none	not provided
Alkalinity, Carbonate	<2	none	not provided
Alkalinity, Phenolphthalein	<2	none	not provided
Alkalinity, Total	6	none	not provided
Calcium	<1	none	not provided
Conductivity @ 25 C	40	none	1,880-1,920
Hardness	<2.5	none	700
Lead	<0.001	none	not provided
Magnesium	<1	none	not provided
Nickel	<0.001	none	not provided
Sodium	6.82	none	not provided

Table C-8: Radionuclides without MCLs		
Contaminant	**CRMWD Reclamation Facility Effluent January 31, 2013 (pCi/L)**	**MCL**
38-Strontium-89	<5	none
53-Iodine-131	<2.3	none
55-Cesium-134	<1.7	none
55-Cesium-137	<1.8	none
82-Lead-212	2.4	none

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-9: Other Sampled Compounds		
	CRMWD Reclamation Facility Effluent - January 31, 2013	MCL
Contaminant	(µg/L)	
1,1,1,2-Tetrachloroethane	<1	none
1,1,2,2-Tetrachloroethane	<1	none
1,1-Dichloropropene	<1	none
1,1-Dichloroethane	<1	none
1,2,3-Trichlorobenzene	<1	none
1,2,3-Trichloropropane	<1	none
1,2,4-Trimethylbenzene	<1	none
1,2-Dibromo-3-Chloropropane	<0.02	none
1,3,5-Trimethylbenzene	<1	none
1,3-Butadiene	<1	none
1,3-Dichloropropane	<1	none
17-Alpha-Ethynylestradiol	<1	none
2,2,3,3,4,4,6-Heptachlorobipheny	<0.5	none
2,2,3,3,4,5,6,6-Octachlorpbiphen	<0.5	none
2,2,3,4,6-Pentachlorobiphenyl	<0.2	none
2,2,4,4,5,6-Hexachlorobiphenyl	<0.2	none
2,2,4,4-Tetrachlorobiphenyl	<0.2	none
2,2-Dichloropropane	<1	none
2,3-Dichlorobiphenyl	<0.2	none
2,4,5-T	<0.5	none
2,4,5-Trichlorobiphenyl	<0.2	none
2,4,-DB	<2	none
2-Chlorobiphenyl	<0.2	none
2-Hexanone	<1	none
3,5-Dichlorobenzoic Acid	<1	none
3-Hydroxycarbofuran	<2	none
Acenaphthene	<0.2	none
Acenaphthylene	<0.2	none
Acetone	<10	none
Acifluorfen	<1	none
Acrylonitrile	<10	none
Aldicarb	<0.5	none
Aldicarb Sulfone	<0.8	none
Aldicarb Sulfoxide	<0.5	none
Aldrin	<0.2	none
Alpha-Chlordane	<0.2	none
Ahthracene	<0.2	none
Baygon	<2	none

Enclosure C: Comparison of CRMWD Reclamation Facility and EV Spence Reservoir Sample Results

Table C-9 continued: Other Sampled Compounds		
	CRMWD Reclamation Facility Effluent - January 31, 2013	MCL
Contaminant	**(μg/L)**	
Bentazon	<2	none
Benzo(A)Anthracene	<0.2	none
Benzo(B)Fluoranthene	<0.2	none
Benzo(G,H,I)Perylene	<0.2	none
Benzo(K)Fluoranthene	<0.2	none
BHC-Gamma	<0.02	none
Bromacil	<0.2	none
Bromobenzene	<1	none
Bromochloroacetic Acid	<1	none
Bromochloromethane	<1	none
Bromodichloromethane	<1	none
Bromoform	<1	none
Bromomethane	<2	none
Butachlor	<0.2	none
Butylbenzyl Phthalate	<2	none
Carbaryl	<2	none
Carbon Disulfide	<1	none
Chloramben	<1	none
Chlorodifluoromethane	<1	none
Chloroethane	<2	none
Chloroform	<1	none
Chloromethane	<2	none
Chrysene	<0.2	none
cis-1,3-Dichloropropene	<1	none
Dibenzo(A,H)Anthracene	<0.2	none
Dibromoacetic Acid	<1	none
Dibromochlormethane	<1	none
Dibromemethane	<1	none
Dicamba	<1	none
Dichloroacetic Acid	<1	none
Dichlorodifluoromethane	<2	none
Dichlorprop	<2	none
Dieldrin	<0.2	none
Diethyl Phthalate	<2	none
Dimethyl Phthalate	<2	none
Di-N-Butyl Phthalate	<2	none
Ethyl Methacrylate	<1	none
Fluorene	<0.2	none

Table C-9 continued: Other Sampled Compounds		
	CRMWD Reclamation Facility Effluent - January 31, 2013	**MCL**
Contaminant	**(µg/L)**	
Gamma-Chlordane	<0.2	none
Hexachlorobutadiene	<1	none
Ideno(1,2,3-CD)Pyrene	<0.2	none
Isopropylbenzene	<1	none
M-Dichlorobenzene	<1	none
Methiocarb	<4	none
Methomyl	<2	none
Methyl Ethyl Ketone	<10	none
Methyl Iodine	<2	none
Methyl Isobutyl Ketone	<2	none
Methyl Methacrylate	<1	none
Methyl Tert-Butyl Ether	<2	none
Metolachlor	<0.2	none
Metribuzin	<0.2	none
Monobromoacetic Acid	<1	none
Monochloroacetic Acid	<2	none
Naphthalene	<1	none
N-Butylbenzene	<1	none
N-Propylbenzene	<1	none
O-Chlorotoluene	<1	none
P-Chlorotoluene	<1	none
Phenanthrene	<0.2	none
Picloram	<0.1	none
P-Isopropyltoluene	<1	none
Prometon	<0.2	none
Propachlor	<0.2	none
Pyrene	<0.2	none
Quinclorac	<1	none
SEC-Butylbenzene	<1	none
Tert-Butylbenzene	<1	none
Tertrahydrofuran	<5	none
Trans-1,3-Dichloropropene	<1	none
Trans-Nonachlor	<0.2	none
Trichloroacetic Acid	<1	none
Trichlorofluoromethane	<2	none
Trifluralin	<0.2	none
Vinyl Acetate	<10	none

Enclosure D: Unregulated Contaminants of Concern

Tables D-1 and D-2 contain are currently unregulated chemical and microbiological contaminants of concern that the TCEQ recommends the system monitor quarterly.

For monitoring of unregulated contaminants — Table D-1: Microbials and Table D-2: Chemicals—the system should identify the analytical methods that they wish to use, and propose those to the TCEQ. If you have any questions concerning this enclosure, please contact Ms. Alicia Diehl by email at Alicia.Diehl @tceq.texas.gov or by telephone at (210) 403-4053.

Table D-1: Microbals

MICROBIALS	Analytical Methods[1]	Regulated
Viruses[2]		
*Enterovirus	1615	UCMR3[3]
*Norovirus		
Rotavirus	1	No[2]
Poliovirus	1	No[2]
Echoviruses	1	No[2]
Coxsackie viruses group A and B	1	No[2]
Adenovirus	1	No[2]
Hepatitis A	1	No[2]
Protozoans		
Naegleria fowleri	4	No
Cyclospora	4	No
Microsporidia (fungus)	4	No
Bacteria		
Enterococci	1600, 1106	No
Salmonella (and / or Shigella, Campylobacter, Pseudomonas[5])	1200	No
Aeromonas	1605	No
Heterotrophic plate count (indicator)	9215	No

* Highly recommended for sampling

1 Method listed is an EPA method unless otherwise noted. List of methods is not exhaustive, but is included for reference only. If a method is not listed, CRMWD will need to research and propose a method to TCEQ.

2 Viruses are regulated as a group through treatment technique requirements at treatment plants for the EPA's Surface Water Treatment Rules and Ground Water Rule

3 Unregulated Contaminant Monitoring Rule (UCMR) 3. Regulations cover distribution levels and removal requirements. Regulatory monitoring required, but not an individual health-based standard set.

4 Methods are in development.

Unregulated Contaminants of Concern

Table D-2: Chemicals

CHEMICALS	Method[1]	Regulated
Disinfection byproducts		
*Nitroso-dimethylamine (NDMA)	521	UCMR3[3]
*Nitroso-pyrolidine (NPYR)		
Organic chemicals		
***Pharmaceutical indicators:** 17-α-ethynylestradiol (ethinyl estradiol), 16-α-hydroxyestradiol (estriol), equilin, estrone, testosterone, 4-androstene-3,17-dione	539	UCMR3[3]
***Chemicals of human origin:** Perfluorooctanesulfonic sulfonate (PFOS), perfluorooctanoic acid (PFOA) perfluorononanoic acid (PFNA) perfluorohexanesulfonic acid (PFHxS) perfluoroheptanoic acid (PFHpA) perfluorobutanesulfonic acid (PFBS)	537	UCMR3[3]
*Sucralose	[2]	No
1,4 dioxane	522	No
Caffeine	1694	No
N,N-Diethyl-meta-toluamide (DEET)	633	No
Gemfibrozil	1694	No
Iopromide	1694	No
Inorganic chemicals		
Perchlorate[4]	314	UCMR2[3]

* Highly recommended for sampling.

1 Method listed is an EPA method unless otherwise noted. List of methods is not exhaustive, but is included for reference only.

2 Acceptable methods exist but have not yet been approved by the EPA. CRMWD should propose the method they plan to use.

3 Regulatory monitoring required, but not a health-based standard set.

4 The EPA has indicated that a maximum contaminant level will be promulgated for perchlorate. EPA will be working with stakeholders to develop a maximum contaminant level.

Appendix B

List of Trace Chemicals and Disinfection Byproducts for Analysis by the Southern Nevada Water Authority Laboratory

Table B1 List of Trace Chemicals Proposed for Testing.

Pharmaceuticals and Personal Care Products (PPCPs) and Consumer Chemicals		
Acetaminophen	Gemfibrozil	Sulfamethoxazole
Atenolol	Ibuprofen	TCEP (*tris*(2-chloroethyl) phosphate)
Caffeine	Meprobamate	Triclocarban
Carbamazepine	Naproxen	Triclosan
DEET (N,N-Diethyl-meta-toluamide)	Primidone	Trimethoprim
Fluoxetine	Sucralose	
Steroid Hormones		
Testosterone	Estrone	Ethinylestradiol
Progesterone	Estradiol	
Perfluorinated Compounds (PFCs)		
All PFC compound names begin with "perfluoro…"		
…butanoic acid (PFBA)	…octanyl sulfonate (PFOS)	…dodecanoic acid (PFDoA)
…hexanyl sulfonate (FHxS)	...nonanoic acid (PFNA)	…pentanoic acid (PFPnA)
…hexanoic acid (PFHxA)	…decanoic acid (PFDA)	…heptanoic acid (PFHpA)
…octanoic acid (PFOA)	…undecanoic acid (PFUdA)	
Nitrosamines		
All nitrosamines compound names begin with "*N*-nitroso…"		
…dimethylamine (NDMA)	…morpholine (NMOR)	…diphenylamine (NDPhA)
…methylethylamine (NMEA)	…pyrrolidine (NPYR)	Total nitrosamines
…diethylamine (NDEA)	…piperidine (NPIP)	
…dipropylamine (NDPA)	…dibutylamine (NDBA)	
Total Trihalomethanes (TTMs)		
Chloroform	Bromodichloromethane	
Bromoform	Dibromochloromethane	
Haloacetic Acids (HAA5)		
Monochloroacetic Acid (CAA)	Trichloroacetic Acid (TCAA)	Dibromoacetic Acid
Dichloroacetic Acid (DCAA)	Monobromoacetic Acid (BAA)	(DBAA)

Appendix C

Sampling Protocols for Microbiological Parameters provided by BioVir Laboratories

BioVir Protocols for Bacterial Sampling (Coliforms, E *Coli*) and Phage

BACTERIAL SAMPLING*

Sampling Containers

Collect samples for microbiological examination in bottles that have been cleansed and rinsed carefully, given a final rinse with distilled water, and sterilized. (Please refer to Standard Methods for the Examination of Water and Wastewater, 18th edition) for wash and sterilization protocols. Alternatively, purchase pre-sterilized containers and integrity check each sealed vessel prior to use.

Sample Dechlorination

Add a reducing agent to containers intended for the collection of water having residual chlorine or other halogen unless they contain broth for direct plating of sample. Sodium thiosulfate ($Na_2S_2O_3$) is a satisfactory dechlorinating agent that neutralizes any residual halogen and prevents continuation of bactericidal action during sample transit. Alternately, purchase pre-sterilized containers appropriate for the volume of sample desired which contain Sodium thiosulfate in pellet form. The examination then will indicate more accurately the true microbial content of the water at the time of sampling.

For drinking water samples, the concentration of dechlorinating agent: 0.1 mL of a 3% solution of Sodium thiosulfate in a 120-mL bottle will give a final concentration of 18 mg/L in the sample and will neutralize up to 5 mg/L residual chlorine. In emergency disinfection with higher concentrations of chlorine add sufficient dechlorination agent to give a concentration of 100 mg/L in the sample.

Sample Collection - General

1. When the sample is collected, leave ample air space in the bottle (at least 2.5 cm) to facilitate mixing by shaking, before examination.
2. Collect samples that are representative of the water being tested, flush or disinfect sample ports, and use aseptic techniques to avoid sample contamination.
3. Keep sampling bottle closed until it is to be filled.
4. Remove stopper and cap as a unit. DO NOT contaminate inner surface of stopper or cap and neck of bottle.
5. Fill container without rinsing.
6. Replace stopper or cap immediately, and if used, secure hood around neck of bottle. Alternately, secure "tamper proof" devices applicable to sample container.

Sample Collection - Potable Water

If the water sample is to be taken from a distribution system tap without attachments, select a tap that is supplying water from a service pipe directly connected with the main, and is not, for example, served from a cistern or storage tank. Open tap fully and let water run to waste for 2-3 minutes, or for a time sufficient to permit clearing the service line. Reduce water flow to permit filling bottle without splashing. If tap cleanliness is questionable, apply solution of sodium hypochlorite (100 mg NaOCl/L) to faucet before sampling; let water run for additional 2 to 3 minutes after treatment. Do not sample from leaking taps that allow water to flow over the outside of the tap. In sampling from a mixing faucet remove faucet attachments such as screen or splash guard, run hot water for 2 minutes, then cold water for 2 to 3 minutes, and collect sample as indicated above.

If the sample is to be taken from a well fitted with a hand pump, pump water to waste for about 5 minutes before collecting sample. If the well is equipped with a mechanical pump, collect sample from a tap on the discharge. If there is no pumping machinery, collect a sample directly from the well by means of a sterilized bottle fitted with a weight at the base; take care to avoid contaminating samples by any surface scum.

In drinking water evaluation, collect samples of finished water and from distribution sites selected to assure systematic coverage during each month. Carefully choose distribution system sample locations to include dead-end sections to demonstrate bacteriological quality throughout the network and to ensure that localized contamination does not occur through cross-connections, breaks in the distribution lines, or reduction in positive pressure. Sample locations may be public sites (police and fire stations, government office buildings, schools, bus and train stations, airports, community parks, commercial establishments (restaurants, gas stations, office buildings, industrial plants), and buildings, and townhouse complexes, and special sampling stations built into the distribution network. Establish sampling program in consultation with state and local health authorities.

Sample Collection - Raw Water Supply

In collecting samples directly from a river, stream, lake, reservoir, spring, or shallow well, obtain samples representative of the water that is the source of supply to consumers. It is undesirable to take samples too near the bank or too far from the point of drawoff, or at a depth above or below the point of drawoff.

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685 Stone Road, Unit 6, Benicia, CA 94510

1-800-442-7342 (Fax) 707-747-1751
E-Mail: Craig Johnson @ csj@biovir.com
Web Site: www.biovir.com

Sample Collection - Surface Waters

Stream studies may be short-term, high-intensity efforts. Select bacteriological sampling locations to include a baseline location upstream from the study area, industrial and municipal waste outfalls into the main stream study area, tributaries except those with a flow less than 10% of the main stream, intake points for municipal or industrial water facilities, downstream samples based on stream flow time, and downstream recreational areas. Dispersion of wastewaters into the receiving stream may necessitate preliminary cross-section studies to determine completeness of mixing. Where a tributary stream is involved, select the sampling point near the confluence with the main stream. Samples may be collected from a boat or from bridges near critical study points. Choose sampling frequency to be reflective of stream or water body conditions. For example, to evaluate waste discharges, sample every 4 to 6 hours and advance the time over a 7 to 10 day period.

To monitor stream and lake water quality establish sampling locations at critical sites. Sampling frequency may be seasonal for recreational waters, daily for water supply intakes, hourly where waste treatment control is erratic and effluents are discharged into shellfish harvesting areas, or even continuous.

Sampling Collection - Bathing Beaches

Sampling locations for recreational areas should reflect water quality within the entire recreational zone. Include sites from upstream peripheral areas and locations adjacent to drains or natural contours that would discharge stormwater collections or septic wastes. Collect samples in the swimming area from a uniform depth of approximately 1 meter. Consider sediment sampling of the water-beach (soil) interface because of exposure of young children at the water's edge.

To obtain baseline data on marine and estuarine bathing water quality, include sampling at low, high, and ebb tides.

Sample Collection - Sediments and Sludges

The bacteriology of bottom sediments is important in water supply reservoirs, in lakes, rivers, and coastal waters used for recreational purposes, and in shellfish-growing waters. Sediments may provide a stable index of the general quality of the overlying water, particularly where there is great variability in its bacteriological quality.

Sampling frequency in reservoirs and lakes may be related more to seasonal changes in water temperatures and storm water runoff. Bottom sediment changes in river and estuarine waters may be more erratic, being influenced by stormwater runoff. increased flow velocities, and sudden changes in the quality of effluent discharges.

Bacteriological examination of sludges from water and wastewater treatment processes is desirable to determine the impact of their disposal into receiving waters, ocean dumping, or burial in landfill operations. Sludge monitoring also may indicate the effectiveness of wastewater treatment processes.

Sample Collection - Manual Sampling

Take samples from a river, stream, lake, or reservoir by holding the bottle near its base in the hand and plunging it, neck downward, below the surface. Turn bottle until neck points slightly upward and mouth is directed toward the current. If there is no current, as in the case of a reservoir, created a current artificially by pushing bottle forward horizontally in the direction away from the hand. When sampling from a boat, obtain samples from upstream side of boat. If it is not possible to collect samples from these situations in this way, attach a weight to base of bottle and lower it into the water. In any case, take care to avoid contact with bank or stream bed; otherwise, water fouling may occur.

Size of Sample

The volume of sample should be sufficient to carry out all tests required, preferably not less than 100 mL.

Sample Identification

Accompany samples by complete and accurate identifying and descriptive data. Do not accept for examination inadequately identified samples.

Sample Preservation and Storage and Shipment

1. Samples must be stored and shipped cold via same-day or overnight delivery.
2. HOLDING TIME: All bacterial samples must be placed on-test within 24 hours of sampling

*Adapted from Standard Methods for the Examination of Water and Wastewater, 18th Edition.

Additional Information

For more information concerning Cryptosporidium spiking studies, sampling, detection, immunofluorescent assay and current regulation, please call BioVir Laboratories at 1-800-GIARDIA (442-7342).

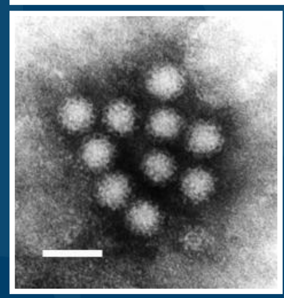
BioVir Protocols for Virus Sampling (EPA 1615)

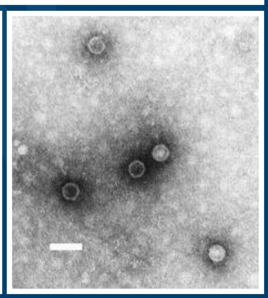
EPA/600/R-10/181 | December 2010 | www.epa.gov/ord

United States
Environmental Protection
Agency

Method 1615

Measurement of Enterovirus and Norovirus Occurrence in Water by Culture and RT-qPCR





Office of Research and Development
National Exposure Research Laboratory, Cincinnati, OH

8.4.4.2. Add 1.0 mL of a QC sample (see item 7.1.2) to the water.

8.4.4.3. Place a magnet into the vessel or container and stir for 10 minutes at a speed sufficient to create a vortex.

8.4.4.4. Pass the water through a sterile standard apparatus containing a sterile electropositive filter using a flow rate of approximately 10 L/minute.

8.4.4.5. Process and analyze the filter using the Elution (step 10), Organic Flocculation (step 11), Total Culturable Virus Assay (step 12) and Enterovirus and Norovirus Molecular (step 13) procedures.

8.4.5. QC sample stocks (item 7.1.2) are also to be used for the Positive Assay Control (see item 7.3.3 and step 12.1.2.3.2).

8.5. PE SAMPLES

8.5.1. PE samples will be sent to analysts in a randomized fashion and may contain no, low, medium, or high levels of Sabin poliovirus type 3 on the filter type (e.g., 1MDS or NanoCeram) used for sampling.

8.5.2. Process and analyze the PE filter using the Elution (section 10), Organic Flocculation (section 11), Total Culturable Virus Assay (section 12) and Enterovirus and Norovirus Molecular (section 13) procedures and according to any additional requirements supplied with the samples.

8.5.3. PE sample results should meet the method performance characteristics defined in section 14.

8.6. MATRIX SPIKE

Matrix spike should be run for every sample location initially and then after every 20^{th} sample from the same location. Matrix spikes duplicates are performed by collecting two samples at the sampling location as described in section 9, except that the sampling volume of the second sample is reduced by 10 L. The last 10L is collected in a 10 L cubitainer (item 6.2.3), shipped back to the laboratory, seeded with 1 mL of the matrix spike (item 7.1.3), passed through the duplicate filter, and analyzed by the method procedures (steps 10 through 12.2.11). The results of the analysis of the matrix spike must meet the performance measures in section 14.

8.7. RECORD MAINTENANCE

Laboratories shall maintain all records related to data quality. This shall include a record of the analyst name, date, and results of all QA controls performed, records of equipment calibration and maintenance, and reagent and material catalog and lot numbers used for all analytical procedures.

9. <u>SAMPLE COLLECTION, PRESERVATION, AND STORAGE</u>

9.1. SAMPLE COLLECTION

9.1.1. Filter sampling apparatus sterilization

9.1.1.1. Before each use, analytical laboratories must wash, and then sterilize the intake and cartridge housing modules, any necessary injector modules, and pumps as described in section 15.2.4.

9.1.1.2. Cover the apparatus module ends and the injector port(s) with sterile aluminum foil.

9.1.1.3. Place the injector module and tubing into a sterile bag or wrapping in such a way that they may be removed without contaminating them.

9.1.1.4. Ship the filter sampling apparatus components to the individuals who will be collecting water samples.

9.1.2. Preparation for sample collection

9.1.3. Note: Individuals collecting water samples for virus analysis must wear surgical gloves and avoid conditions that can contaminate a sample with virus. Gloves should be changed after touching human skin or handling components that may be contaminated (e.g., water taps, other environmental surfaces). Care must be taken to ensure that cartridge filters are properly seated in the housings. Housings with properly seated filters must not leak. Filters should be checked for proper seating upon opening the housing at the analytical laboratory by examining the gaskets for depressions that do not extend beyond the edge of the filter.]

9.1.3.1. Purge the water tap to be sampled before connecting the filter apparatus. Continue purging for 2-3 minutes or until any debris that has settled in the line has cleared.

9.1.3.2. Remove the foil from the backflow regulator. Loosen the swivel female insert slightly to allow it to turn freely and connect the backflow regulator to the tap. Retighten the swivel female insert. Disconnect the cartridge housing module at the quick connect, if connected, and cover the open end with sterile foil.

9.1.3.3. Remove the foil from the ends of the discharge module and connect it to the regulator module. Place the end of the regulator module or the tubing connected to the outlet of the regulator module into a 1 L plastic bottle.

9.1.3.4. Slowly turn on the tap and adjust the globe valve until the flow meter/totalizer reads 10 L/min. If the tap is incapable of reaching this flow rate, adjust the valve to achieve the maximum flow rate. Slower flow rates will result in longer sampling times.

9.1.3.5. Flush the apparatus assembly with at least 75 L of the water to be sampled. While the system is being flushed, measure the chlorine residual, pH, temperature, and the turbidity of the water collecting in and overflowing from the 1 L plastic bottle.

9.1.3.6. Record the pH, temperature, and turbidity values onto a sample data sheet.

9.1.3.7. Turn off the water at the tap.

9.1.4. Injector module adjustment (Note: If a NanoCeram filter is being used and if the water pH is 9.0 or less and if it does not contain a disinfectant, skip to section 9.1.5. If disinfected waters above pH 8.0 are being used with a 1MDS cartridge filter, substitute a double injector module for the single injector module in the following steps. With 1MDS filters under these conditions, use a second metering pump connected to the second connection on the double injector module to add 0.12 M HCl at a rate, which brings the pH of the water exiting the discharge module to 6.5 to 7.5.)

9.1.4.1. If the sample contains a disinfectant, turn off the water at the tap and disconnect the discharge module from the regulator module.

9.1.4.2. Remove the foil from the ends of an injector module and connect the module to the quick connect of the regulator module.

9.1.4.3. Turn on the metering pump. Set the pump to deliver 2.4 or 6±0.2 mL/minute for flow rates of 4 or 10 L/minute, respectively (see Table 2). Measure the flow exiting the injector module for several minutes to ensure that the flow rate is correct. Measure the chlorine residual and if present, re-adjust the flow rate until no residual is present. Re-mark the setting, if necessary. Turn off the metering pump.

9.1.5. Virus collection

9.1.5.1. If connected, remove the discharge module. Remove the foil from the cartridge housing module and connect it to the end of the regulator module, or if used, the injector module. Connect the discharge module to the outlet of the cartridge housing module.

9.1.5.2. If the water sample has turbidity greater than 75 NTU, remove the foil from each end of the prefilter module and connect the prefilter module between the regulator module or, if used, the injector module and the cartridge housing module.

9.1.5.3. Record the unique sample number, location, date, time of day and initial totalizer reading onto a sample data sheet (section 17.1).

9.1.5.4. If an injector module is being used, turn on the metering pump.

9.1.5.5. With the filter housing placed in an upright position, slowly open the water tap until it is completely open (Note: If the cartridge housing has a vent button, press it while opening the tap to expel air from the housing. When the air is totally expelled from the housing, release the button, and open the sample tap completely. If the housing does not have a vent button, allow the housing to fill with water before completely opening the tap).

9.1.5.5.1. After the tap is opened completely, check the flow rate and readjust to the recommended rate from Table 2, if necessary.

9.1.5.5.2. Check and readjust the metering pump rate, if necessary.

9.1.5.6. Using the totalizer readings, pass a volume of water through the apparatus that equals the volume specified in Table 2.

9.1.5.7. Turn off the flow of water at the sample tap at the end of the sampling period and record the date, time of day, and totalizer reading onto a sample data sheet (see section 17.1). Although the totalizer reading may be affected by the addition of thiosulfate, the effect is insignificant and may be ignored.

9.1.5.8. Loosen the swivel female insert on the regulator module and disconnect the backflow regulator from the tap. Disconnect the cartridge housing module and the prefilter housing module, if used from the other modules.

9.1.5.9. Turn the filter housing(s) upside down and allow excess water to flow out. Turn the housing(s) upright and cover the quick connects on each end of the modules with sterile aluminum foil.

9.2. SHIPMENT OF SAMPLES

9.2.1. Pack the cartridge housing module(s) into an insulated shipping box.

9.2.2. Add 6-8 small ice packs (prefrozen at -20°C) or double bagged ice cubes around the cartridge housings to keep the sample cool in transit (the number of ice packs or bags may have to be adjusted based upon experience to ensure that the samples remain cold, but not frozen).

9.2.2.1. Add an iButton (or other temperature recording devise) to a location in the shipping box where it will not come in direct contact with the ice packs or bags.

9.2.2.2. The temperature during shipment must be in the range of 1-10°C.

9.2.3. Drain and add the regulator and injector modules used.

9.2.4. Place the sample data sheet (protected with a closable plastic bag) in with the sample.

9.2.5. Drain and then cover the ends of the discharge module with foil. The discharge module may remain at the sampling site, if samples will be taken on a routine basis. If not, pack the module into the shipping box.

9.2.6. Close the insulated portion of the shipping box and tape to prevent any leakage of water. Close and label.

9.2.7. If the shipping box cannot be directly transported to the laboratory for virus analysis by close of business on the day collected or by the next morning, ship it to the laboratory by overnight courier.

9.3. LABORATORY HOLDING TIME AND TEMPERATURE

9.3.1. Record the date of arrival and the arrival condition on the sample data sheet packed with the sample. Print out the transit temperature reading from the iButton.

9.3.1.1. Attach the readout of the iButton or other temperature-recording device for recording the temperature during shipment to the sample data sheet.

9.3.1.2. Warning: The cartridge filters must arrive from the utility or other sampling site in a refrigerated, but not frozen, condition. The temperature during shipment must be in the range of 1-10°C.

9.3.1.3. Brief transient temperatures outside the acceptable range associated with the initial packing and closing of the shipping box and its opening at the analytical laboratory may be ignored.

9.3.2. Filters must be refrigerated immediately upon arrival. Ideally, viruses should be eluted from filters within 24 h of the start of the sample collection, but all filters must be eluted within 72 h of the start of the sample collection.

10. <u>FILTER ELUTION PROCEDURE</u>

10.1. ELUTION EQUIPMENT SETUP

10.1.1. Attach sections of braided tubing to the inlet and outlet ports of the cartridge housing containing the cartridge filter (see Figure 4). Note: If a prefilter or more than one electropositive filter was used to collect a sample, each filter must be eluted and analyzed separately using the procedures below.

10.1.2. Place the sterile end of the tubing connected to the outlet of the cartridge housing into a sterile 2 L glass or polypropylene beaker.

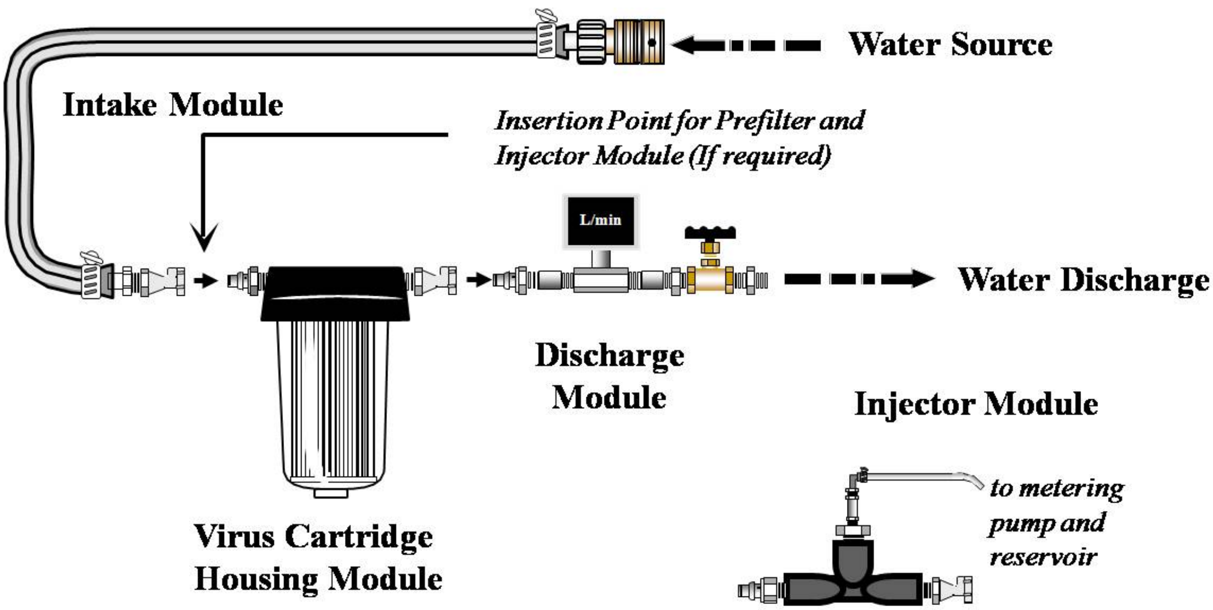


Figure 3. Sample Filtration Apparatus

Figure 4. Elution of an Electropositive Filter with Beef Extract

BioVir Protocols for Field-Filtered *Cryptosporidium* and *Giardia* Sampling (EPA 1623)

BIOVIR LABORATORIES, INC.

EXAMPLE PROCEDURE FOR COLLECTING FILTERED WATER SAMPLES (Using HV Envirochek Capsule Filters) FOR METHOD 1622/23 ANALYSIS

NOTE! The EPA method 1623: Cryptosporidium and Giardia in Water by Filtration/IMS/FA December 2005
Sample arrival temperature requirement is 0° C to < 20°C *
EPA target arrival temperature <10°C

* Adapted from EPA Document. See http;/www.epa.gov/microbes

Example Procedure for Collecting Filtered Water Samples for Method 1622/1623 Analysis

1.0 Required Materials

Have the following materials available prior to sampling:

- Several pair of new latex gloves*
- Sample Data sheet*
- HV Envirochek capsule Filter and Filer Sampling Equipment w/ 10L cubitainer*
- Small Return cooler w/ 250 mL Temperature blank
- Waterproof Sample label*
- Waterproof Pen
- Cooler / vessel for chilling of sample prior to shipment
- Ice for chilling of sample prior to shipping
- 2 plastic liners (bags)*
- 4-5 Gel Pacs (Frozen)* or
- Ice (cubes or crushed) for shipping
- 5 large ziplocks bags*
- Strapping or duct tape to seal cooler prior to shipping
- Shipping air bill (completed by utilities)

2.0 Collecting the Sample from a Pressurized Source

- Put on a pair of latex gloves.
- Flush the system for 2 to 3 minutes until any accumulated stagnant water or debris has cleared, or temperature and turbidity has become visibly uniform before connecting the sampling unit to the tap.
- While system is flushing record following information on the sample data sheet:
  - Public Water System (PWS)Name and Address
  - Sampler Name
  - PWS ID Number
  - Facility Name and PWS facility ID number
  - Sample collection point name and ID number
  - Sample collection date
  - Source water type (required for E. Coli sample forms)
  - Assay Requested (indicate if Regular or Matrix sample)
- After system has flushed, measure and enter water quality parameters such as temperature, turbidity, pH.
- Connect assembled sampling unit to the sample tap **(without capsule filter)** to sample tap, flush sampling unit for 2-3 minutes and test for leaks, and slowly adjust up an adequate flow. **(maximum** values 100 psi w/ flow restrictor).
- Turn off sample tap, install filter capsule **(retain blue vinyl caps)**, insert three (3) foot length tubing into effluent 10L cubitainer .
- Record start time on sample data sheet. Slowly turn on sample tap. When 10L cubitainer has reached fill mark, turn off sample tap. Record stop time
- **If taking a Matrix spike sample with this sample the two volumes must be the same (within 10%)**
- Hold Capsule filter (inlet pointing up), remove tubing allowing water to drain through the “out port” of the filter. Open bleed valve to speed draining process, and disconnect tubing from capsule filter.
- Seal capsule filter ends with blue caps, close bleed valve, and place into gallon ziplock bag. Seal and place into a second ziplock bag (ie. Double bag)

3.0 Pre-Chilling of Filter

*Supplied if Requested

• Place bagged filter and temperature blank into an ice bath. The filter will float semi- submerged in the ice water.
• A 25˚C filter and temperature blank will chill to approximately 6˚C in 1.5 hours
• Filter and temperature blank should be stored between 0 - 8˚C from time of filtration.
• Sample testing must be completed within 96 hours of sample collection.

4.0 Packing and Shipping the Sample Using Ice Cubes/Crushed Ice

• Create a double liner by inserting one plastic liner into the other. Line the cooler with the liners
• Divide 8-lbs of ice(cubes or crushed) into the ziplock bags, expel as much air as possible then seal. Secure the ends with tape.˚
• Place the chilled filter and temperature blank into the sample cooler, cover with a layer of bubble wrap or similar material. Place an ice pack on top of the insulating material.
• Seal each liner by twisting the top of each bag, and secure with tape.
• Place the completed sample data sheet (chain of custody) into a ziplock bag, seal and tape to the inside cooler lid.
• Close and seal the cooler lid.
• Attach your completed air bill to the cooler, retain sender copy. Send to processing lab
• Alert BioVir at least 24 hours prior to sample shipment date. Indicate courier used and request BioVir contact client if sample not received.
• If problems are encountered with the shipment, communicate with the shipping company and BioVir to resolve.

5.0 Packing and Shipping Sample Using Frozen Gel Pacs

• Create a double liner by inserting one bag liner into the other. Line cooler with the liners.
• Place each **FROZEN** gel pac into a ziplock.
• Place the pre-chilled filter and temperature blank into cooler, cover with a layer of bubble wrap or similar material. Place a frozen gel pac on each side and on top of the filter and temperature blank.
• Seal each liner by twisting the top of each bag, and securing with tape.
• Place the completed sample data sheet (chain of custody) into a ziplock, seal and tape to the inside cooler lid.
• Close and seal the cooler lid.
• Attach your completed air bill to the cooler, retain sender copy. Send to processing lab
• Alert BioVir at least 24 hours prior to sample shipment date. Indicate courier used and request BioVir contact client if sample not received.
• If problems are encountered with the shipment, communicate with the shipping company and BioVir to resolve.

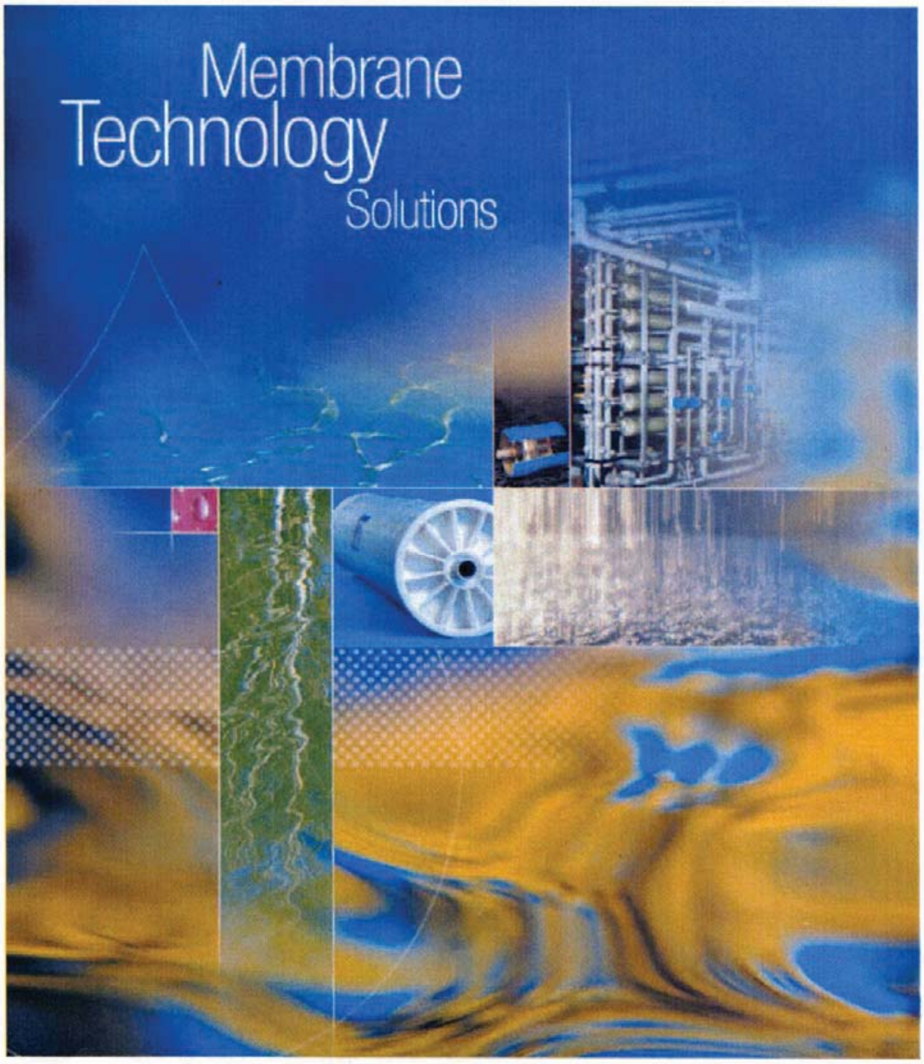
NOTE ! It is very important to use the double liners and ziplocks to prevent leakage from the sample cooler. Shipping companies may delay shipment if leakage occurs.

*Supplied if Requested

Appendix D

Operation, Maintenance, and Handling Manual for Toray Reverse Osmosis Membranes

Operation, Maintenance and Handling Manual for membrane elements



Version: October 2012

Notice

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This manual supersedes all previous versions. Technical modification of products or production technology may necessitate changes to information in this manual without prior notice. Please verify that your version of the manual is the latest version available by either contacting Toray, or checking online at www.toraywater.com

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Version: October 2012

Contents

Introduction

General

Proper operation and maintenance of Reverse Osmosis (RO) system are key factors in maximizing long-term plant availability and efficiency, and minimizing fault-related down time..

This manual contains check-lists and procedures for commissioning elements at start-up as well as providing useful information relating to normal operation and maintenance procedures. Separate sections cover membrane element performance data recording and normalization.

Conventions and symbols


Danger

This symbol indicates an imminent hazardous situation which will result in serious injury or death when the instruction is not observed.


Warning

This symbol indicates a potentially hazardous situation which will result in serious injury or death when the instruction is not observed


Caution

This symbol indicates a potentially hazardous situation which might result in injury or property damage when the instruction is not observed


Prohibited

“Prohibited”

This symbol indicates a prohibited action or procedure.


Instruction

“Instruction”

This symbol indicates an important action or procedure which has to be taken without fail.

Installation of RO elements

Prior to installation - preparations

1) Before directing any pre-treated feed water to elements, make sure piping system and pressure vessels are free of dust, oil, metal residues, organic deposits etc. This check should also be made when elements are reloaded or replaced.

2) Verify feed water quality matches system design values.

3) Flush system (without elements loaded) with pre-treated feed water for approx. 30 minutes.

4) Remove end plates from both ends of pressure vessel, check inside of the vessel and if necessary clean mechanically.

Instruction

If the inside of the pressure vessels are dirty, they should be cleaned. A soft mop or swab should be used, occasionally flushing with pre-treated water. Care must be taken not to scratch the inside surface of the vessels.

5) Install brine end adapter with O-rings into the permeate port of brine side end plate. Lubricate both parts using glycerin. Thrust ring should be used according to following note.

Note:

with “thrust ring”	without “thrust ring”
TM-series 8inch	others

Make sure “thrust ring” for absorption of axial thrust (this is a part of the pressure vessel) is installed for TM-series 8inch such that it will transmit axial forces from brine side element (this is the first element to be installed).

6) Optionally, permeate adapter with O-rings is inserted into the permeate port of brine side end plate at this stage. The risk of seal damage can, however, be minimized if this installation is done as last step, before re-fitting piping connections.

7) Attach brine side end plate onto the brine side of the vessel and install retaining ring set according to instruction manual of the pressure vessels.

To facilitate final control of element installation, it is useful to remove the head seal prior to insertion. Verification of full element insertion is easier this way, since the installed head seal usually provides for additional resistance upon removal of the end plate.

Instruction

All required parts (except the vessel permeate adaptors) are shipped with each element package from Toray.
Permeate adaptors and thrust devices are typically supplied by the pressure vessel manufacturer.
When ordering pressure vessels, please specify type of RO element to be installed to ensure correct parts are provided by the vessel manufacturer.

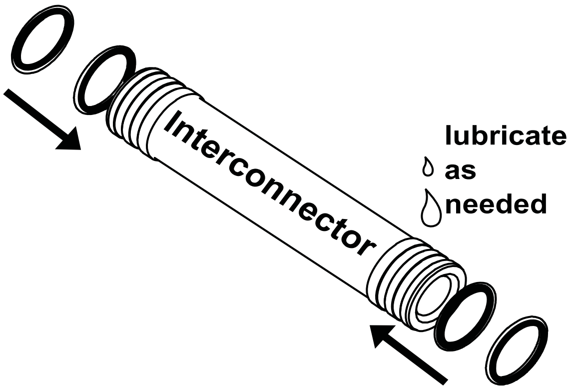
Unpack the elements.

1) Open element boxes, and remove RO elements and accessories. The accessories are separately packaged in small plastic bags inside the element box. Put empty boxes aside.

2) Prepare necessary parts as shown in the following table:

Parts	Required quantity
Brine seals	One per element
O-Rings	4 per element
Permeate port adaptor (open)	One per pressure vessel
Permeate plug adaptor (solid)	One per pressure vessel
Interconnectors	(qty. of elements) − (qty. of pressure vessels)

3) Assemble interconnectors with supplied O-rings carefully to avoid any scratches. Use glycerine as lubricant. Keep assembled interconnectors in a clean place until insertion into permeate tubes.



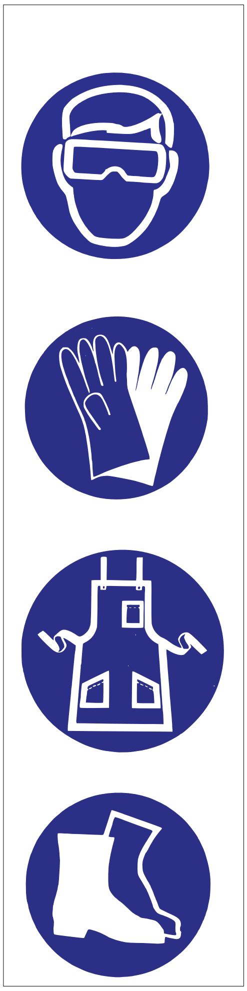
4) Safety considerations prior to opening of element packing bags:

Danger As shipped from Toray, new elements are packaged in approx. 0.5-1.0% sodium bisulfite solution, or sodium chloride solution with deoxidizer. Do not ingest these solutions. Solutions may be irritating to eyes and skin. Protection equipment is required. For details, see MSDS of sodium bisulfite solution.
The element shell is FRP (Fiber Reinforced Plastic). Beware of glass fiber strands and use correct safety equipment.

5) Cut open the element's shipping bag and prepare for insertion, following illustrations provided below.

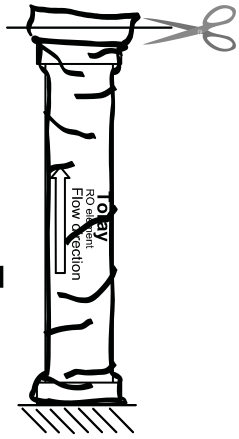
Toray elements come with a “flow direction arrow” laminated into the element shell. The arrow is simply provided to help ensure the brine seal is oriented in the right direction during installation. The arrow does not indicate a mandatory installation direction – the element can in fact be installed either way. The important point is the correct installation of the brine seal relative to direction of brine flow (see illustrations below)

Sample procedure



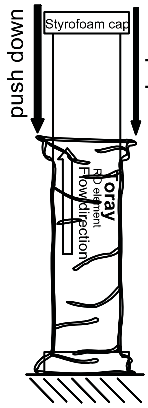
1.

Cut open the element's shipping bag at the top end

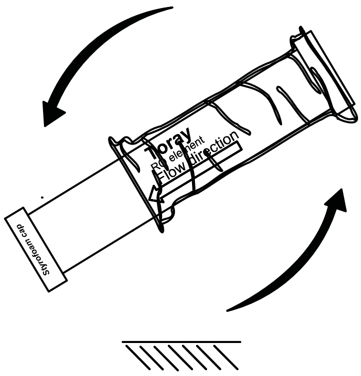


2.

Push down shipping bag. Leave upper styrofoam cap in place.

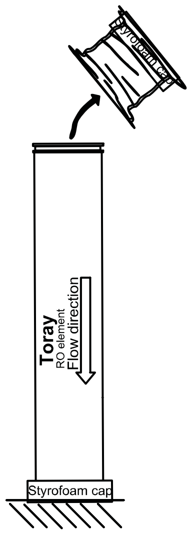


3.



Turn the element over. Element will stand on styrofoam cap now.

4.



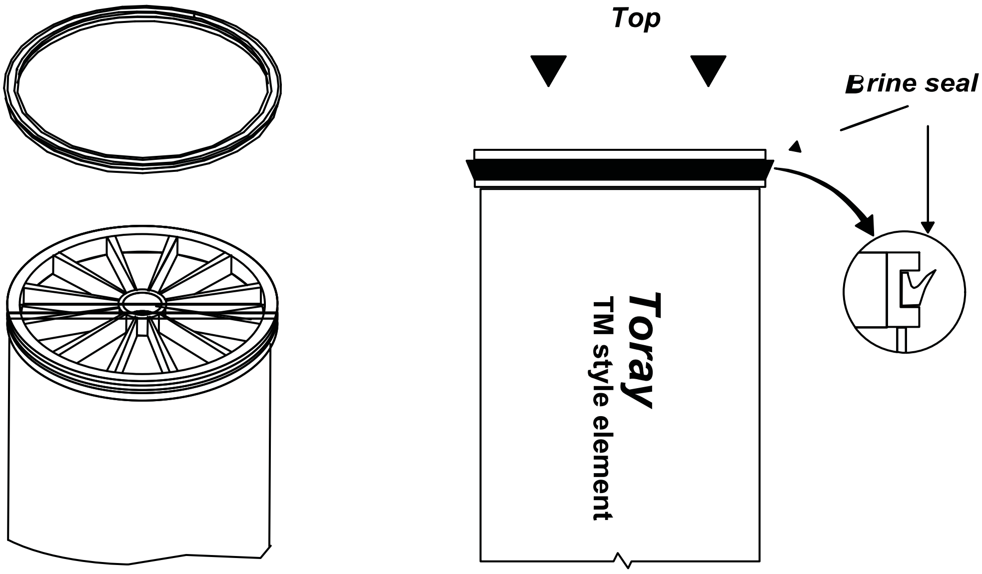
Remove top styrofoam cap, together with shipping bag.

The shipping bags are made of a special material which is a barrier to oxygen. This improves the useful lifetime of the preservation solution in the bag. If the bags are carefully and cleanly cut open at one end, some can be kept and re-used in case any RO elements need to be conserved or shipped.

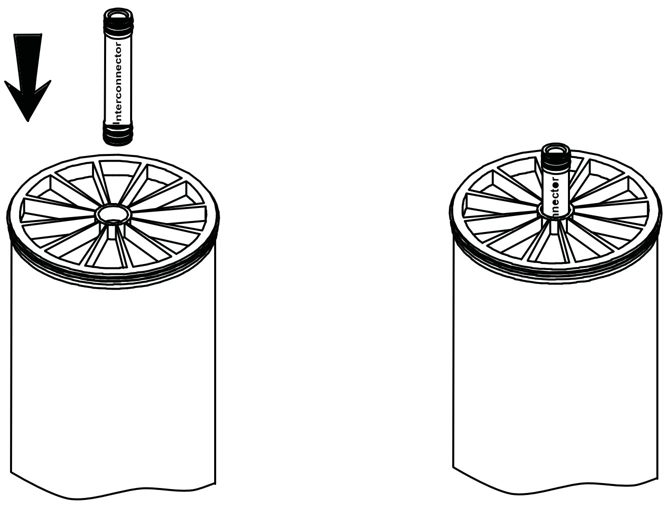
Assembly of element and accessories

1) Install brine seal:

Toray elements shipped from Toray Membrane USA will come with brine seal pre-installed, so this step can be omitted. Just check correct position of seal in this case. For other regions, follow subject illustration.



2) Install interconnector. Lubricate using glycerine as necessary.



Insertion of elements

Instruction

This is best done by a team of two persons.

Verify position and direction of the V-shaped brine seal as in illustration TMM-200.1.

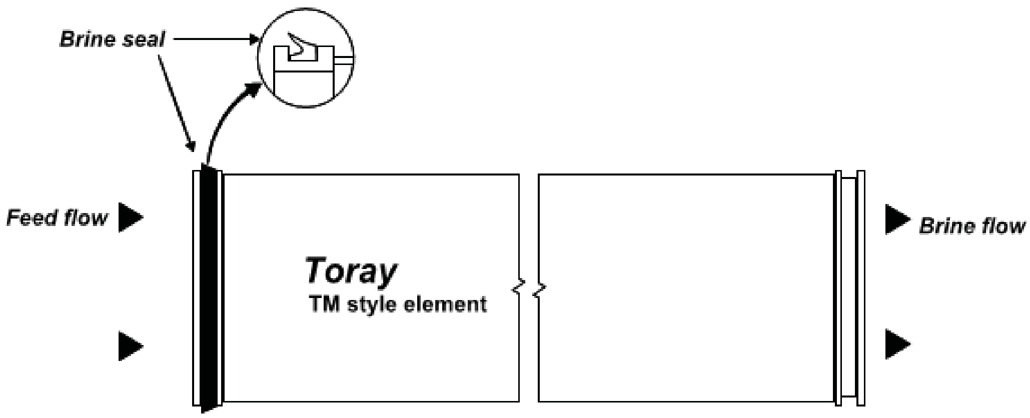


Illustration TMM-200.1: Orientation of brine seal

Caution Only one brine seal per element is required. Do NOT install two. The brine seal is typically fitted at the feed end of the element.

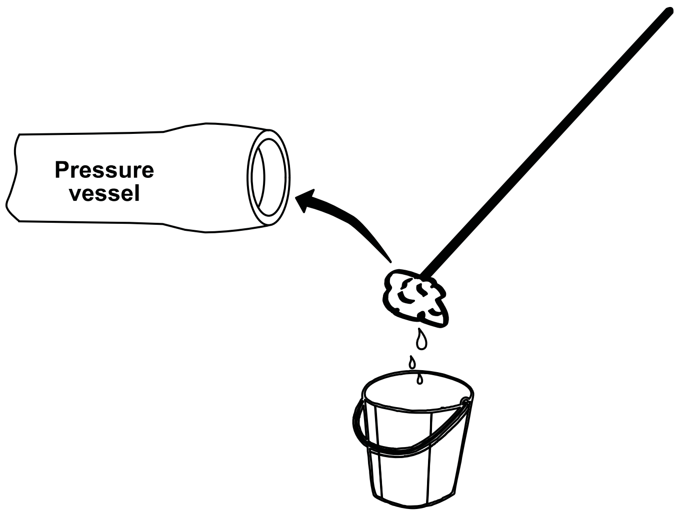
If not already performed, open the RO pressure vessel's feed side

This procedure can be prepared by removing any head locking devices, prior to starting unpacking of elements, if site conditions allow this.

Lubricate the inside of RO pressure vessel with water and glycerine. This will facilitate installation of elements (especially with longer pressure vessels containing multiple elements). Consider using approximately 100 ml of glycerine for each pressure vessel. If the viscosity of the glycerine is too high, dilute with clean water as needed for better lubrication.

Limit ingress of foreign matter, dust and dirt to vessels to a minimum by only opening/ closing one vessel at a time.

Use of a clean, soft mop or swab or similar tool will enable lubrication of the full length of the vessel. Take care not to scratch the inner surface of the pressure vessel.



After lubricating brine seals and vessel's inner surface with glycerine, insert element from feed side end into the pressure vessel. Approximately 2/3 of its length should be in the vessel, and 1/3 outside the vessel (see Illustration TMM-200.2), Insert element carefully and smoothly, especially the first element.

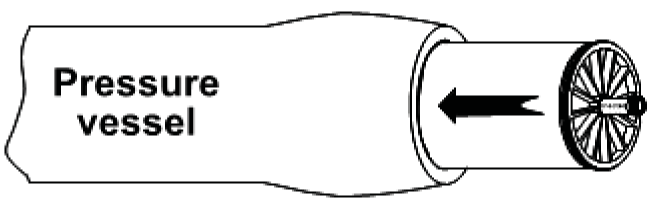


Illustration TMM-200.2: Insertion of first element

Attach brine seal to the second element as described for first element. Connect the two elements at the inter-connector, see Illustration TMM-200.3. The partly inserted element is best held in place by a helper. Now push both elements smoothly and firmly into vessel, keeping them in line to avoid damages to inter-connector or brine seal.

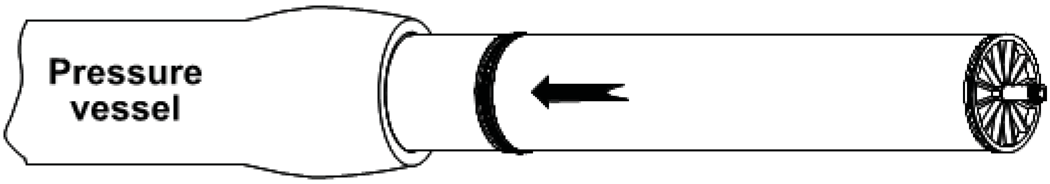


Illustration TMM-200.3: Insertion of following elements

Repeat procedure (see Illustration TMM-200.3). Insert elements one by one into the pressure vessel.

Insert the last element until only 1/3 of the element is outside the vessel

Locate and install correct brine end permeate adaptor (with O-rings) into the internal permeate port of the brine side end plate.

Note: if permeate is to be collected from the brine end of the vessel install the permeate port adaptor. If permeate is not to be collected at the brine end install the solid permeate plug adaptor.

Lubricate all O-rings with glycerine. (Note: this step can wait until just prior to end plate installation into the pressure vessel to minimize any risk of O-ring damage)

Locate and install Thrust ring into the brine side end of the pressure vessel (if provided)

A Thrust Ring is typically necessary for 8 inch (and larger) diameter elements. It’s purpose is to help absorb axial loads transmitted through the elements in the vessel during operation. It should not be omitted. Omission may result in the possibility of mechanical damage to the downstream elements.

Insert brine side end cap into the brine side of the vessel and install retaining ring set according to pressure vessel manufacturer’s instructions

It can be useful to check for complete adaptor insertion into the downstream element and correct position of the brine side end plate relative to the retaining ring groove by first removing the end plate seal (located on the circumference of the end plate). This reduces the resistance to movement of the end plate. The end plate seal MUST be replaced prior to final installation of the end plate.

Push the last element home until the downstream element permeate adaptor tube is firmly connected, and brine side end plate is securely located against the retaining ring set

To prevent premature wear of permeate seal rings, the elements cannot be allowed to move in the axial direction. The permeate ports are typically supplied by the pressure vessel manufacturer. Shim rings are also typically available from the pressure vessel manufacturer to fill remaining gaps or tolerances (see Illustration TMM-200.4).

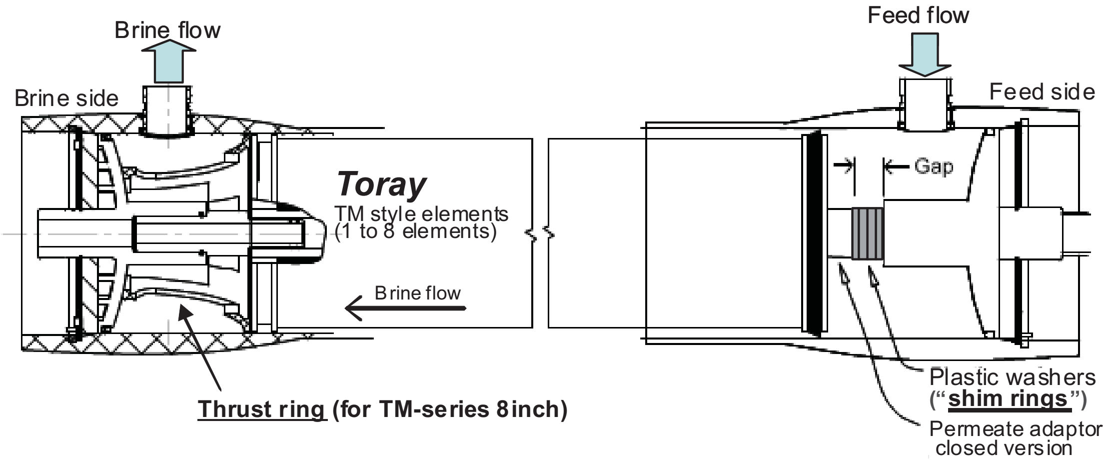


Illustration TMM-200.4: Applying shim rings

After installing all membranes, check distance "A" (see Illustration TMM-200.5). If distance "A" is bigger than the thickness of shim provided by the pressure vessel manufacturer, use the shim to fill the excess distance. Remained distance should be smaller than the thickness of shim. Shims must be positioned on the upstream end of the vessel.

The risk of mechanical disconnection of permeate adapters is especially high if the permeate header is connected to feed side of pressure vessel. The pressure vessel brine side is preferable over the feed side for installation of the permeate output connection to pipework.

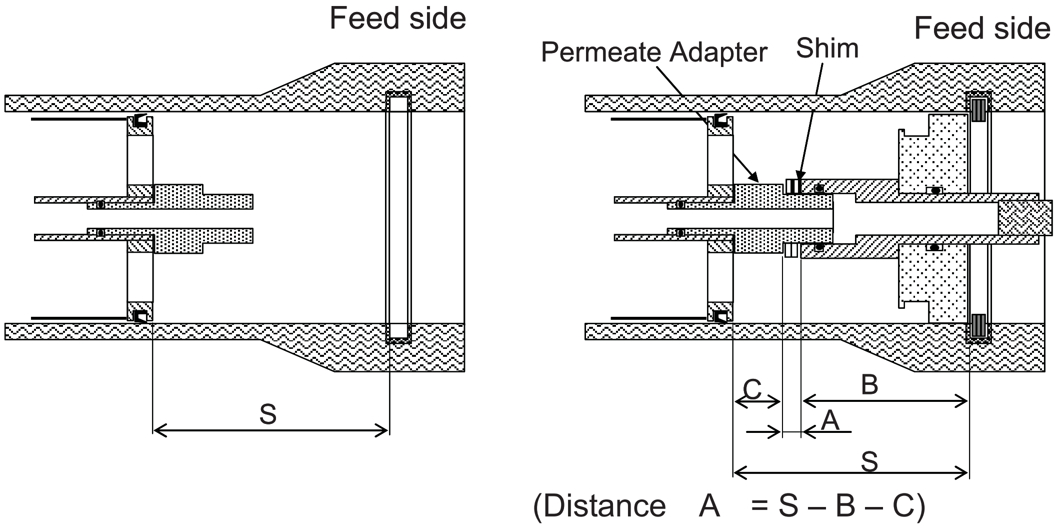


Illustration TMM-200.5: Shimming procedure

Permeate ports not used are best plugged with “closed” or “solid” type permeate adaptors (Permeate plugs) supplied by pressure vessel manufacturer. This provides the best protection against brine entering the permeate stream

Attach the feed side end plate of pressure vessel, and fit piping system to end plates. IMPORTANT: Make sure head seals for all pressure vessel end plates are installed at this time.

Documentation of loading process

Toray membrane elements bear individual serial numbers, which can be used to trace element origin and factory test results. It is recommended to record the numbers of RO elements installed during the loading process, indicating their exact installed location. A successful way to do so is to create a “membrane map” or “loading Diagram” similar to the sample below. Identification of the pressure vessel and elements are such facilitated for performance monitoring and troubleshooting:

Pressure vessel no. (or row/column position)	Brine	Element # 12345677	Other Element #'s …..	Element # 1234556	Feed

Pressure vessel no. (or row/column position)	Brine	Element # 12345687	Other Element #'s …..	Element # 1234546	Feed

(continue for further pressure vessels).

This can most easily and successfully be done using spreadsheet software (such as Microsoft Excel).

Initial start-up checks

After completely connecting piping works, carry out sequence of initial start-up checks as described in TMM-220 of Toray's Operation, Maintenance and Handling Manual for RO elements.

Element Removal

Elements may have to be removed from the pressure vessels. Some possible reasons are:

- Inspection
- Long term storage
- Shipment
- Replacement

The procedure to remove elements is as follows:

Caution

Before removing connection from the feed, brine and permeate piping ports on the pressure vessel, the remaining water in pressure vessel should be drained out to release the pressure inside.

1) Remove connection fittings from the feed, brine and permeate piping ports on the pressure vessel.

For side port and multiport pressure vessel configurations, removal of the permeate piping connections from the end plates is all that is required.

2) Remove the pressure vessel end plates from both the feed and concentrate ends of the pressure vessel.

3) Push the element stack into the vessel from the feed end of the pressure vessel. Push the element stack forward so the brine end element sticks out of the pressure vessel far enough for the operator to be able to grip the element and pull the reminder of the element out of the pressure vessel.

4) When removing the downstream element from the brine end of the pressure vessel, pull the element straight out. Do not apply any load up, down, or side to side on the interconnector that connects the element being removed to the upstream element(s) still remaining in the pressure vessel. Excessive load can damage the interconnector, product tube, brine seal, or interconnector O-rings.

5) Repeat procedures 3) and 4) to remove the remaining element(s) in the pressure vessel. A section of PVC pipe can be used to push the elements forward towards the brine end of the vessel for removal.

6) As elements are removed, take care to remove and retain all interconnectors and permeate end plate adapters. These parts may be reused. It is good engineering practice to replace all 0-ring seals with new ones prior to replacement.

If re-installation of elements is expected in the near future, it is recommended the elements are packed immediately into clean plastic bags, (see TMM-500: Storage).

For reloading elements, proceed according to TMM-200: Installation of RO elements.

For proper disposal of removed elements as industrial waste, please check local regulations and dispose accordingly.

Start-up checks for RO

Checks before commissioning

1) Prior to loading membrane elements and allowing water to enter the RO system, check the following:

- Feed water quality matches design values for selected RO elements
- Verify all dust, grease, oil, metal residues etc. have been removed from pipework installation.
- Ensure cleanliness of system; if necessary, clean according to TMM-200: Installation of RO elements.
- Fouling Index (SDI15)
- Turbidity (NTU)
- Chlorine and/or any other oxidants are absent from the RO feed
- Sufficient bisulfite surplus can be dosed (if used for chlorine removal).
- Verify all instruments and components are operating properly

Caution

- If chlorine dioxide is used for raw water sanitation, a combination of bisulfite dosing and activated carbon is strongly recommended for reliable total removal of oxidants. Experience has shown that bisulfite dosing alone will not suffice in this situation.

- Pretreatment is working correctly. Ensure dosing of any flocculants used in the pretreatment (in particular cationic compounds and some nonionic compounds), are optimized so such compounds are not present in the RO feed water

Caution

Filter Cartridges must be free of surfactants, lubricants and textile aides. Either ensure the filters are supplied without such additives, or, if unsure if they are present, flush the cartridges according to published guidelines of cartridge manufacturer.

Install RO elements. Refer to Section TMM200: Installation. Make sure all fittings are tight (in particular Victaulic® couplings and pressure vessel end plate retaining rings).

2) Following element installation, purge air from piping system, including all headers and RO vessels, for minimum one hour. Use pre-treated feed water at low feed pressure, with brine valve fully opened. Pay attention not to exceed allowed ranges for flow and differential pressure!

To avoid a "water hammer" condition resulting from a mixture of air and water being present in the piping, it is recommended that the piping be vented to atmosphere to purge any entrained air while filling the piping. The initial flow rate should be kept low to avoid unsafe conditions.
Once brine flow is observed from the brine piping, increase the flushing flow rate to expel any remaining air that may be present in the piping through the vent ports.
Some pockets of air can be difficult to remove. It is recommended that the flush procedure be started and stopped several times to help move any remaining pockets of air to the venting port(s). Continuous flushing may only pressurize the air while allowing it to remain trapped in the piping.
Suggested flush flow rates when venting air from piping depend on the pressure vessel diameter.

- For 8" vessels regulate the flush flow rate to 40 l/min (11.0 gpm) per vessel
- For 4" regulate the flush flow rate to 10 l/min (3.0 gpm) per vessel.

While flushing to remove air in the piping, keep the line pressure < 0.1MPa(15 psi).

It is important to open any permeate side isolating valves, and minimize permeate side back pressure during flushing procedure. Brine pressure should be always higher than permeate side pressure to avoid permeate back pressure problems.
For detailed instructions for flushing procedure, see TMM-250: Flushing procedure.

Pressure drop (feed to brine) across a pressure vessel / a single RO element must never exceed the following values:

Element types TM	Per vessel	Per single element
8”	0.4 MPa (60psi)	0.15 MPa (22psi)
4”	0.4 MPa (60psi)	0.15 MPa (22psi)

3) After bleeding all air from the system, the initial trial run for the RO can commence according to design operating parameters

In particular, adjust the following parameters to design values:

- Permeate flow rate
- Recovery ratio

And check the Operating pressure

Operate for at least 1hour, and check permeate quality.

During the initial trial run, dump permeate and brine to drain. Do not operate any internal concentrate recirculation during trial run, (if the system has recirculation capability)

4) Check quality of permeate and system performance as follows:

Check the permeate conductivity for each vessel. If conductivity of permeate is much higher than expected, check O-rings, brine seals etc. of the vessel affected, and change parts if necessary. Log all data and record corrective measures taken.

Data should be taken as a minimum requirement 1, 24, and 48 hour after start-up.ly. These data points should be used for normalization standard data. It is therefore very important all the instrumentation is correctly calibrated before start up.

The following data should be considered the minimum to be recorded during initial operation:

- Feed conditions:
  - RO feed pressure
  - Water temperature
  - TDS (conductivity)
  - pH
  - Silt Density fouling index (SDI15)
  - Turbidity (NTU)
  - Chlorine (must be not detectable*)),

- Brine:
  - Flow
  - TDS (conductivity),
  - pH
- Permeate:
  - Permeate flow of each stage (and total system)
  - TDS (conductivity) from each vessel and total system.
  - Permeate pressure (for each bank)
- differential pressure across each RO bank,

It is recommended to take feed water, brine water and permeate water samples for analysis of individual ions.

A typical data log sheet is shown in section TMM-230 Operation Monitoring.

*) : If $NaHSO_3$ is dosed for chlorine removal, a minimum of 0.5 mg/l HSO_3 must be detectable in brine at any time to ensure full removal of chlorine

Regular start-up checks for daily operation

1) Check feed water quality is meeting recommendations for membrane elements loaded in the system.

2) Flush RO system with pre-treated feed water at low feed pressure prior to start of high pressure pump to remove air from the system.

NOTE: Following instructions are for a “generic” start procedure for a system using a centrifugal pump with feed and brine flow control valves. For other options, see later section “General Start-up procedures for different High pressure pump (HPP) configurations”

Regulating valve between high-pressure pump discharge and membranes should be nearly closed at high pressure pump start-up to avoid excessive flows and possibility of water hammer.

3) Gradually increase feed pressure and feed flow rate to RO elements while throttling brine flow rate. Avoid excessive flow rates and differential pressures across RO banks during start up!

Caution

At any time, maximum pressure drop across any vessel is 0.4 MPa (60 psi) for TM-element types. Details are given on specification sheets published for each element type.

5) Adjust RO operating parameters to design permeate and brine flow rates. Do not exceed design recovery ratio (defined as permeate flow/feed water flow) during any stage of operation.

5) Dump permeate water to drain until required water quality is obtained.

Parameters for start-up procedures

The following parameters are important, and must be maintained during start up of RO systems. The design and control of the RO system must be suitable to ensure the following can be maintained

1. Pressure increase < 0.07Mpa (10psi) / sec at any time during startup sequence
2. Feed flow increase < 5% / sec of final flow
3. Permeate pressure lower than brine pressure at all times, **especially during flushing phase, and transient conditions during start up sequence**.

Caution

The installation of check valves alone on the permeate header may be insufficient to ensure requirement #3, especially with ultra-low pressure element types. During flushing, ensure that the permeate line is truly at atmospheric pressure and permeate pressure is always lower than brine pressure. Alternatively, direct the brine and permeate flows to one common discharge line during flushing sequence, ensuring equal static water column for both streams.

General Start-up procedures for different High pressure pump (HPP) configurations

NOTE: The information provided here is for general reference only. Pumps , energy recovery devices (ERD's) and associated control equipment are not supplied by, or operated by Toray, and Toray accepts no liability which may result from incorrect usage or installation of such devices. Consult your OEM equipment manual or the pump supplier for information regarding safe operation of specific pump models on your system. For detailed instructions regarding safe operation of energy recovery devices (ERD's), please consult your OEM equipment manual, or contact your ERD supplier.

This section describes typical start-up procedures, sorted by type of HPP.
RO systems will usually employ one of those four different types of high-pressure pumps:

1) Plunger (displacement) pump system with constant speed motor (Illustration TMM-220.1)

1. Open brine control valve (V_B), to approx. 50%.
2. Open relief loop valve (V_R).
3. Close feed pressure control valve (V_F), if installed.
4. Start high pressure pump (HPP).
5. Slowly open V_F and close V_R until brine flow reaches design value.
6. Close V_B until brine flow starts decreasing. Feed pressure now starts to increase.
7. Check feed pressure, pressure drop and permeate flow.
8. Repeat procedure 5-7 step by step until permeate and brine flow match design.

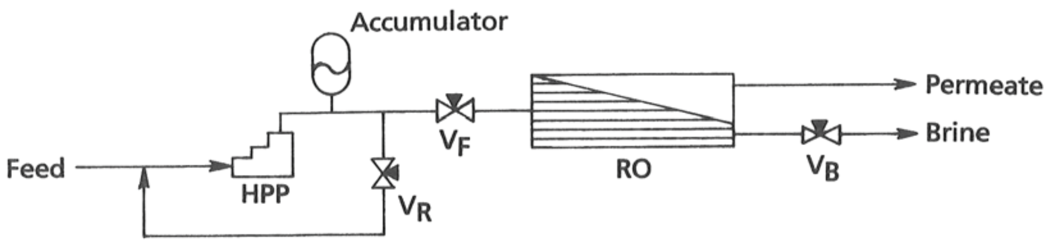


Illustration TMM-220.1: Plunger (displacement) pump system with constant speed motor

2) Centrifugal pump system with constant speed motor (Illustration TMM-220.2)

1. Open brine flow control valve (V_B), to approx. 50%.
2. Open minimum flow valve (V_M).
3. Close feed pressure control valve (V_F). If no V_M is installed, throttle to minimum flow.
4. Start high pressure pump (HPP).
5. Slowly open V_F until brine flow reaches design value (observe note!).
6. When minimum flow for HPP is reached, close V_M (if installed).
7. Close V_B until brine flow starts decreasing. Feed pressure now starts to increase.
8. Check feed pressure, pressure drop and permeate flow.
9. Repeat procedure 5-7 step by step until permeate and brine flow match design.

Note: In case excessive brine flow is obtained at point 4 (watch ΔP), brine flow control valve V_B must be throttled from step (1).

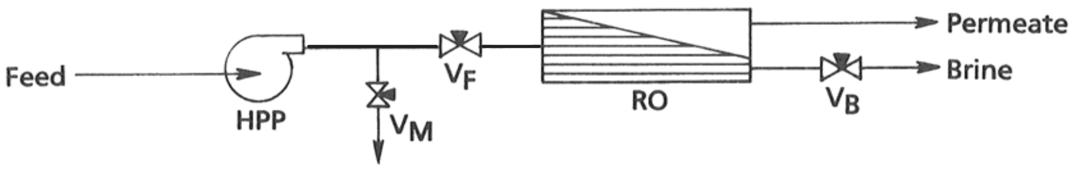


Illustration TMM-220.2: Centrifugal pump system with constant speed motor

3) Centrifugal pump system with constant speed motor and soft start (Illustration TMM-220.3)

1. Open brine flow control valve (V_B).
2. Throttle feed pressure control valve (V_F) to approx. 10% .
3. Start high pressure pump (HPP), (see note (A),(B)).
4. Slowly open V_F until design brine flow is reached.
5. Close V_B until brine flow starts decreasing. Feed pressure now starts to increase.
6. Check feed pressure, pressure drop and permeate flow.
7. Repeat procedures 4-6 step by step until permeate and brine flow match design.

Note(A): In case excessive brine flow is obtained, (watch ΔP), brine flow control valve (V_B) should be set to throttled position in advance.

Note(B): In order to avoid excessive feed flow, feed valve is to be throttled from the beginning.

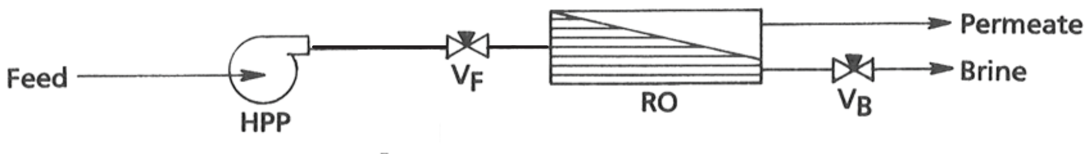


Illustration TMM-220.3:
Centrifugal pump system with constant speed motor and soft start

4) Centrifugal pump system with frequency controlled motor (Illustration TMM-220.4)

1. Open brine flow control valve (V_B).
2. Start high pressure pump (HPP) at minimum frequency (speed).
3. Increase speed of HPP until design brine flow is reached.
4. Close V_B until brine flow starts decreasing. Feed pressure now starts to increase.
5. Check feed pressure, pressure drop and permeate flow.
6. Repeat procedure 3-5 step by step until permeate and brine flow match design.

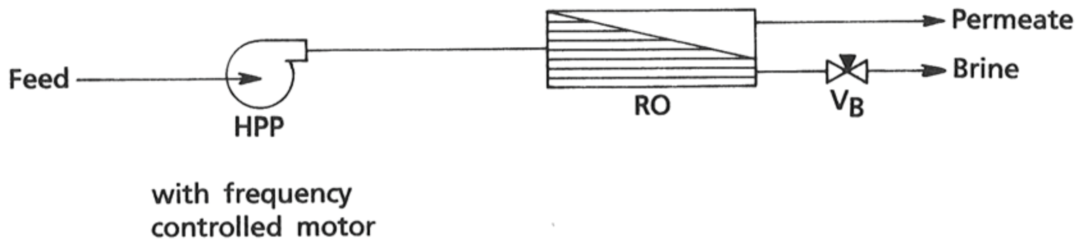


Illustration TMM-220.4: Centrifugal pump system with frequency controlled motor

Note: Above Illustrations TMM-220.1 – 220.4 are for general explanation of high-pressure pump start-up procedures only. Some of the necessary equipment and instruments are not shown.

Operation Monitoring

Monitoring of a RO system's performance is a fundamental prerequisite to ensure dependable RO system performance. Regular RO system performance records will provide a solid basis for troubleshooting and evaluating membrane element and system performance.

Monitoring

Operating data to be logged and data logging intervals are listed in Tables 1.A through Table 1.C.

Table 1.D summarizes typical water analysis items for periodic comparison to earlier (original) analytical data.

Table 1.E summarizes items for scheduled or system performance related maintenance.

Regular Monitoring and Check Points

When feed water quality and operating parameters (such as pressure, temperature, differential pressure and recovery) are constant, permeate flow rate and permeate quality should also remain essentially constant (±5 %).

If operating parameters change, regular performance normalizations of current data are necessary to compare normalized data to original (start up) performance values. Confirm that the current normalized performance is in agreement with the original (Start-up) system design parameters.

Frequency of normalizations required will depend on the extent and frequency of variations in feed water quality and operating conditions.

It is also advisable to perform normalization calculations before and after any scheduled maintenance procedures. If, after such maintenance procedures, the normalized performance data indicates significant deviations from original operating parameters, system adjustments may be required to return performance to the original RO system design parameters.

Logbook

A log book should be maintained. All relevant operational events (however trivial they may seem to be at the time) and their date of occurrence should be recorded for future reference. Some key operational parameters to record are as follows:

Parameters	Key factors affecting performance
Permeate quality	• Feed water chemical composition (total concentration of ions) • Feed pH • Feed water Temperature • Pressure of Feed, Brine and permeate for each stage • Feed Water quality (total ions, colloids and suspended solids; fouling tendency (SDI15 by Millipore Type HA) • Recovery (conversion) ratio
Permeate flow rate	• Recovery (conversion) ratio • Pressure at Feed, Brine and permeate of each stage • Feed Water Temperature • Feed Water quality (total ions, colloids and suspended solids; fouling tendency (SDI15 by Millipore Type HA)

Normalization of system performance

In order to effectively evaluate current system membrane element performance, it is necessary to compare currently recorded membrane performance data to initial membrane performance data recorded at the time the membranes were first placed in service.

As the current conditions of operation may be different (different salinity of the feed, different water temperature etc.) the current data must be “”normalized” to the original start up operating conditions to allow direct and meaningful comparison. “Normalization” therefore refers to the manipulation of current data to reflect what the flows, and quality parameters would be if the plant was actually operating at the original (start up) conditions.

By comparing initial membrane performance data (new elements) with current “normalized” membrane performance data, we can determine if any membrane element maintenance (such as a chemical cleaning or system adjustments) is required.

Toray normalization software (TorayTrak) performs these calculations. It is available to download on the Toray web site at no charge:

Download site: http://www.toraywater. com

For general information on TorayTrak, see this section “Normalization program TorayTrak”, page 40.

Precautions and useful information for monitoring operating data

Daily monitoring of operating parameters provides a solid basis for evaluation of RO system performance.

Quick recognition of undesirable trends in normalized operating data allows timely application of appropriate countermeasures, and avoids irreversible damage to membrane elements or other system components

Guidelines for maintenance (considerations for cleaning) are described in TMM-310: Guidelines for RO cleaning

Troubleshooting guides are described in the Troubleshooting Sections TMM 600 and 610

Typical signs of system performance change are shown in section TMM-610: Typical Performance Changes and Countermeasures

In order to evaluate actual system status and to detect trends early, a graph of normalized performance data is highly recommended. (see Illustration TMM-230.1)

For specific projects and special membrane element applications, please consult the Toray warranty for special conditions and requirements regarding the extent and frequency of plant monitoring.

RO System Operation Parameters and logging intervals

Table1. A: Softened drinking or well water, SDI < 2, peak 3; NTU < 0.3, peak 0.5

Parameters	Online Monitoring (Continuously)	Daily (datasheet)	Periodically[1]	Alarm &safety system
1. Date and time of data logging		X		
2. Total operating hours		X		
3. Number of vessels in operation			X	
4. Feed water conductivity	X[2]	X		
5. Total hardness		X		X
6. Feed water pH	X	X	X	
7. Feed water FI (SDI_{15})		X		
8. Feed water temperature	X[3]	X		X[3]
9. Feed water pressure	X	X		X
10. Feed water chlorine concentration	X[4]	X[4]		X[4]
11. Feed water ORP *)	X[8]	X		
12. Brine surplus of HSO_3 (> 0.5 mg/l) **)		X		X
13. Feed water individual ion concentration			X[6]	
14. Brine conductivity		X		
15. Brine pH	X[7]		X	
16. Pressure drop of each bank	X	X		X
17. Brine flow rate	X	X		X
18. Total permeate conductivity	X	X		X
19. Permeate conductivity of each vessel			X	
20. Permeate pressure	X[5]	X		X[5]
21. Total permeate flow rate	X	X		X
22. Permeate flow rate for each bank		X		
23. Permeate individual ion concentration			X[6]	
24. Total recovery ratio		X		
25. Recovery ratio for each bank			X	
26. Normalized salt passage			X	
27. Normalized permeate flow rate			X	
28. Brine pressure	X	X		
29. Brine pressure - Permeate pressure	X	X		X

*) The ORP meter reading should always be below 350 mV with SBS dosing.
**) HSO_3^- surplus in brine >= 0.5 mg/l if raw water is chlorinated

Notes:
(1) Log these parameters monthly from initial start-up operation. In case of trouble shooting or fluctuating operating conditions, the operating party is requested to check these parameters more frequently, depending on particular situation.
(2) In case of significant fluctuations

(3) In case of high fluctuations or heat exchanger systems
(4) If chlorine is detected in feed water, plant must be stopped immediately and flushed with chlorine-free water.
(5) In case of fluctuating pressure > 0.5 MPa, closed permeate loop or (automatic) valve → risk of water hammer.
(6) Recommended procedure is water analysis of individual ions, comparing results with projected data. Required typical ions are listed in Table 1D.
(7) In case of high fluctuations or acid dosing
(8) In case of prechlorination / dechlorination only

Table1B: Drinking or well water, SDI < 3, peak 4; NTU < 0.3, peak 0.5

Parameters	Online Monitoring (Continuously)	Daily (datasheet)	Periodically[(1)]	Alarm &safety system
1. Date and time of data logging		X		
2. Total operating hours		X		
3. Number of vessels in operation		X	X	
4. Feed water conductivity	X[(2)]	X		
5. Feed water pH	X[(3)]	X		X[(3)]
6. Feed water FI (SDI_{15})		X		
7. Feed water turbidity (NTU)	X		X	
8. Feed water temperature	X[(4)]	X		X[(4)]
9. Feed water pressure	X	X		X
10. Feed water chlorine concentration	X[(5)]	X[(5)]		X[(5)]
11. Feed water ORP *)	X[(9)]	X		
12. Brine surplus of HSO_3 (> 0.5 mg/l) **)		X[(8)]		X
13. Antiscalant concentration in feed water		X		X[(5)]
14. Feed water individual ion concentration			X[(6)]	
15. Brine conductivity		X		
16. Brine pH	X[(3)]	X		
17. Pressure drop of each bank	X	X		X
18. Brine flow rate	X	X		X
19. Total permeate conductivity	X	X		X
20. Permeate conductivity of each vessel			X	
21. Permeate pressure	X[(7)]	X		X[(7)]
22. Total permeate flow rate	X	X		X
23. Permeate flow rate for each bank		X		
24. Permeate individual ion concentration			X[(6)]	
25. Total recovery ratio		X		X
26. Recovery ratio for each bank			X	
27. Normalized salt passage			X	
28. Normalized permeate flow rate			X	
29. Brine pressure	X	X		
30. Brine pressure - Permeate pressure	X	X		X

*) The ORP meter reading should always be below 350 mV with SBS dosing.
**) HSO_3^- surplus in brine >= 0.5 mg/l if raw water is chlorinated

Notes:
(1) Log these parameters monthly from initial start-up operation. In case of trouble shooting or fluctuating operating conditions, the operating party is requested to check these parameters more frequently, depending on particular situation.
(2) In case of significant fluctuations
(3) In case of high fluctuations or acid dosing
(4) In case of high fluctuations or heat exchange system
(5) If there is any possibility of chlorine content in feed water

(6) Recommended procedure is water analysis of individual ions, comparing results with projected data. Required typical ions are listed in Table 1D.
(7) In case of fluctuating pressure > 0.5 MPa, closed permeate loop or (automatic) valve → risk of water hammer.
(8) Volumetric recording of daily consumption, divided by total daily feed flow.
(9) In case of prechlorination / dechlorination only

Table1C: Surface water/tertiary effluent, SDI < 4, peak 5; NTU < 0.3, peak 1.0

Parameters	Online Monitoring (Continuously)	Daily (datasheet)	Periodically[1]	Alarm &safety system
1. Date and time of data logging		X		
2. Total operating hours		X		
3. Number of vessels in operation		X		
4. Feed water conductivity	X	X		
5. Feed water pH	X	X		X
6. Feed water FI (SDI_{15})		X		X
7. Feed water turbidity (NTU)	X	X		X
8. Feed water temperature	X	X		X
9. Feed water pressure	X	X		X
10. Feed water chlorine concentration	X	X		X
11. Feed water ORP *)	X	X		
12. Brine surplus of HSO_3 (> 0.5 mg/l) **)		X		X
13. Antiscalant concentration in feed water		X		X
14. Feed water individual ion concentration			X[2]	
15. Brine conductivity		X		
16. Brine pH	X	X		
17. Pressure drop of each bank	X	X		X
18. Brine flow rate	X	X		X
19. Total permeate conductivity	X	X		X
20. Permeate conductivity of each vessel			X	
21. Permeate pressure	X	X		X
22. Total permeate flow rate	X	X		X
23. Permeate flow rate for each bank		X		
24. Permeate individual ion concentration			X[2]	
25. Total recovery ratio		X		X
26. Recovery ratio for each bank			X	
27. Normalized salt passage			X	
28. Normalized permeate flow rate			X	
29. Brine pressure	X	X		
30. Brine pressure - Permeate pressure	X	X		X

*) The ORP meter reading should always be below 350 mV with SBS dosing.
**) HSO_3^- surplus in brine >= 0.5 mg/l if raw water is chlorinated

Notes:
(1) Log these parameters monthly from initial start-up operation. For trouble shooting or fluctuating operating conditions, additional check-ups are required, depending on particular situation.
(2) Recommended procedure is water analysis of individual ions, comparing results with projected data. Required typical ions are listed in Table 1D.

Table 1D: Typical Water Analysis Items

Items		Feed Water	Permeate
1. Conductivity (25 °C)	(µS/cm)	X(1)	X
2. Total dissolved solids	(TDS)	X	X
3. pH	(-)	X	X
4. Chloride	(Cl^-)	X(1)	X
5. Nitrate	(NO_3^-)	X	X
6. Bicarbonate	(HCO_3^-)	X(1)	X
7. Sulfate	(SO_4^{2-})	X	X
8. Phosphate	(PO_4^{3-})	X	
9. Fluoride	(F^-)	X	
10. Sodium	(Na^+)	X	X
11. Potassium	(K^+)	X	X
12. Ammonium	(NH_4^+)	X	
13. Calcium	(Ca^{2+})	X(1)	X
14. Magnesium	(Mg^{2+})	X(1)	X
15. Strontium	(Sr^{2+})	X	
16. Barium	(Ba^{2+})	X	
17. Iron as ion	(Fe^{3+})	X	
18. Manganese	(Mn^{2+})	X	
19. Silicate	(SiO_2)	X	X
20. Silicic acid	(SiO_3^-)	X	X
21. Boron	(B)	X(2)	X(2)
22. Chemical oxygen demand	COD	X	
23. Biological oxygen demand	BOD	X	
24. Total organic carbon	TOC	X	X
25. Carbon Dioxide	(CO_2)	X	
26. Microorganism	(unit/cc)	X	
27. Hydrogen Sulfide	(H_2S)	X	
28. Temperature	(°C)	X	

Note:

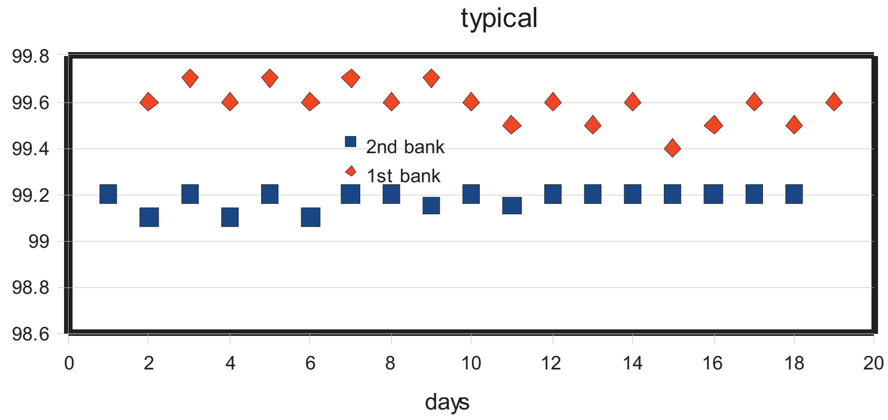
Above table is for reference only. Selection of required ions for analysis will also depend on feed water quality and required permeate quality.

(1) These values constitute the minimum information required for a qualified RO lay-out. Ions not analyzed will not be available for calculation of scaling potentials.
(2) In case of specified data for permeate quality.

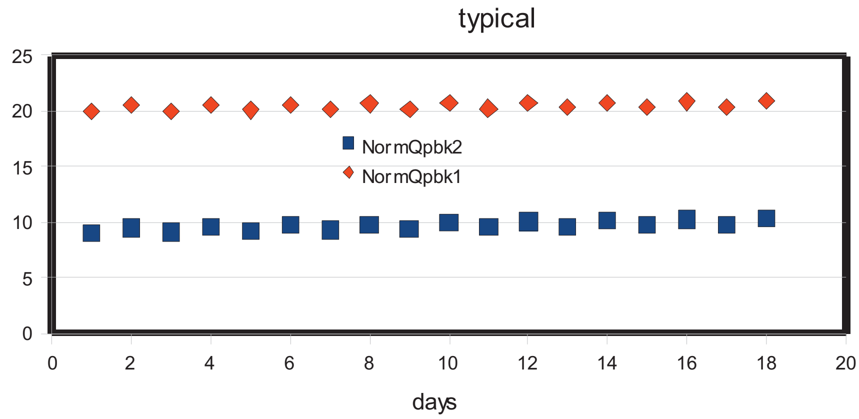
Table 1.E: RO System Maintenance Items (to be noted in System Log)

Items	Frequency & Procedure
1.Instruments 1) pressure sensors & indicators 2) System control devices 3) Safety shut-down facilities	Regular calibration and maintenance should be performed according to the maintenance manual supplied by manufacturer.
2.Cartridge Filter Change Use only new pre-washed filter cartridges free of surfactants and chemical additives introduced during cartridge filter manufacture.	Record cartridge filter housing differential pressures before and after installation of cartridge filters It is also beneficial to record the date of installation and filter model #
3.RO system cleaning As a minimum, record the following: Type of cleaning solution the solution concentration and conditions during the cleaning (pressure, temperature, flows, pH, conductivity)	Perform according to maintenance manual supplied by system manufacturer. TORAY membrane element cleaning guidelines and instructions are referenced in TMM Sections 310 and 320.
4.Membrane Treatment upon shutdown Record preservation method, concentration of preservative solution, operating conditions before shut down and duration of shutdown.	Perform according to system manufacturer's operating manual. TORAY guidelines & instructions for long and short term membrane element preservation can be found in TMM Sections 240 and 260
5.Pretreatment Operating Data RO system performance depends largely on proper operation of the pretreatment systems.	Residual chlorine conc., Discharge press. of booster pump, consumption of all chemicals, calibration of gauges and meters.
6.Maintenance Log	Record any routine system maintenance procedures, mechanical,failure events and change of position or replacement of any membrane elements. .

Normalized Salt Recjection



Normalized Permeate Flow Rate



Differential pressure

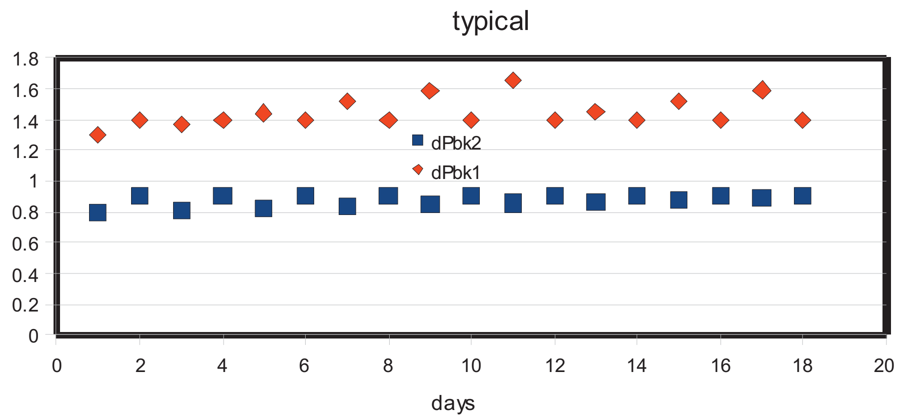


Illustration TMM-230.1: Typical monitoring chart for an RO system

--Daily monitoring and data normalization are recommended. Watch out for performance change trends. In the above example, Illustration TMM-230.1, no performance changes are indicated, which is typical for reasonable system operation.

Normalization program TorayTrak

To assist in RO system performance data normalization TORAY developed a RO performance data normalization program called TorayTrak. TorayTrak is available as a free download at the Toray web site www.toraywater.com.

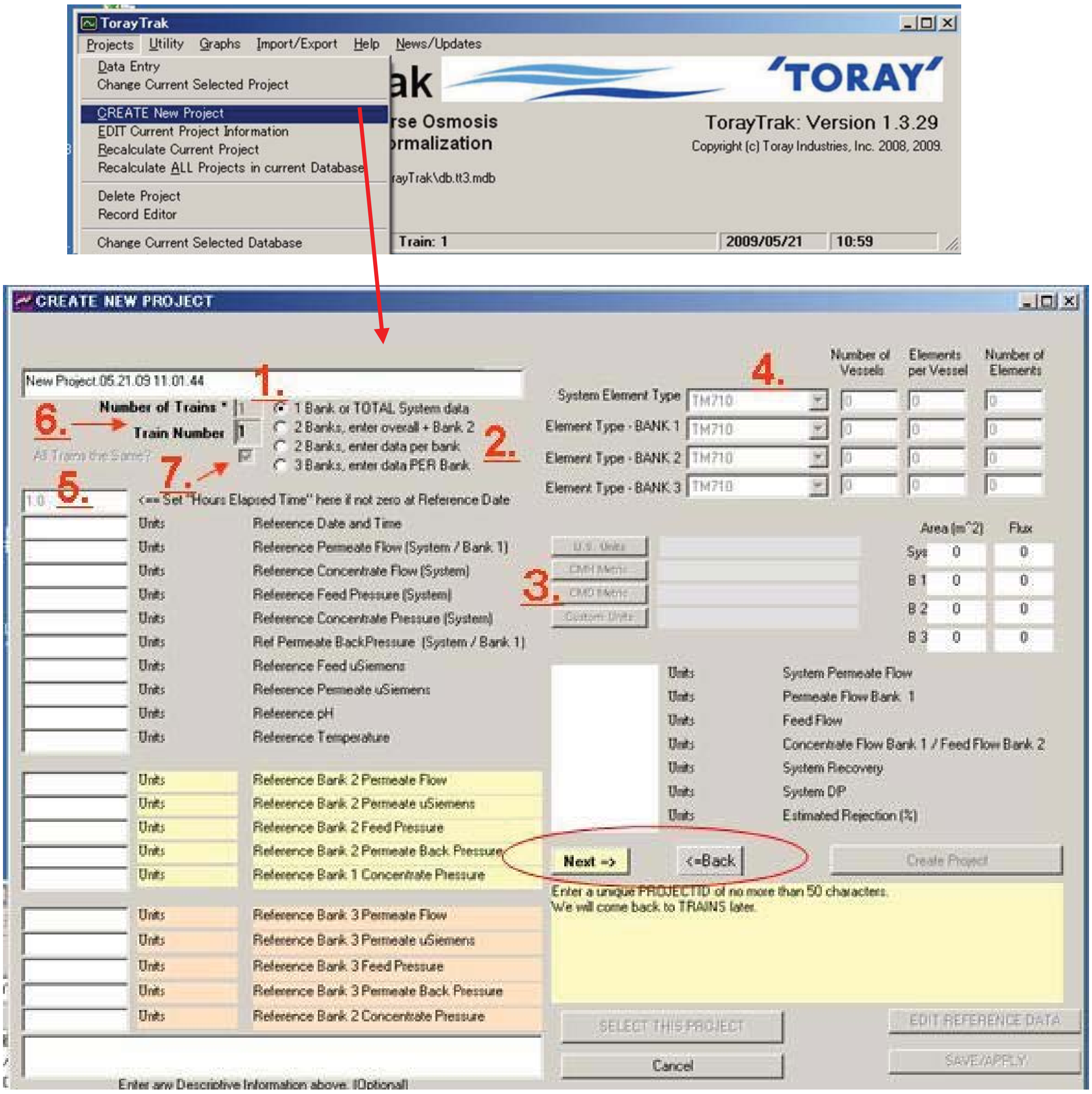
Procedures for normalization are given in ASTM D 4516.

The following is a general introduction to TorayTrak.

RO operating data normalization is executed by using a Microsoft Excel file running in the background of the Toray Trak program..

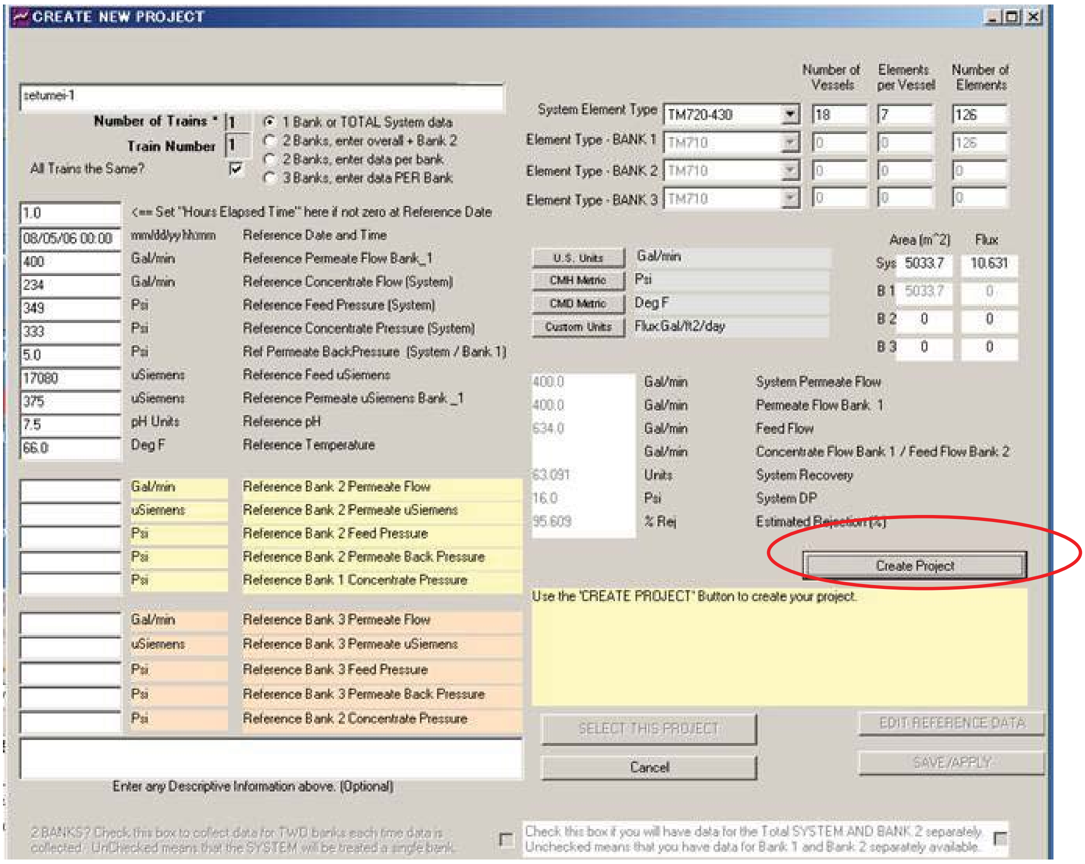
An example of Excel data entry files are shown in Illustration TMM-230.2.

1) Create New Project



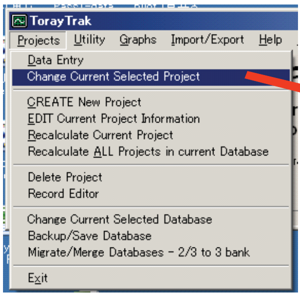
1. Input project name and click “Next “.
2. Select number of banks and click “Next “.
3. Set desired engineering units and click “Next “.
4. Set the number of elements and vessels and click “Next “.
5. Input reference data (baseline data for normalization) and click “Next “.
6. Input number of Trains at the facility and click “Next “.
7. Check, if all train conditions are the same.

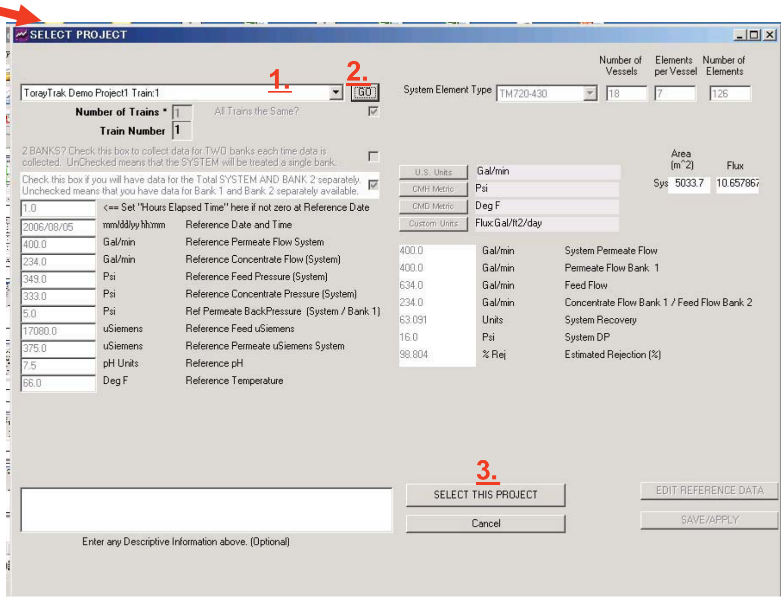
If some entries need modification click ” Back ” and enter correct information and continue as before by clicking “Next”, .



When all data has been entered click" Create Project".

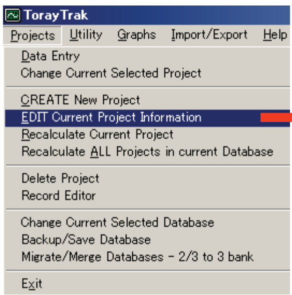
2) Select project

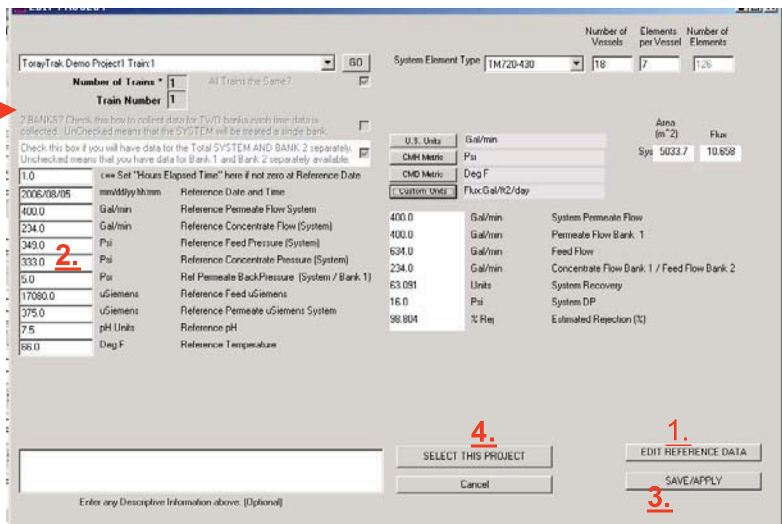




1. Select project name.
2. Push "GO"
3. Push "Select this PROJECT"

3) Edit Current project Information (Edit Reference data)





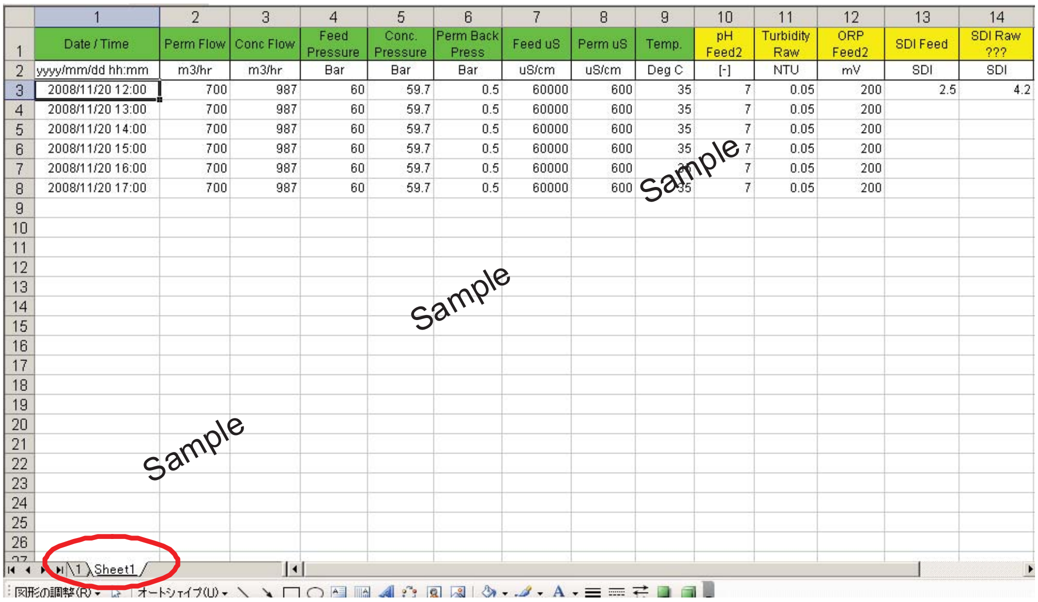
1. Push " EDIT REFERENCE DATA".
2. Input new data.
3. Push "SAVE/APPLY"

   New data was saved.

4. Push "Select this PROJECT"

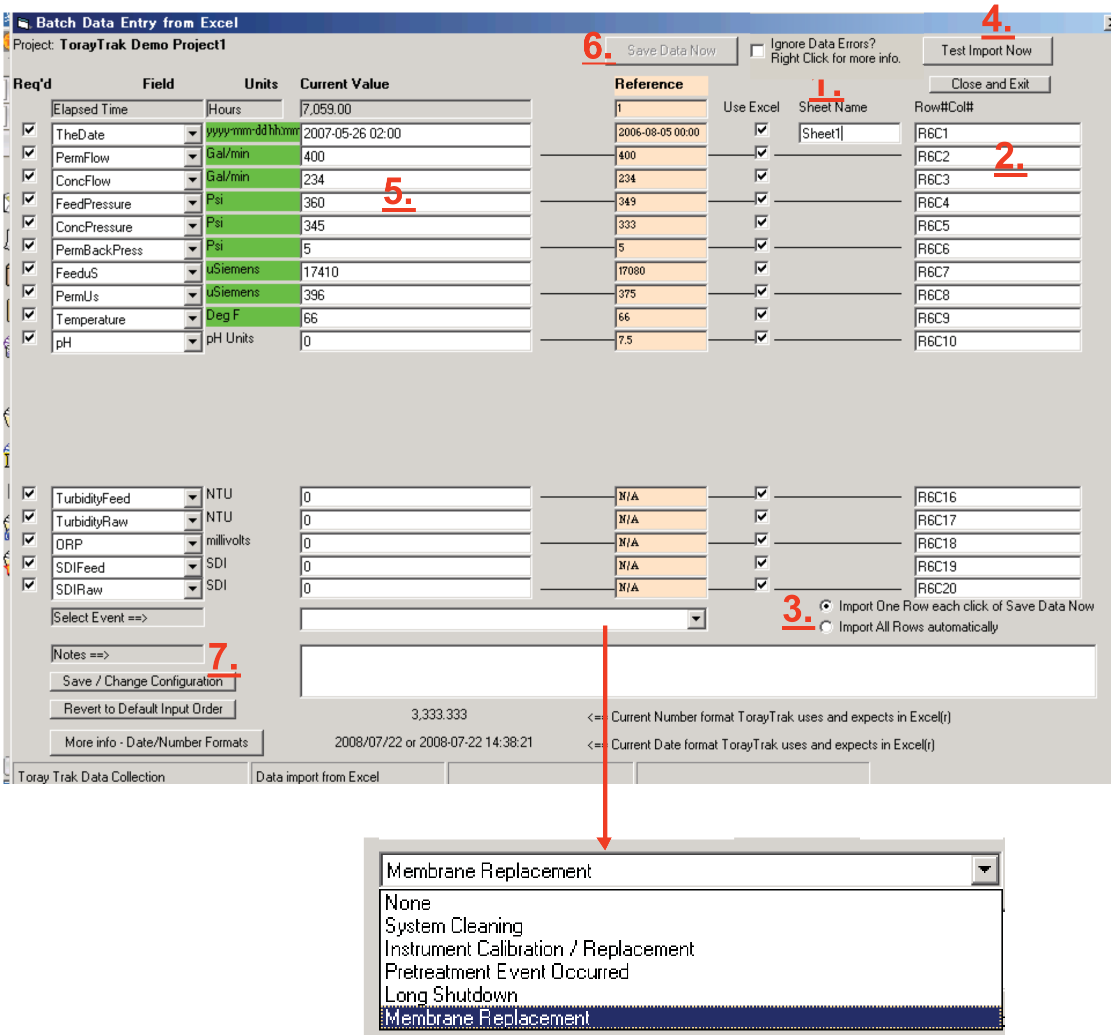
4) Import data from Excel data sheet

Open the Excel file of RO operation.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Date / Time	Perm Flow	Conc Flow	Feed Pressure	Conc. Pressure	Perm Back Press	Feed uS	Perm uS	Temp.	pH Feed2	Turbidity Raw	ORP Feed2	SDI Feed	SDI Raw ???
2	yyyy/mm/dd hh:mm	m3/hr	m3/hr	Bar	Bar	Bar	uS/cm	uS/cm	Deg C	[-]	NTU	mV	SDI	SDI
3	2008/11/20 12:00	700	987	60	59.7	0.5	60000	600	35	7	0.05	200	2.5	4.2
4	2008/11/20 13:00	700	987	60	59.7	0.5	60000	600	35	7	0.05	200		
5	2008/11/20 14:00	700	987	60	59.7	0.5	60000	600	35	7	0.05	200		
6	2008/11/20 15:00	700	987	60	59.7	0.5	60000	600	35	7	0.05	200		
7	2008/11/20 16:00	700	987	60	59.7	0.5	60000	600	35	7	0.05	200		
8	2008/11/20 17:00	700	987	60	59.7	0.5	60000	600	35	7	0.05	200		

Select this item



1. Enter Excel sheet name located on the lower tab of Excel data sheet screen

2. Enter Excel data positions as they appear on the Excel sheet by row and column number for example : R6C1 (row 6 column 1)

3. Select appropriate option if rows are to be imported one at a time or all rows at one time

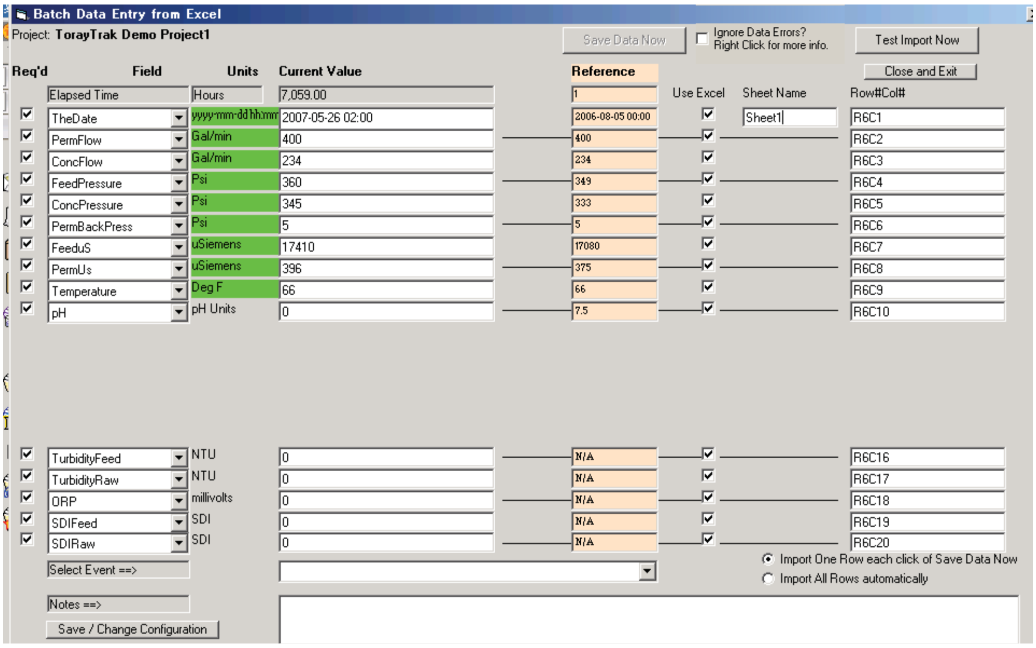
4. Click the “ Test Import Now”.button

5. If no error messages are displayed click “Save data now”

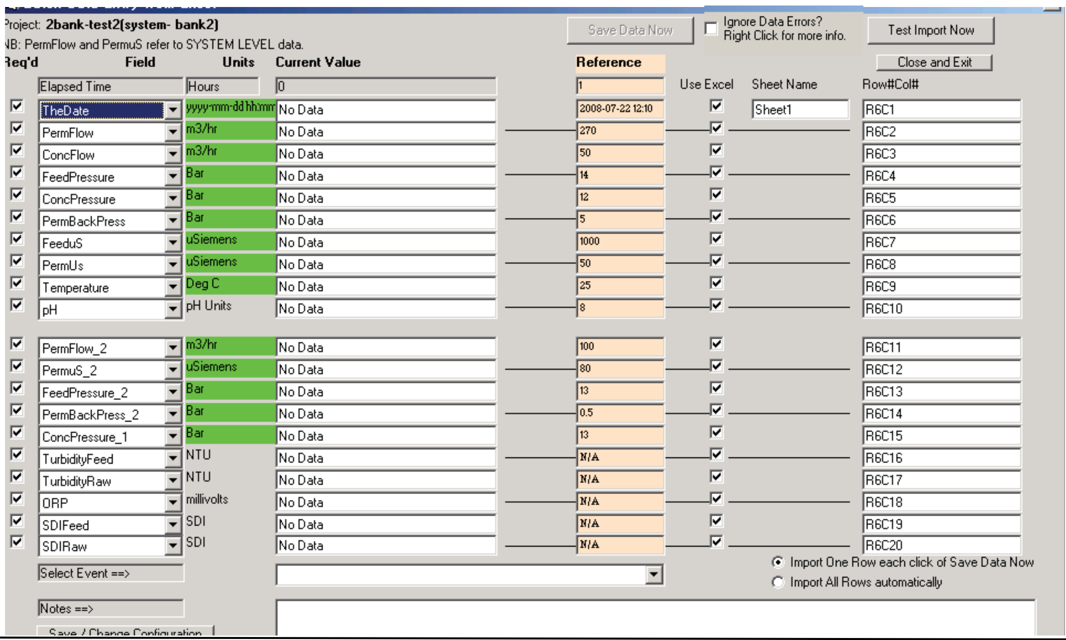
6. Now click on ”Save/Change Configuration”.

Data entry display for a <u>one bank system</u>

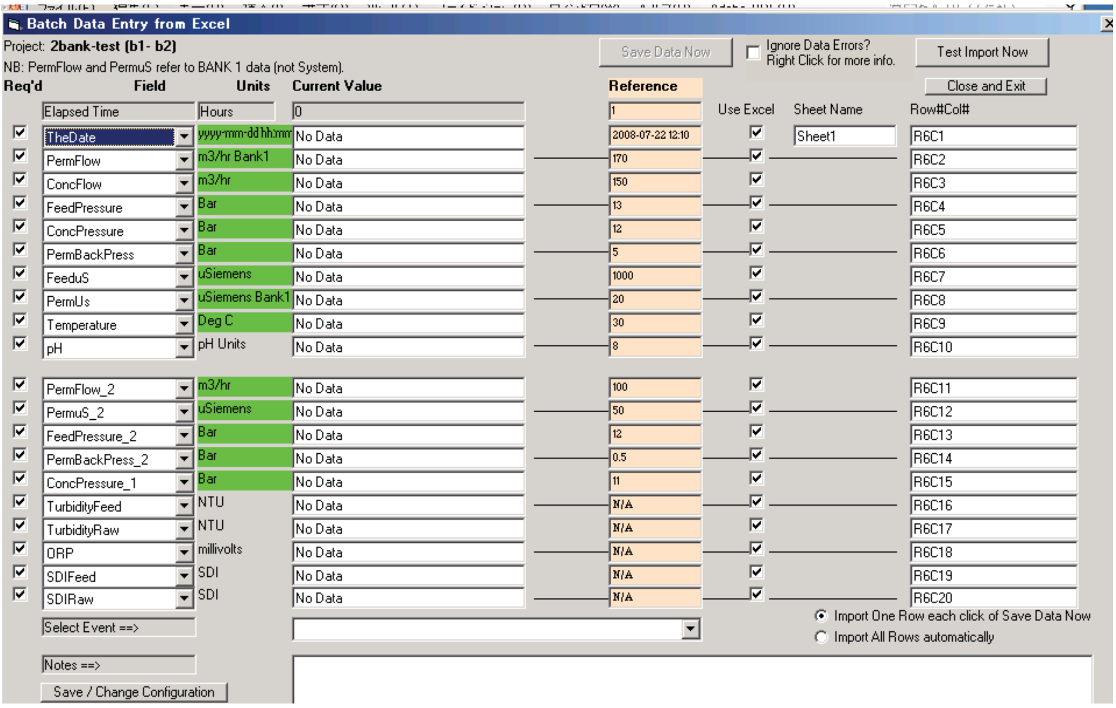
<u>All green colored fields are required data entry fields needed for normalization calculations.</u>



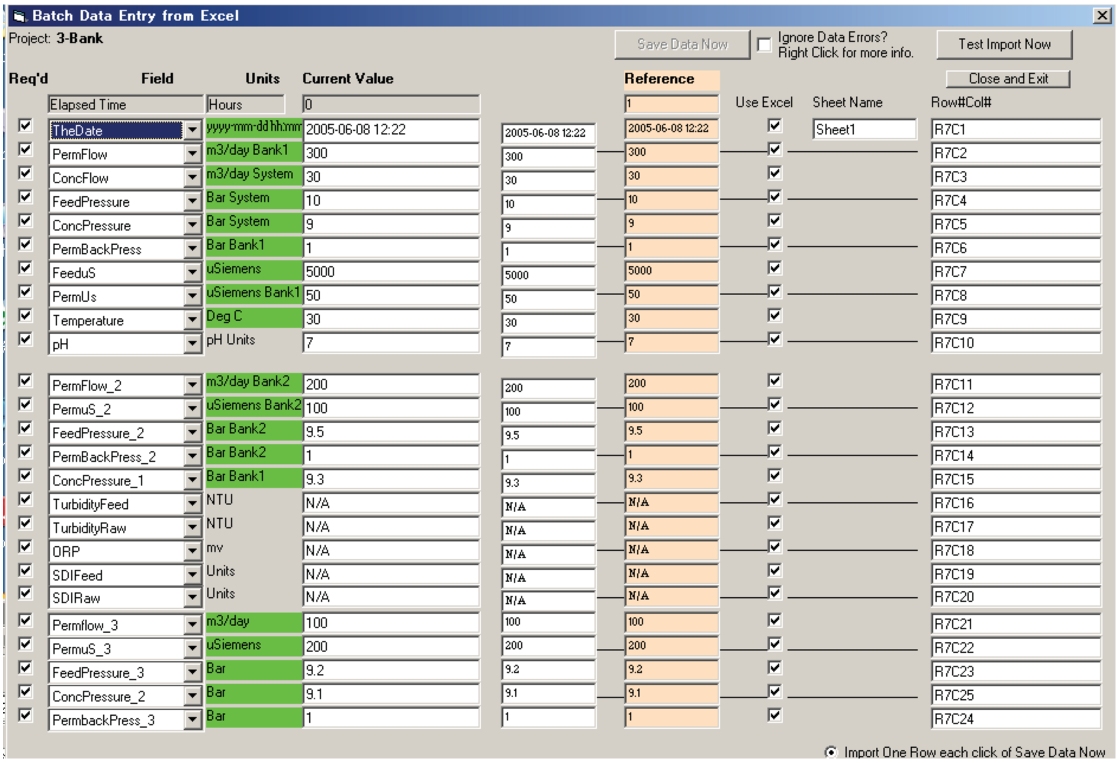
Data entry display for a <u>2 bank system</u> where bank 2 data is complete and bank 1 is to be calculated



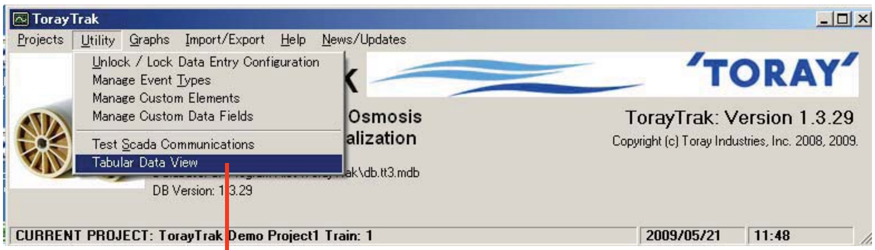
Data entry display of a 2 bank system when complete data is available for both bank1and bank2 Each bank will be normalized separately

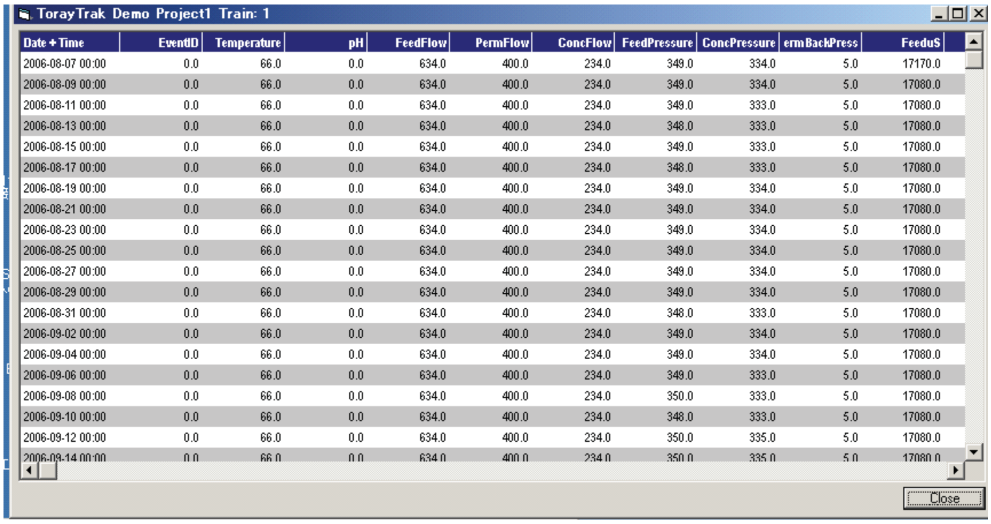


Data entry display for a <u>3bank system Complete bank by bank data is required for this option</u>



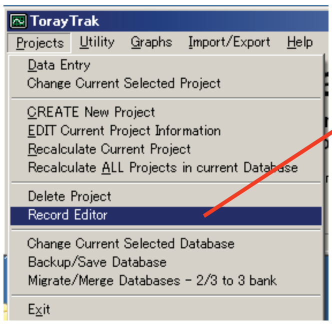
5) Confirm data input

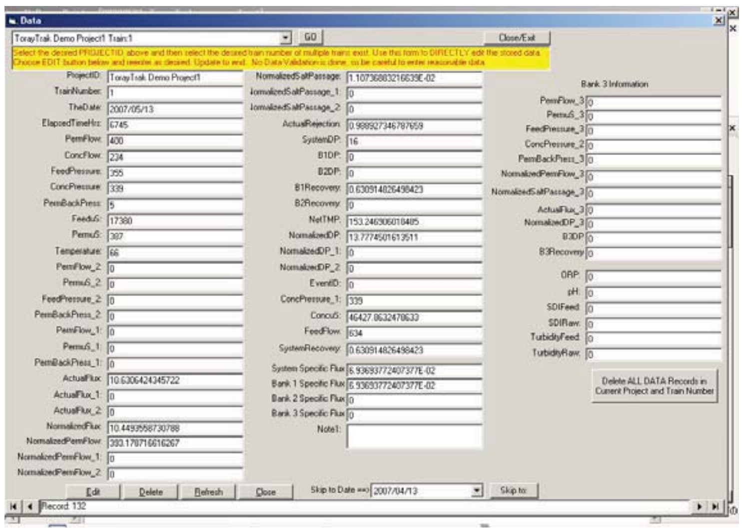




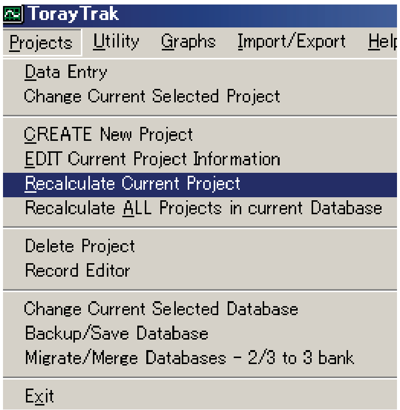
Date + Time	EventID	Temperature	pH	FeedFlow	PermFlow	ConcFlow	FeedPressure	ConcPressure	ermBackPress	FeeduS
2006-08-07 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17170.0
2006-08-09 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-11 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	333.0	5.0	17080.0
2006-08-13 00:00	0.0	66.0	0.0	634.0	400.0	234.0	348.0	333.0	5.0	17080.0
2006-08-15 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	333.0	5.0	17080.0
2006-08-17 00:00	0.0	66.0	0.0	634.0	400.0	234.0	348.0	333.0	5.0	17080.0
2006-08-19 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-21 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-23 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-25 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-27 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-29 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-08-31 00:00	0.0	66.0	0.0	634.0	400.0	234.0	348.0	333.0	5.0	17080.0
2006-09-02 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-09-04 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	334.0	5.0	17080.0
2006-09-06 00:00	0.0	66.0	0.0	634.0	400.0	234.0	349.0	333.0	5.0	17080.0
2006-09-08 00:00	0.0	66.0	0.0	634.0	400.0	234.0	350.0	333.0	5.0	17080.0
2006-09-10 00:00	0.0	66.0	0.0	634.0	400.0	234.0	348.0	333.0	5.0	17080.0
2006-09-12 00:00	0.0	66.0	0.0	634.0	400.0	234.0	350.0	335.0	5.0	17080.0
2006-09-14 00:00	0.0	66.0	0.0	634.0	400.0	234.0	350.0	335.0	5.0	17080.0

6) Edit data input (Record Editor)

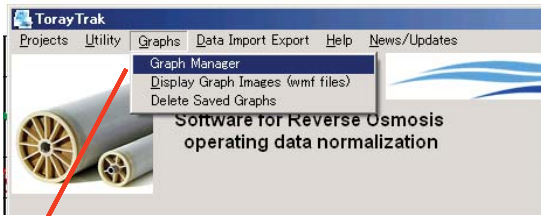


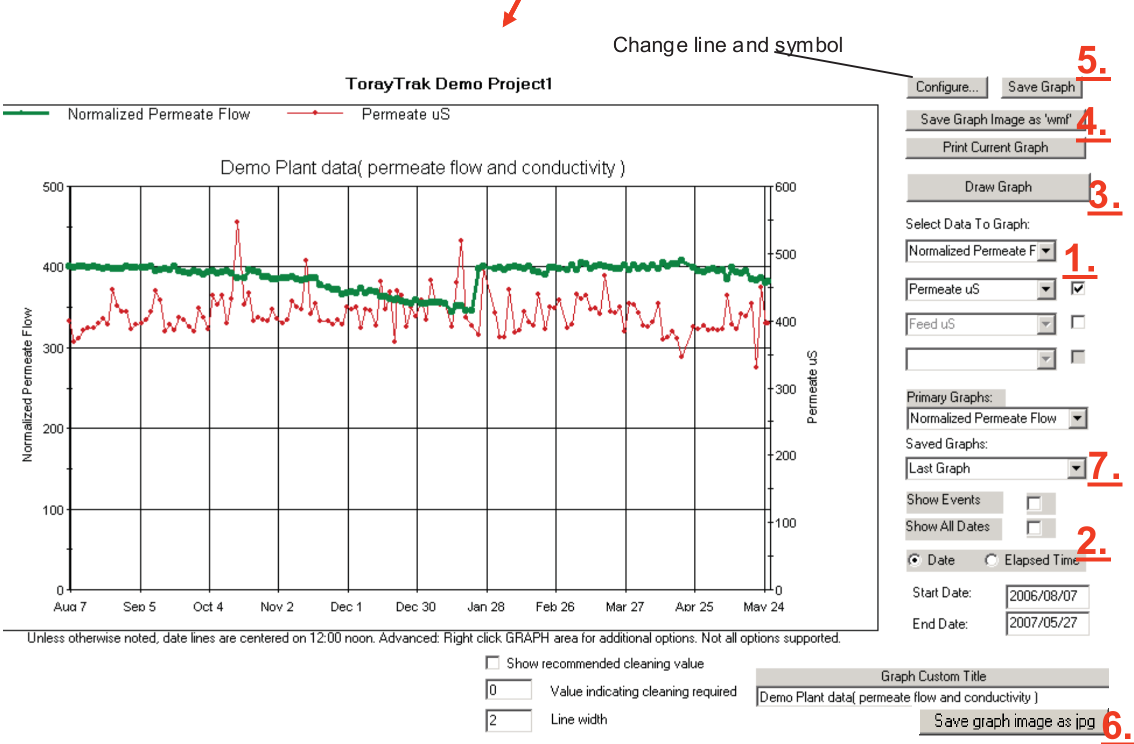


7) Recalculate



8) Create trend graph





1. Select performance parameter(s) from the drop down menu. Example
   (Normalized permeate flow, Normalized Salt passage, Normalized DP, etc.)

2. Select desired data range dates

3. Click “Draw Graph” and the graph window will open showing the selected performance data (item 1) in graph format
4. Click on “Save Graph Image as a ‘wmf’ ‘ file. Ten (10) graphs can be saved for each project in Toray Trak. Additional saved graphs will result in oldest saved graph to be overwritten

5. Click “Save Graph” to save the selected graph.

6. If it is preferred the graph image can be saved in jpg format by clicking on the tab labelled “Save graph image as jpg”. .

7. Save graphs can be accessed by clicking ”Saved graph” button. and making a selection from the drop down menu

9) Delete Saved Graphs

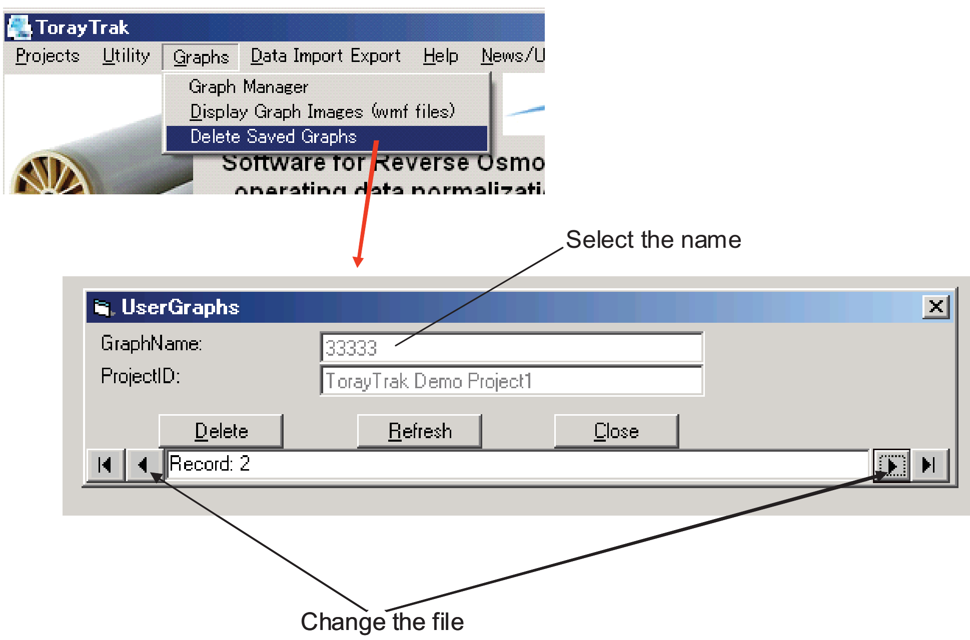


Illustration TMM-230.2 : Sample data sheet

Data sheet of Toray Trak

Green color data are used for normalization calculation.

SWRO

Date / Time	Perm Flow	Conc Flow	Feed Press	Conc. Press	Perm Back Press	Feed uS	Perm uS	Temp.	pH Feed2	Turbidity Raw	ORP Feed2	SDI Feed	SDI Raw
yyyy/mm/dd hh:mm	m3/hr	m3/hr	Bar	Bar	Bar	uS/cm	uS/cm	Deg C	[-]	NTU	mV	SDI	SDI

BWRO (Bank1-Bank2)

Date / Time	Perm Flow (Bank1)	Brine Flow (system)	Feed Press (system)	Brine Press (system)	Perm Press (Bank1)	Feed uS	Perm uS (Bank1)	Temp.	Feed pH	Perm Flow (Bank2)	Perm uS (Bank2)	Feed Press (Bank2)	Perm Press (Bank2)	Brine Press (Bank1)
yyyy/mm/dd hh:mm	m3/hr	m3/hr	Bar	Bar	Bar	uS/cm	uS/cm	Deg C	[-]	m3/hr	uS/cm	Bar	Bar	Bar

3bank (Bank1-Bank2-bank3)

Date / Time	Perm Flow (Bank1)	Brine Flow (system)	Feed Press (system)	Brine Press (system)	Perm Press (Bank1)	Feed uS	Perm uS (Bank1)	Temp.	Feed pH	Perm Flow (Bank2)	Perm uS (Bank2)	Feed Press (Bank2)	Perm Press (Bank2)	Brine Press (Bank1)	Perm Flow (Bank3)	Perm uS (Bank3)	Feed Press (Bank3)	Brine Press (Bank2)	Perm Press (Bank3)
yyyy/mm/dd hh:mm	m3/hr	m3/hr	Bar	Bar	Bar	uS/cm	uS/cm	Deg C	[-]	m3/hr	uS/cm	Bar	Bar	Bar	m3/hr	uS/cm	Bar	Bar	Bar

Shutdown considerations for RO systems

1) When shutting down a RO system the system should be thoroughly flushed at low pressure with sufficient quality flushing water to displace all the brine from the pressure vessels. (see TMM-250 Flushing procedures)

   Acceptable water for flushing are: Pre-treated feed water (refer to table 240-1), or RO product water

   Water used for flushing should not contain any oxidants, Maintain the flush water solution pH between 3-8.5 at all times

Table 240-1: Suggested flushing water for various RO feed water treatment system

RO feed water type	Flushing water
Sea water	Pre-treated feed water
Brackish water	Pre-treated feed water
Waste water	RO product water
High pH Feed water, (such as 2nd pass high pH feed water)	• Pre-treated feed water without NaOH • 1st pass product water without NaOH

2) Ensure membrane elements are kept wet, properly sanitized, and protected from freezing at all times during the shut-down period.

3) Ensure guidelines for temperature and pH of the preservative solution are observed during shut-down period.

Take care that product back pressure never exceeds 0.05 MPa at any time. Product back pressure should be assessed on an individual stage basis.

Product backpressure is defined as product pressure minus feed resp. brine pressure.

Caution

If multiple RO trains are running in parallel, and one train is to be shut down, care should be taken to assure the train to be shut down is properly isolated from the common header piping using check valves or isolation valves. It is most important that pressure relief valves be present and installed on each individual train permeate line.

4) Membrane elements should not, under any circumstances, be exposed to chlorine or other chemical oxidants. Any such exposure may result in damage to the membrane, possibly resulting in irreversible increase in salt passage.

5) Extra care must be taken to avoid chlorine exposure

- When disinfecting piping or pretreatment equipment upstream of the membrane
- When preparing cleaning or storage solutions
- Care must be taken to ensure that no trace of chlorine is present in the feed water to the RO membrane elements.
- If residual chlorine is known to be present in the RO feed, it must be removed with sodium bisulfite (SBS) solution in stoichiometric excess , allowing sufficient contact time to accomplish complete dechlorination.

Short-Term Shut-down

Definition:

Short-term shut-down is for periods where an RO plant must remain out of operation for more than one day, but fewer than four days, with the RO elements remaining loaded in the vessels.

Prepare each RO train as follows:
Flush the RO section with flushing water, while simultaneously venting any air from the system feed piping.

1) When the pressure vessels are filled with flushing water, isolate the train by closing all isolation valves.

2) Repeat 1) and 2) above every 24 hours.

For detailed instructions of flushing procedures, see TMM-250: Flushing procedure.

Long-Term Shut-down

Definition:
Long-term shut-down is for periods where an RO plant must remain out of operation for more than four days with the RO elements remaining in the pressure vessels.

Prepare each RO train as follows:

Case.1) Flushing the RO system when sufficient flushing water is available.

Flush with flushing water for 0.5-1.0 hour at least every 2 days, while simultaneously venting any air from the system. When the pressure tubes are filled, close the valves.

For detailed instructions, see TMM-250 Flushing procedure

Case.2) Flushing the RO system when no flushing water source is available

a) Circulate permeate through the system. While circulating permeate through the system inject the RO system flush line with a 500 to 1000 mg/l (maximum) SBS solution. This solution will serve to inhibit biological growth during the shut down period. Circulate for 30 – 60 minutes.

b) Make sure the RO system is completely filled with the SBS solution . To prevent the solution from draining from the system take care to close all system isolation valves.

c) The pH of the preservative solution should never be allowed to drop below 3.0. The pH should be checked regularly. If the pH drops below 3.2, the preservative solution should be drained and replaced as soon as possible.

d) If pH measurement of preservation solution is not possible, repeat Steps a) and b) with fresh solution.
- Every thirty (30) days if the temperature is less than 80°F (27°C)
- Every fifteen (15) days if the temperature is equal to or greater than 80°F (27°C)

Notes: Any contact of the SBS solution with air (atmospheric oxygen) will oxidize SBS to sulfate, and the preservative solution pH will begin to drop. Care should be taken to keep the SBS preservative solution isolated from atmospheric oxygen. If the SBS is allowed to revert to sulfate the potential for biological activity will increase.

Flushing procedures

One simple procedure for removal of foulants is to flush the system with flushing water. Flushing scours the membrane surface by taking advantage of high velocity at low pressure. A large volume of flush water is required. This procedure can be an effective method for the removal of light organic fouling provided it is applied before significant performance decline has been observed.

General operating conditions for flushing are as follows:

Flushing water: Use pre-treated feed water (refer to table 250-1), or RO product water.

Flushing water should not contain any oxidants

Flushing water pH range should be maintained between 3-8.5.

Table 250-1: Flushing water to use for various RO feed water treatment systems

RO feed water type	Flushing water
Sea water	Pre-treated feed water
Brackish water	Pre-treated feed water
Waste water	RO product water
High pH Feed water, (such as 2nd pass high pH feed water)	• Pre-treated feed water without NaOH • 1st pass product water without NaOH

Pressure: Low pressure (0.1 – 0.2 MPa [15 - 30 psi])

Water flow rate: High flush water flow rate is best but do not exceed recommended vessel pressure drop.
Limit pressure drop to max 0.2 MPa [30 psi] per stage.

Maximum feed flow rate per vessel

• 8.0 inch element:	• 200 l/min (53gpm)
• 4.0 inch element	• 50 l/min (13gpm)

Temperature:	< 40°C (104°F)
Period:	0.5 - 1.0 hour

It is important to keep the permeate side isolation valve(s) open to keep the permeate back pressure to a minimum during the flushing procedure Feed/brine pressure should always be higher than permeate pressure to avoid any membrane damage.

Instruction

Flush each stage (bank) separately.
Do not re-circulate flushing water.

Preservation procedures for RO elements

The objective is to store elements under clean conditions to maintain performance and to prevent bacteria growth.

Instruction After system shut-down, displace brine in the system with flushing water.

General conditions for preservation:

Flushing water: Use Pre-treated feed water (see Table 260-1), or RO product water.

Water for the flushing should not contain any oxidants

Flushing water pH range should be maintained between 3-8.5.

Table 260-1: Flushing water of various RO feed water treatment system

RO feed water type	Flushing water
Sea water	Pre-treated feed water
Brackish water	Pre-treated feed water
Waste water	RO product water
High pH Feed water (such as 2nd pass high pH feed water)	• Pre-treated Pass 1 feed water without NaOH • 1st pass product water without NaOH

Caution If potential for scaling and fouling exists, membranes must be flushed on shutdown according to TMM-250 Flushing procedures.

1) To maintain performance, elements must be wet at all times.

2) To prevent bacterial growth in the pressure vessels, sanitization procedures may be required - see TMM-400: Sanitization Methods

3) If elements are contaminated/fouled and extended shutdown is scheduled, it is recommended to perform chemical cleaning prior to preservation. This removes foulant from membranes and minimizes bacterial growth. Please review:

- TMM-300: General instructions and conditions for RO cleaning
- TMM-310: Guidelines for RO cleaning
- TMM-320: Instructions for chemical cleaning.

4) Allowable temperature range for preservation solutions 5° – 35°C (41 – 95°F)

5) Allowable pH range during preservation in the pressure vessel is 3 – 8.5

6) Make-up water for preservation solution must be free from residual chlorine or other oxidizing agents.

For preservation of elements, use sodium bisulfite solution. For details see section TMM-400: Sanitization Methods

General instructions and conditions for RO cleaning

The surface of an RO membrane is subject to fouling by suspended solids, colloids and precipitation. Pre-treatment of feed water prior to the RO process should be designed to avoid contamination/fouling of membrane surface as much as possible.
Operation at optimum conditions (permeate flow rate, pressure, recovery and pH-value) will result in less fouling of the membranes.
SDI15 is a measurement of particulates present in the feed water. With high SDI15 values (even in allowable range), membrane fouling due to particulates can cause performance decline in long-term operation.
Fouling can also be a consequence of large variations in raw water quality, or of errors in RO operation mode.
Fouling of the membrane surface will result in a performance decline, i.e. lower permeate flow rate and/or higher solute passage and/or increased differential pressure loss from feed side of a stage to the brine side.
Illustration 1 illustrates the effect of flux decrease due to fouling, and restoration of flux through cleaning. If the source of the foulant is not addressed and corrected, foulant removal will only bring temporary relief, as illustrated by the "saw tooth" pattern of the permeate flow in Illustration TMM-300.1.

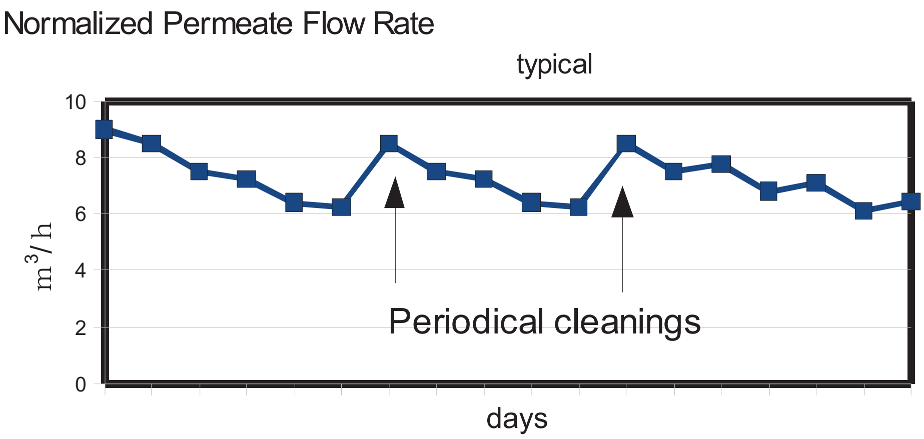


Illustration TMM-300.1: Effect of fouling on permeate flow rate

It should be noted that the best solution is typically to remove the foulant through improved pretreatment rather than subject the membranes to repeated cleanings.

Guidelines for RO cleaning

When to clean:

For best efficiency of cleaning procedure, elements must be cleaned before fouling has fully developed. If cleaning is postponed for too long, it will be difficult or impossible to completely remove foulants from the membrane surface and re-establish full performance.

Commence cleaning when


Instruction

1. Normalized differential pressure increases more than 20%
OR
2. normalized permeate flow rate decreases by more than 10 %
OR
3. normalized salt passage increases by more than 20 %.

Weighing an element is an easy check for the occurrence of fouling. If the weight of the element is much higher than that of new element, fouling has occurred. Before weighing the element, stand it vertically on a perforated plate or drain for 60 minutes to allow drainage of fluids.

The approximate weight of new elements (drained condition) are:

- 4 inch diameter x 40 inch long: 4Kg,
- 8-inch diameter x 40 inch long (400ft2 membrane area): 15Kg
- 8-inch diameter x 40 inch long (440ft2 membrane area): 16 kg

Determination of foulant type

It is important to determine the type of foulants on the membrane surface before cleaning. The best approach for this is a chemical analysis of residues collected with a membrane filter during an SDI15 value determination for pretreated water.

In situations where chemical analysis is not available, it is often possible to classify foulants by color and consistency of residue on the membrane filter. A brownish color residue will typically indicate iron fouling. White or beige color typically indicates silica, loam, calcium scale, or biological fouling. Crystalline constitution is a feature of calcium scale or inorganic colloids. Bio-fouling or organic material will – besides the smell - often show slimy/sticky consistency.

Selection of cleaning procedure

Once contamination of the membrane surface has been identified, the correct cleaning procedure must be selected.

Instruction

- If foulants are believed to be metal hydroxides, such as ferric hydroxide, or calcium scale, acidic cleaning procedures are promising, (see TMM-320: Instructions for chemical cleaning, TMM-330: Citric acid cleaning procedure).

- If foulant is believed to be organic or biological fouling, a cleaning procedure with detergents is recommended, (see TMM-320 Instructions for chemical cleaning, and TMM-340.Dodecyl Sodium Sulfate (DSS) Detergent Cleaning Procedure).

Evaluation of the effectiveness of cleaning

Descriptions of various cleaning procedures are given in TMM-320: Instructions for chemical cleaning. If the recommendations are followed, good results are generally obtained in many cases. Pressure drop across the modules should be reduced to initial value while permeate flow rate and solute rejection will be restored.

If performance is not sufficiently improved after cleaning, a different cleaning procedure may lead to a better result. Foulants will frequently adhere to membrane surface or remain in spacer material. Final removal may take several successive cleaning procedures. As foulants may be present as layers on the membrane surface, alternating citric acid and detergent (acid/ alkali) cleans are frequently more effective than repeated cleans with only one type of cleaner..

Instructions for chemical cleaning

General guidelines

Chemical maintenance cleanings are performed to remove contaminates from membrane surfaces by dissolving and/or separating through physical and chemical interaction with cleaning chemicals.

Instruction

It is good practice to perform a system flush prior to initiating a chemical maintenance cleaning If the RO system is to be shut down for and extended time it is recommended that a chemical cleaning be performed prior to the introduction of any chemical preservatives After any chemical cleaning, it is recommended that the system be thoroughly flushed with either pre-treated raw water or permeate to insure removal of any residual cleaning chemicals dissolved or suspended solids from the RO system. See TMM Section 250 for flushing procedures.

CIP agents:	Generic cleaning chemicals are listed in Table 320-1
Make-up water:	Softened water or permeate, free of heavy metals, residual chlorine or other oxidizing agents.
Required quantity of CIP solution:	• 40 – 80 liters (11 - 22 gallons) per 8 - inch element (depending on the severity of the fouling) • 10 – 20 liters (3 - 6 gallons)per 4 - inch element (depending on the severity of the fouling)
CIP pressure:	Low pressure (0.1 – 0.2 MPa [15 – 30 psi])
CIP flow rate	
Recommended flow rate:	100 - 150 L/min ([25-40gpm], [6-9m^3/h]) per 8inch Vessel; 25 - 36 L/min ([6.5-10gpm], [1.5-2.2m^3/h]) per 4inch Vessel; The goal is to try and achieve the recommended cleaning flow rates above while keeping the cleaning solution pressure within the CIP pressure range of 15-30 psi.
Min. feed flow rate:	50 l/min (13.2 gallons/min) for each 8 - inch vessel 10 l/min (2.7gallons/min) for each 4 - inch vessel

Temperature:	The Maximum temperature of cleaning solution is depended on the pH of cleaning solution as below: Temperature < = 35°C, (pH2-11) Temperature > 35°C and <= 45°C, (pH2-10) For other pH, please contact Toray representative.
Cleaning technique	Clean each bank separately. It is also helpful to recirculate the cleaning solution then allow the membranes to soak in the solution... This procedure can be repeated several times to assist in the membrane cleaning process. See below suggested recirculation time intervals.
Recirculation intervals	0.5 - 1 hour (repeat 2 - 3 times) monitor solution temperature (see maximum temperatures above)
Soaking period:	2 - 24 hours incl. recirculation time (times depend on type and degree of fouling)
Method of cleaning:	Recirculation followed by soaking of each bank
Final flushing period:	Minimum. 1 – 2 hours, depending on application

It is important to keep any permeate side valves open to keep permeate back pressure to a minimum during the flushing procedure.
Feed/brine pressure should always be higher than permeate pressure to avoid any membrane damage. See TMM Section 250 for more details on flushing an RO System.

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Contamination	**CIP chemical**	**Cleaning Conditions**	Instruction **Ref. description**
Calcium scale Metal hydroxides Inorganic colloids	Citric acid 1 – 2 %,adjust with ammonia (NH_3)	pH value: 2 – 4	10.TMM-330 Citric acid cleaning procedure
Organic matter, bacterial matter*)	Dodecyl Sodium Sulfate (DSS, Sodium Lauryl Sulfate), 0.03 - 0.2% with alkaline solution or Polyoxyethylene Sodium Lauryl Sulfate(PSLS), 0.1 – 0.5% with alkaline solution	pH value : 7 – 11, adjust with sodium hydroxide, or sodium tripolyphosphate or trisodium phosphate	11.TMM-340 Dodecyl Sodium Sulfate (DSS) Detergent Cleaning Procedure
Acid insoluble Scaling**) CaF; $BaSO_4$; $SrSO_4$;$CaSO_4$	SHMP 1 % Sodium hexametaphosphate	pH value 2; adjust with hydrochloric acid	12.TMM-350 Sodium Hexa Meta Phosphate + hydrochloric acid Cleaning Procedure

1) Alkaline solution with 1% EDTA is more effective in some cases.

Table 320-1: CIP chemicals

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*) Combining sterilization and detergent cleaning is effective for bacterial contamination. First, perform sanitization, and then detergent cleaning, (see TMM-400 Sanitization methods for RO+NF – elements)

**) It is recommended to start with an acid cleaning to remove any other (combined) acid soluble fouling materials (such as e.g. $CaCO_3$). Acid insoluble scaling is difficult or impossible to remove if fouling layer is aged. Cleaning should be done within one week after such scaling is recognized.

Membrane Cleaning system design considerations

For a typical flow diagram of a cleaning system, see Illustration TMM-320.1, Typical arrangement of a CIP system.

Required useful volume of the membrane cleaning tank can be calculated as follows:

- Consider system volume (piping, pressure vessels etc.) for preparation of cleaning solution.

Instruction

- Useful volume Vn= A - B – C, where

A =	Quantity of cleaning solution per element, times number of elements: ● 40 - 80 liters (11-22 gallons) for each 8“ element, ● 10 - 20 liters (3-6 gallons) for each 4“ element, Depending on the extent of fouling suggested volumes 8”/4” are: 1. = slightly fouled: 40/10 liters (11/3 gallons), 2. = medium fouled: 50/12 liters (13.2/3.2 gallons), 3. = heavily fouled: 60/15 liters (16/4 gallons),
B =	System volume (cleaning system piping and pipe headers.)
C =	Water volume of elements in pressure vessel subject to simultaneous cleaning. (20 liters [6 gallons] for 8“, 5 liters [1.3 gallons] for 4“)

Table 320-2: CIP volumes and flowrates for dimensioning the CIP Tank

The required useful volume Vn represents the volume of cleaning solution remaining in the tank after the elements and the CIP pipework are filled with cleaning solution. Note that the depth of solution remaining in the tank (Vn divided by tank cross sectional area) must be sufficient to meet any Net Positive Suction Head (NPSH) requirements for the selected cleaning pump.

Cleaning flow rate measured as the discharge flow rate of the cleaning pump should be as follows:.

100 - 150 L/min ([25-40gpm], [6-9m^3/h]) per 8inch Vessel;

25 - 36 L/min ([6.5-10gpm], [1.5-2.2m^3/h]) per 4inch Vessel;

The goal is to achieve the recommended maximum flow rate while maintaining CIP pressure range between 0.1-0.2 MPa (15-30 psi).

Example		1	2	3	3
Degree of contamination		slightly fouled	moderately fouled	heavily fouled	heavily fouled
Element size	mm (inch)	200 (8)	200 (8)	200 (8)	100 (4)
# vessels being cleaned in parallel	pc.vessels	30	10	6	3
Total CIP flow	Liter/min (m^3/h)	3000 (180)	1000 (60)	600 (36)	75 (4.5)
# Elements / vessel	pcs.	6	6	4	3
Total elements	pcs.	180	60	24	9
CIP Solution required per element	liter	40	50	60	15
Total CIP volume (A)	liter	7200	3000	1440	135
ID of CIP piping	mm	150	100	60	25
Length of CIP piping	m	130	100	60	20
ID of header	mm	200	200	100	20
Length of header	m	10	0	4	3
Volume of CIP piping +headers (B)	liter	2611	785	231	11
CIP solution contained / element	liter	20	20	20	5
Total CIP solution contained in elements (C)	liter	3600	1200	480	45
Useful volume of cleaning tank Vn required:	liter	989	1015	729	70

Table 320-3A: Examples of CIP calculations: Metric units

Note: See Table 320-2 “CIP volumes and flow rates for dimensioning CIP tank” for values used in the examples

Example		**1**	**2**	**3**	**3**
Degree of contamination		slightly fouled	moderately fouled	heavily fouled	heavily fouled
Element size	inch	8	8	8	4
# vessels being cleaned in parallel	pc.vessels	30	10	6	3
CIP flow/ vessel	USGPM	25	25	25	6.5
Total CIP flow	USGPM	750	250	150	19.5
Elements per vessel	pcs.	6	6	4	3
Total elements	pcs.	180	60	24	9
Volume CIP Solution required per element	USGall	10.6	13.2	15.9	4.0
Total CIP volume (A)	USGall	1908	792	382	36
ID of CIP piping	inch	6	4	2.5	1
Length of CIP piping	feet	430	330	195	65
ID of header	inch	8	8	4	1
Length of header	feet	33	0	12	9
Volume of CIP piping +headers (B)	USGall	717	215	58	3
CIP solution contained / element	USGallon	5.3	5.3	5.3	1.3
Total CIP solution contained in elements (C)	US Gallon	954	318	127	12
Useful volume of cleaning tank Vn	USgallon	237	259	194	21

Table 320-3B: Examples of CIP calculations: US typical units

Note: See Table 320-2 "CIP volumes and flow rates for dimensioning CIP tank" for values used in the examples

Instruction

Pump head is calculated from:

- max. differential pressure across RO elements (approx. 0.2 MPa) [30 psi]
- pressure loss of piping system and pressure vessel connections
- max. differential pressure across cleaning cartridge filter (approx. 0.2 MPa) [30 psi]

IMPORTANT NOTES:

Instruction

1. Provide a separate return line for permeate. It is important to keep any permeate side valves open to keep permeate back pressure to a minimum during the flushing procedure. Feed/brine pressure should always be higher than permeate pressure to avoid any membrane damage.

Caution

2. Design of cleaning tank must allow for complete draining.

Instruction

3. To avoid excess foaming of cleaning solutions the cleaning solution and permeate return lines should be of sufficient length to extend below the level of the solution in the CIP cleaning tank.
4. Spent cleaning solutions must be neutralized before discharge. Consider local regulations for discharge.

Warning

5. When working with chemicals, follow safety regulations indicated in material safety sheets. Wear suitable protection, such as eye protection, protective gloves and rubber apron!

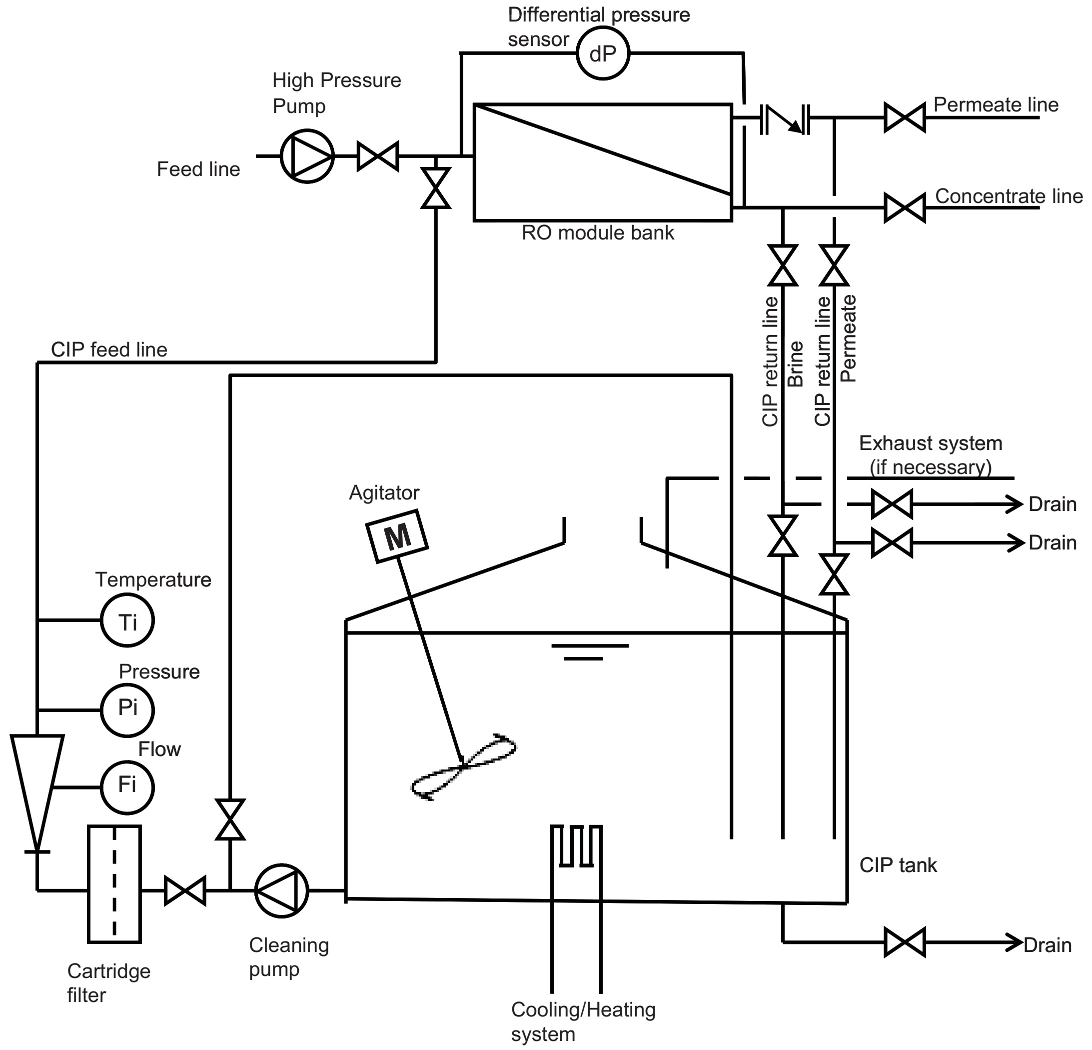


Illustration TMM-320.1: Typical CIP system arrangement

Citric acid cleaning procedure

Flushing of elements

Prior to cleaning with citric acid solution, it is advisable (although not mandatory) to flush elements with softened water or RO permeate (see TMM-250.Flushing procedures).

Preparation of a 2 % citric acid solution

Instruction

1) Fill cleaning tank with water

Cleaning tank should be filled with RO permeate or softened water, free of oxidizing agents. The amount of cleaning water is determined by the size of the RO system and the extent of fouling, (see TMM-320 Instructions for chemical cleaning).

2) Dissolve citric acid

Add citric acid (white powder), in small increments to the cleaning water to obtain a 2 % (by weight) - solution. Continuous agitation (or recirculation of the cleaning solution directly from the cleaning pump into the cleaning tank) will help to dissolve the citric acid quickly and completely. Break up any large chunks or lumps of citric acid prior to adding to the tank to avoid damaging the agitator or circulation pump parts.

Example: To prepare 1000 liters (264.2gallons) of 2% (by weight) solution, 20 kg (44 lbs) of citric acid are required

The solution pH should be adjusted with either ammonia (NH_3) or sodium hydroxide (NaOH) to the specified value (see TMM-320 Instructions for chemical cleaning).

3) Adjusting the pH of the solution with ammonium hydroxide should be performed with the agitator or recirculation pump in operation. Use an exhaust system if necessary to draw off released ammonia gas. Use of an electric drum transfer pump or manual drum transfer pump helps to minimize the release of ammonia gas.

The amount of ammonium hydroxide (NH_4OH), required to adjust the pH to 3.5 can be calculated approximately in proportion to the amount of citric acid by following formula

Amount of NH_4OH (100 %) = 0.1 x Amount of Citric acid (100 %) in kg

For example, if the calculated amount of citric acid is 20.4 kg, the required amount of ammonium hydroxide (30% by weight) is 6.8 kg = (0.1 x 20.4) / 0.3.

Circulation of cleaning solution

Circulate the cleaning solution at low pressure – less than 0.2MPa (30psi) is recommended. Elevated solution temperature will improve cleaning results..

Caution

Note: Cleaning efficiency can be improved by recirculating the cleaning solution for longer periods of time. It is necessary to monitor the cleaning solution temperature to make sure not to exceed recommended maximum allowable cleaning solution temperature (refer to TMM-320 Instructions for chemical cleaning)

Instruction

Soaking elements in the cleaning solution can be an effective procedure to dissolve metal foulants. Alternating soaking intervals with recirculation of the cleaning solution can also be beneficial..

Citric acid cleanings are used when the suspected foulant(s) are metal compounds. If the elements are severely fouled, the citric acid cleaning solution may become less effective as the cleaner reacts with the metal foulant(s). The initial cleaning solution will have a greenish yellow color. As the metals react with the cleaning solution during the recirculation phase the color may begin to turn a dark yellow progressing to a darker red brown color. This color shift indicates the cleaning solution effectiveness has been impaired due to chemical interaction with the foulant(s).. When the solution color approaches the darker color it is recommended that the solution be discarded. A fresh citric acid solution should be prepared and the cleaning procedure repeated to assure a complete and effective cleaning.

Flush elements

Once the chemical cleaning circulation is finished completely drain and rinse the cleaning solution tank. Next fill the cleaning solution tank with permeate or oxidant free feed water. Fill the tank with sufficient flush water to displace all cleaning solution remaining in the cleaning system piping, RO system headers, and pressure vessels. All flush water should be directed to drain for proper disposal. .Refer to TMM section 250

Instruction

Flush each bank separately. Do not re-circulate flushing water.

General description of citric acid

Danger

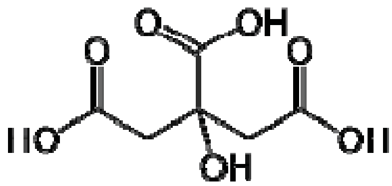
Appearance:	white crystalline powder
pH:	~ 1.7 (100 g/l water, 20 °C)
Density:	1665 g/cm3 (18 °C)
CAS Number:	77-92-9
IUPAC name:	2-hydroxypropane-1,2,3-tricarboxylic acid
Molecular Formula:	$C_6H_8O_7$
Molecule Shape	
Safety precautions:	low hazard potential, irritant

Table 330- 1: Properties of citric acid

Instruction

NOTE: Please consult the Material Data Safety Sheet available from the chemical supplier for full safety details BEFORE handling this chemical. Use all recommended safety equipment.

DSS (Dodecyl Sodium Sulfate) Detergent Cleaning Procedure

Flushing of elements

Prior to cleaning with DSS solution, it is advisable (although not mandatory) to flush elements with softened water or RO permeate, (see TMM-250.Flushing procedures).

Preparation of a 0.03 % DSS solution

1) Fill cleaning tank with water

Fill the cleaning tank with RO permeate or softened water, free of any oxidizing agents. The amount of cleaning solution required is determined by size of RO system and extent of the fouling (see TMM-320 Instructions for chemical cleaning).

2) Dissolve DSS

Add sufficient DSS to the cleaning water to obtain a 0.03 % (by weight) - solution. CAUTION - this chemical can form a film on the surface of the cleaning water capable of trapping gases resulting in the formation of foam. Precautions should be taken to minimize the potential mixing of air with the DSS when making up the cleaning solution to avoid excessive foam formation. It is recommended that the DSS be dissolved in a small volume of cleaning water then added to the bulk solution in the cleaning tank, Continuous, slow agitation of the solution is required to evenly disperse the DSS. To minimize the potential for foam production, use the lowest speed setting on the mixer.

Example: To prepare1000 liters (264.2 gallons) of the solution 0.3 kg (0.66 lbs) of DSS are required

3) Monitor pH value

The pH of the detergent solution should be maintained within the recommended pH range . (see TMM-320: Instructions for chemical cleaning) If the pH falls outside the recommended range, solution pH adjustment will be required. The expected pH of the DSS solution is 7.

Circulate cleaning solution

Instruction

The initial flow of cleaning solution within the cleaning return line may contain a high concentration of contaminants. Discard the initial 10 – 15% of the cleaning solution volume to drain prior to circulating the cleaning solution to the cleaning tank.

Increasing the cleaning solution temperature will improve the efficiency of the cleaning. Do not exceed recommended temperature guidelines. In addition it is beneficial to perform the cleaning at low pressures. Do not exceed (approx.0.2MPa [30psi]) during circulation of the cleaning solution.

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Caution

Note: Extending the circulation time is beneficial to maximize the efficiency of the cleaning. The cleaning solution temperature should be monitored closely during the circulation of the cleaning solution, Take care not to exceed recommended maximum temperature value. (refer to TMM-320 Instructions for chemical cleaning)

To minimize the potential for foam formation within the CIP solution tank make sure the cleaning solution return line and permeate lines extend below the level of the cleaning solution..

Instruction

Efficiency of chemical cleanings can be improved if the elements are allowed to soak in the cleaning solution for an extended length of time. Repeated intervals of soaking followed by circulation of the cleaning solution can also improve cleaning results.

Flush elements

Once the chemical cleaning circulation is finished completely drain and rinse the cleaning solution tank. Next fill the cleaning solution tank with permeate or oxidant free feed water. Fill the tank with sufficient flush water to displace all cleaning solution remaining in the cleaning system piping, RO system headers, and pressure vessels. All flush water should be directed to drain for proper disposal. Refer to TMM section 250.

Flush each bank separately.
Do not re-circulate flushing water.

General description of DSS

Appearance:	Powder or aqueous solution
pH:	7 - 8 as 1 % solution (based on powder)
Charge in solution	Anionic
Solubility in water:	10 g/100 ml
Main component:	CH3(CH2)11SO3Na Dodecyl Sodium Sulfate (Sodium Lauryl Sulfate)
CAS no.:	151-21-3

General description of TSP (Trisodium phosphate)

Appearance:	White crystalline powder, without chunks
pH:	strong alkalinity in solution
Density:	1.630 g/cm^3 (18°C)
Solubility in water:	28.3 g/100 ml
Main component:	Na_3PO_4
CAS no.:	7601 – 54 – 9

General description of NaOH (Sodium hydroxide)

Appearance:	White crystalline powder or granular or chunks
pH:	strong alkalinity in solution
Density:	2.130 g/cm^3 (18°C)
Solubility in water:	soluble in random ratio
Main component:	NaOH
CAS no.:	1310 – 73 – 2

Safety precautions

- Consult material safety data sheet (MSDS) of supplier of detergent before use.

Danger

- Inhalation: Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. May cause allergic reaction in sensitive individuals. Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

- Ingestion: Large doses may cause gastrointestinal distress, nausea and diarrhoea. Remove to fresh air. If not breathing, give artificial resuscitation. If breathing is difficult, give oxygen. Get medical attention. If conscious, induce vomiting.

- Skin Contact: Mildly irritating to skin, causes dryness and a rash with continued exposure. May cause allergic skin reactions. Immediately flush skin with plenty of soap and water. Remove contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.

- Eye Contact: Causes irritation, redness, and pain. Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Acidic SHMP CIP procedure

Flushing of elements

Prior to this cleaning procedure it is advisable, especially if operating on raw water having a high total hardness concentration, to flush elements using softened water or RO permeate, (see TMM-250.Flushing procedures).

Preparation of a 1 % SHMP solution

1) Fill cleaning tank

Cleaning tank should be filled with RO permeate or softened water, free of oxidizing agents. The amount of cleaning water required is determined by size of RO system and the perceived extent of fouling, (see TMM Section 320 .Instructions for chemical cleaning).

2) Dissolve SHMP

Add SHMP (white powder) to water to obtain a 1.0 % (by weight) - solution. Continuous agitation of the solution by motorized mixer or recirculation pump will be needed to completely dissolve the chemical. SHMP should be added to the cleaning tank in small batches to avoid clogging.

For example: To prepare 1000 liters (264.2 gallons) of cleaning solution, 10 kg (22 lbs) of SHMP is needed.

3) Add hydrochloric acid

Slowly add HCl to the SHMP solution until you reach a pH value of 2.

Warning HCl is an aggressive inorganic acid, pay attention to safety precautions when handling HCL

4) Check pH value

The pH of the cleaning solution should remain just above 2 pH If the pH increases above 3.5 during circulation of the cleaning solution, add HCl until the pH is again just above pH 2. Should the pH go below 2 adjust the pH to slightly above pH 2 by adding caustic soda (NaOH).

Warning

Caustic soda is an aggressive inorganic base; pay attention to applicable safety rules when handling it. The expected pH of a 1 % SHMP solution is neutral.

Circulate cleaning solution

The first 10-15% of the original cleaning solution volume returned from the RO system may contain high concentrations of contaminants. It is therefore recommended to dispose of this portion of the cleaning solution to drain and not recycle it back into the solution tank. Once this initial volume has been discarded, direct all the returned cleaning solution back to the solution tank for re-circulation..

Low feed water pressure should be applied during re-circulation (approx.0.2MPa [30psi])
Higher cleaning solution temperature can improve the cleaning efficiency.

Caution

Note: Longer periods of circulation are beneficial for chemical cleanings,. However, prolonged circulation will result in an increase in cleaning solution temperature. Monitor the solution temperature to make sure it does not exceed recommended maximum allowable temperature. (refer to TMM-320 Instructions for chemical cleaning).

When mixing the SHMP there is a potential for excessive foaming. To reduce this foaming potential make sure the permeate return line and cleaning solution return line are extended below the liquid level in the cleaning solution tank.

Soaking the elements in the cleaning solution can help to break up and remove contaminants. Alternating periods of soaking and circulation of the cleaning solution can improve the chemical cleaning efficiency. Stopping the re-circulation process for a total of two 15 min soaking periods during a typical one hour cleaning schedule is recommended.

If the pH value during circulation increases above pH 3.5, add

Instruction

more HCl until pH value drops to just above pH 2.. If pH of the returned cleaning solution increases rapidly the effectiveness of the solution has been reduced due to reaction with contaminants. Should a rapid rise in pH be noted discard the spent cleaning solution and mix up a fresh batch and proceed as before with the cleaning process.

Flush elements

At the end of the chemical cleaning process it will be necessary to flush all the spent cleaning solution from the cleaning piping, RO headers, and pressure vessels. Begin by draining the solution tank and rinse the tank thoroughly. Next it will be necessary to displace all residual cleaning solution from elements, pressure vessels and pipe lines with feed water or RO permeate.

Flush each bank separately.
Do not re-circulate flushing water.

Fill the rinsed cleaning tank with softened water or permeate. Use the cleaning system pump and piping to direct flush water through the RO system. To prevent spent cleaning solution from mixing with the clean flush water in the cleaning tank direct all return lines to drain just prior to the cleaning tank. Repeat as needed to assure complete displacement of the residual cleaning solution.(see TMM-250.Flushing procedures).

General Description of of SHMP (NaPO3)n

Appearance:	white powder, odorless
pH:	approx. pH 7 (1 % solution)
Solubility:	almost unlimited
Concentration:	approx. 67 %
Density:	0.95 – 1.05 g/cm3 (20 °C)
CAS No.:	10124-56-8

Safety precautions:

- Consult material safety data sheet (MSDS) of supplier of SHMP before use.

Danger

- Normal safety-equipment like gloves and eye protection should be worn during handling of SHMP

- In case of eye contact flush eye immediately with a large amount of water and consult a physician.

- Prolonged contact with skin should be avoided. Avoid breathing dust.

Sanitization methods for RO/NF elements

Sanitizing solutions

Formaldehyde

One effective method to prevent propagation of bacteria, is to soak the membrane elements in a sanitizing solution of 0.2 - 0.3 weight-% formaldehyde (HCHO) at pH 6–8, The sanitizing solution pH can be adjusted by the addition sodium bicarbonate (NaHCO3).

This sanitization method is a satisfactory and effective method to control biological activity for short or long term shut downs.

Immersion of membrane elements in a formaldehyde sanitization solution is not applicable for new elements. Elements must have been in full operation at design conditions for at least 72 hours prior to any formaldehyde sanitization procedures. Exposure of elements to formaldehyde prior to 72 hours of operation may result in irreversible flux loss.

Alternate Sanitizing solutions

If the use of formaldehyde sanitization is not permitted the following alternative solutions can be employed (see chart below). Membrane elements can be soaked in these alternate solutions during system shut downs.. Please note that membrane exposure time to these alternate solutions is limited. Refer to the chart below for recommended soak intervals

Sanitizing solution	Concentration [ppm]	Duration of treatment*) [hr]	Applicable to Membrane type:
Hydrogen Peroxide H_2O_2 **)	2000 – 10000	1 ***)	Other than 800 series
Sodium Bisulfite	500 – 1000	no limit ***)	All types

Caution

1. The water used to prepare all sanitizing solutions must be free of residual chlorine or other equivalent oxidizing agents.
2. Be sure that the selected chemicals are appropriate and chemically compatible with the membrane type to be sanitized. Refer to the chart above.

*) Contact time with sterilizing solutions must not exceed recommended durations to avoid membrane performance decline.

**) Use of hydrogen peroxide in presence of heavy metal residues will lead to fast and irreversible damage of composite membranes as well.
Hydrogen peroxide for this application must be prepared with de-ionized feed water with less than 0.2 ppb iron. If the concentration of iron is above 0.2 ppb in the solution make up water the membrane elements can be irreversibly damaged resulting in an increase in salt passage..
If heavy metal precipitates of any type (iron, manganese etc) is suspected to be present on the membrane surface, it is mandatory to clean the membranes with an acid solution prior to exposure to hydrogen peroxide. For details of citric acid cleaning procedure see TMM-330. Failure to do so may result in catalysed oxidation of the membrane surface by the hydrogen peroxide resulting in irreversible salt passage increase.

***) After sterilization completely flush the system with permeate or pre-treated raw water prior to placing the system back online. If the membranes are to be preserved during an extended shut down it is necessary to completely flush the system prior to introduction of any preservative solutions into the system.

Biocide

DBNPA(2,2-dibromo-3-nitrilopropionamide) is a highly effective non-oxidizing broad-spectrum biocide used for the control of bacteria, algae and fungus in reverse-osmosis systems as well as other industrial water applications.

This product is normally applied as a shock treatment to control biological activity within membrane elements. Dosing frequency depends on the microbiological activity of the RO feed water and the condition of the membranes.

There are several DBNPA-based products available. For more information about DBNPA, refer to DBNPA supplier technical data and Material Safety Data Sheet or contact your chemical supplier for recommendations.

Heat Sanitization of RO Elements (TS types)

Occasional or periodic hot water sanitization (pasteurization) is a preventive measure to reduce bacteria and fungus growth. The following recommendations are applicable for TORAY hot water resistant elements (TS types):

Caution

- Temperature slope during heating & cool down period: maximum 2.0 °C / minute
- It is preferable to use permeate water, or at least softened water, for this procedure
- Heat sanitization cannot be applied to standard RO products – it will cause irreversible damage.

Instruction

- For effective sanitization water temperature can be increased up to 80°C. (Temperature required depends on bacteria strains present). Above 80°C, modules can be irreversibly damaged.

Caution

- Feed pressure during hot water treatment must be always < 0.15 MPa (22psi)
- Differential pressure max. 0.1 MPa (15psi) / element

Frequency of hot water treatment depends on feed water quality and use of product water. Average frequency of treatment should, however, not exceed 1 treatment / week.

Instruction

- The necessity and effectiveness of high temperature sanitization treatment must be determined by microbiological testing of feed, brine and permeate streams

It is important to open permeate side valve and to maintain no permeate side back pressure condition during high temperature treatment. Feed and/or brine pressure should be higher than permeate side pressure at all times to avoid permeate back pressure problems.

Storage

General

To prevent biological growth on membrane surfaces during storage and performance loss in subsequent operation, TORAY RO elements must be preserved in a solution.

Element preservation is necessary for:

- Long term storage of new and used elements
- RO system shutdown > 24hours

If the RO elements have been in service, see TMM-240 Shutdown considerations for RO systems.

Storage of new elements

It is recommended that new elements be stored in their original packaging until such time the membrane elements are to be loaded into the pressure vessels for system start up. Recommended storage conditions are listed below:.

1) Store elements in cool, dry place inside a closed building. Keep elements away from exposure to direct sunlight.

2) Avoid freezing temperatures and temperatures above 35 °C (95°F).

3) New elements are shipped in preservation solution of 0.5 – 1 % sodium bisulfite solution ($NaHSO_3$) or sodium chloride solution with deoxidizer packets.

4) New elements are packed in special oxygen impermeable plastic bags under a slight vacuum. The elements are shipped in durable carton boxes. It is recommended that the elements be stored and remain in the original shipping cartons until the time they are to be installed in the system pressure vessels. . Used bags and deoxidizers can be disposed as normal municipal solid waste.

Storage of used elements

1) For storing elements that have been in service refer to TMM Section 240: Shutdown consideration for RO systems. Using RO permeate or softened water, prepare a 500 – 1000 ppm sodium bisulfite solution. To prepare the solution, use food grade sodium metabisulfite (SMBS). SMBS reacts with water to form sodium bisulfite (SBS) according to this reaction:

$$Na_2S_2O_5 + H_2O \Longrightarrow 2\ NaHSO_3$$

2) After soaking the elements for about 1 hour in the bisulfite solution, remove the elements and place them in a plastic oxygen barrier bag.. Oxygen barrier bags can be obtained from Toray. Seal and label the bag(s), indicating packaging date

3) Storage conditions for used/repackaged elements are the same as for new RO elements. See page 1 of this section

4) When used elements are sent back to Toray, please contact Toray or its representative before unloading elements.

Handling of New Elements

In order to maintain good element performance, observe the following:

Precautions during storage

1) The elements are shipped from TORAY in sealed oxygen impermeable plastic bags and sturdy carton boxes. Only open the element boxes just prior to element installation.

2) Elements can be stored within a temperature range of 5 °C to 35 °C (41°F to 95°F). Avoid storage in direct sunlight.

3) If the element storage area ambient temperature is expected to drop below freezing point (0°C), measures should be taken to keep the elements at a temperature above freezing. Do not allow elements to freeze.

4) Don't stack more than 5 layers of carton boxes when re-stacking from originally delivered packing (export packing).

5) Keep the original element packaging dry at all times to preserve their structural integrity.

General notes for installation into pressure vessels.

1) Carefully open plastic bags at one end. Be careful when opening the plastic bags. It is recommended some of these bags are retained for possible future use.

2) It is also a good idea to retain some of the packaging boxes in case an element needs to be removed and placed in storage

3) When loading membrane elements, record the position of each membrane element by serial number within the system. It will be necessary to make note of the system train # (where multiple trains exist), pressure vessel number or position within the pressure vessel array, and finally the position of the membrane element within each of the pressure vessel(s). This procedure should be followed when loading every membrane element in the RO system. If an element is moved or replaced, element positions may change Changes in position should be appropriately recorded.

4) To avoid damage handle each element with care. Avoid dropping the membrane element. To minimize the potential for contamination handle the elements with clean hands or gloves. Take precautions to keep the exterior of element clean.

5) See detailed procedures in TMM-200 Installation of RO elements.

Introduction to troubleshooting

Potential problems in an RO system can be recognized early by monitoring the changes of permeate flow rate*, salt passage (salt rejection)* and differential pressure * of the RO pressure vessels. It is, therefore, recommended that the system operator(s) record and review operational data frequently. Early detection of system performance decline will alert the operators to potential operational problems and allow them to initiate appropriate countermeasures to restore membrane element performance..

Typical performance changes and their countermeasures are shown in the following Section TMM 610

Basic steps of troubleshooting are summarized below:

Action	Item concerned
Check:	Calibration of Instruments - Pressure, Temperature, Conductivity, pH, flow etc.
Review:	Daily operational data, normalized data, maintenance logs, and comparison of current performance to design specifications
Investigate:	Reasons for performance changes and their possible causes. Refer to TMM-610 Typical Performance Changes and Countermeasures
Troubleshoot:	Initiate corrective measures, perform countermeasures in a timely fashion e.g. chemical cleaning, sterilization, replacement of defective parts, system adjustments

Permeate Center pipe probing method

If the permeate conductivity measured from a specific pressure vessel indicates a sudden and significant increase in permeate conductivity it is helpful to know if this increased salt passage is due to a faulty 0-ring seal (mechanical leak) or due to membrane loss of rejection. Probing the elements will help determine the cause of the increase in salt passage. Probing apparatus is shown in Illustrations TMM-600.1-2. Water quality (conductivity) can be easily measured at different positions within the pressure vessel by sampling the water using the center pipe probing technique.

*) Normalization of values marked with * is required in order to properly understand the operation data. Procedures for normalization are described in section TM230:Operation monitoring

Illustration TMM-600.1 : Center pipe probing method (1)

Recommended Piping Arrangement and Permeate Sampling Probe for Each Element in One Module

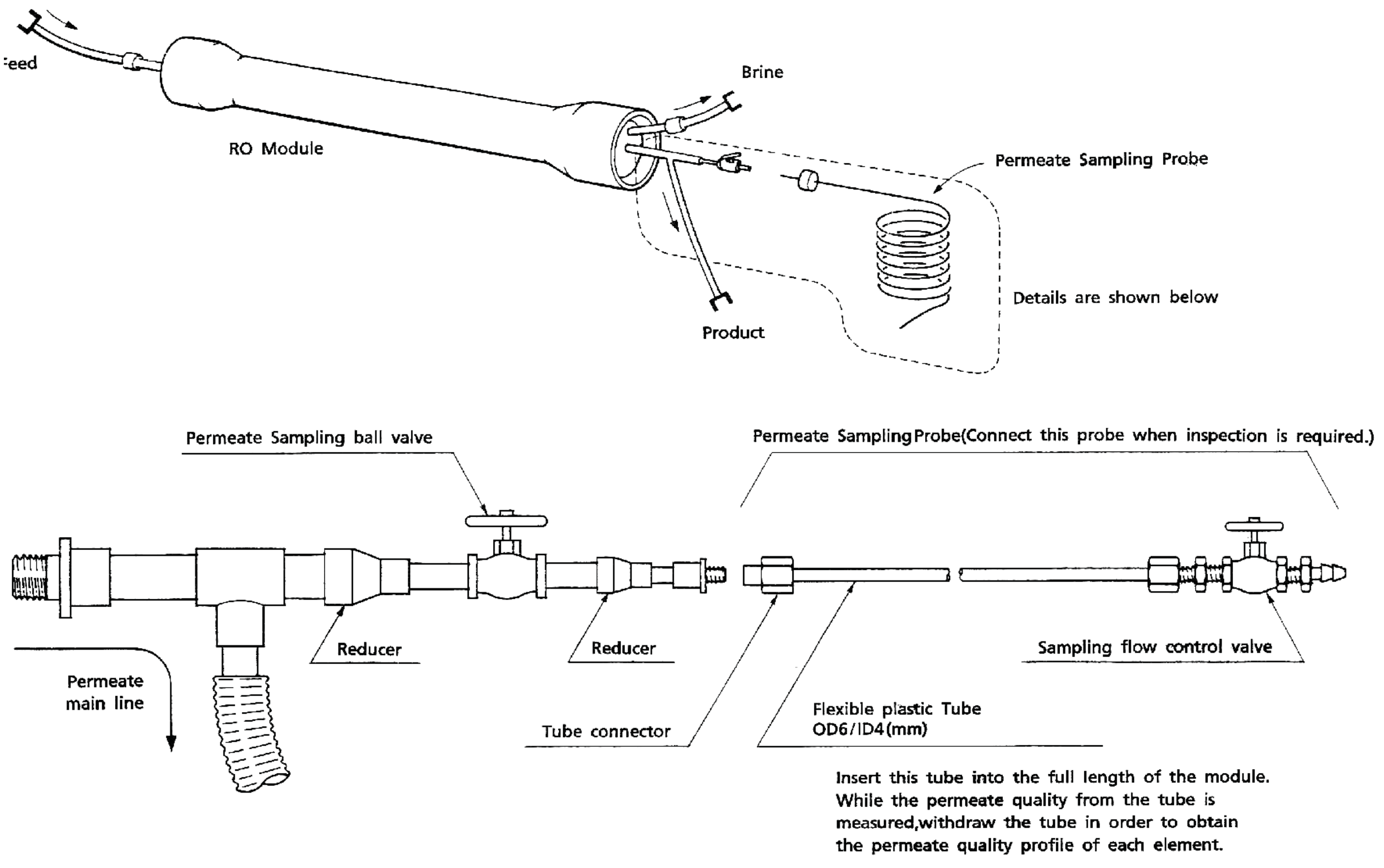
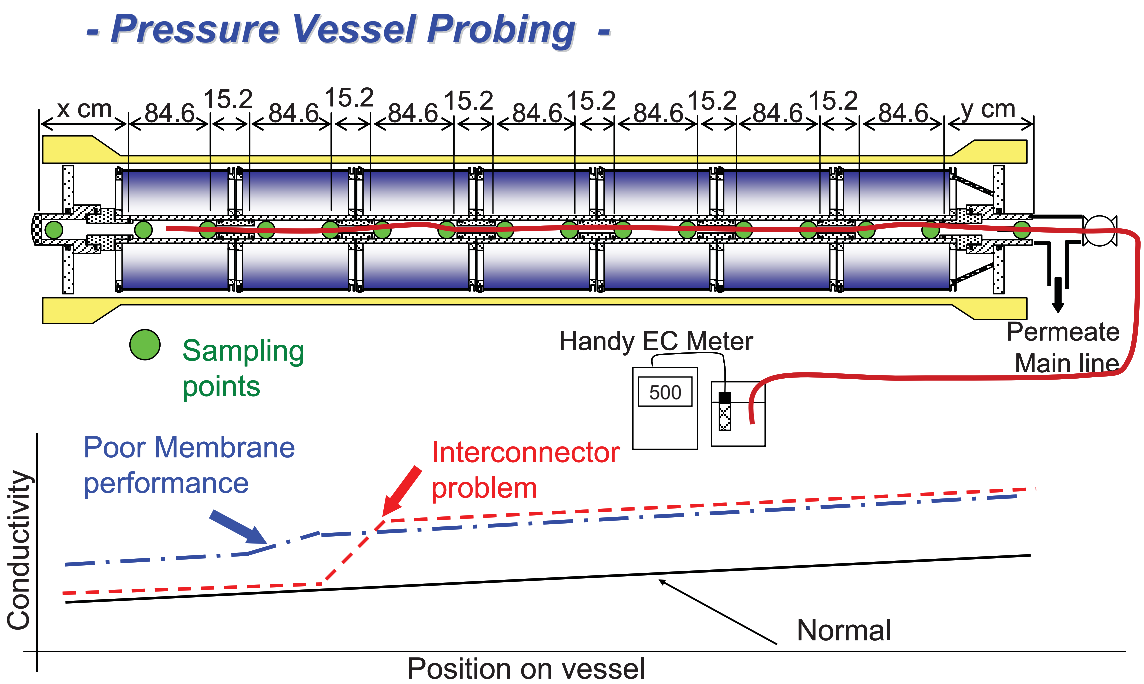


Illustration TMM-600.2 : Center pipe probing method (2)



Sampling tube apparatus

Supple thin wall gum rubber (5cm) Cut open the edge of the tube (3cm)

Typical Performance Changes and Countermeasures

To properly evaluate the performance of a RO system it is essential that reliable operational data be recorded on a daily basis. To assure the collected performance data is accurate, a regular instrument calibration schedule should be adopted. Logging of collected data and all maintenance procedures are important for proper system evaluation. Analysis of the recorded historical system data will help determine what remedy is best suited to recover any lost system performance.

This section is about problems and countermeasures regarding salt passage and permeate flow rate. The impact of feed water conditions such as pressure, temperature, concentration, pH and recovery ratio in the system performance is discussed in section TMM 230 .Operation Monitoring.

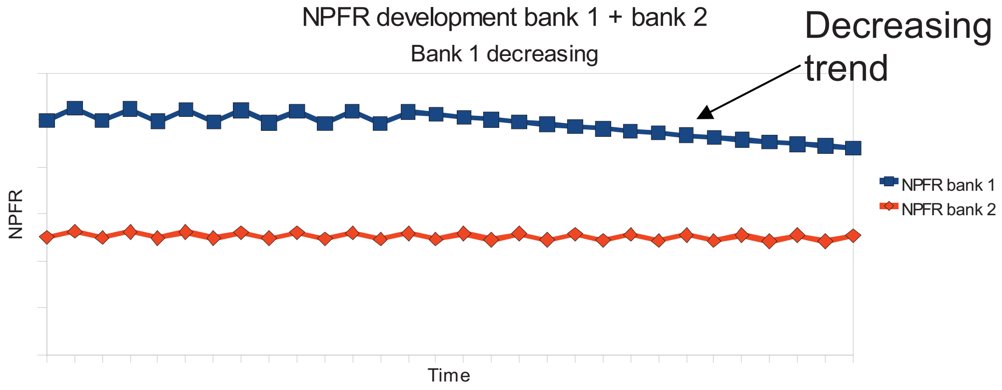
The following abbreviations are used in this section:

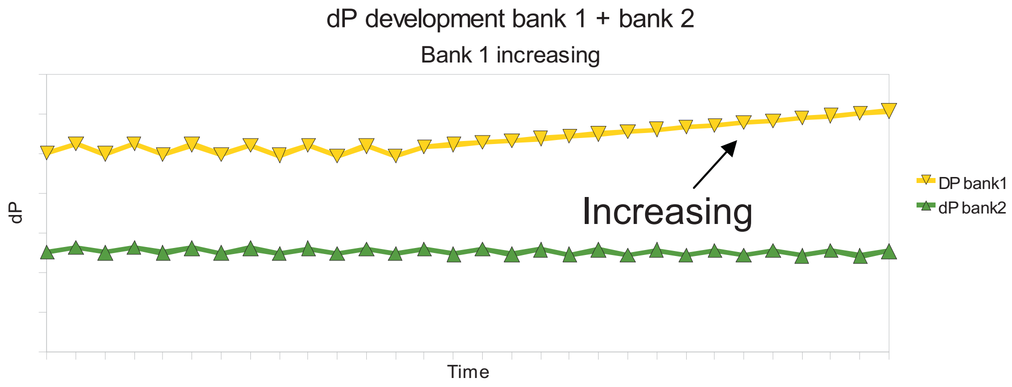
NPFR = Normalized permeate flow rate

NSP = Normalized salt passage

DP = Differential pressure

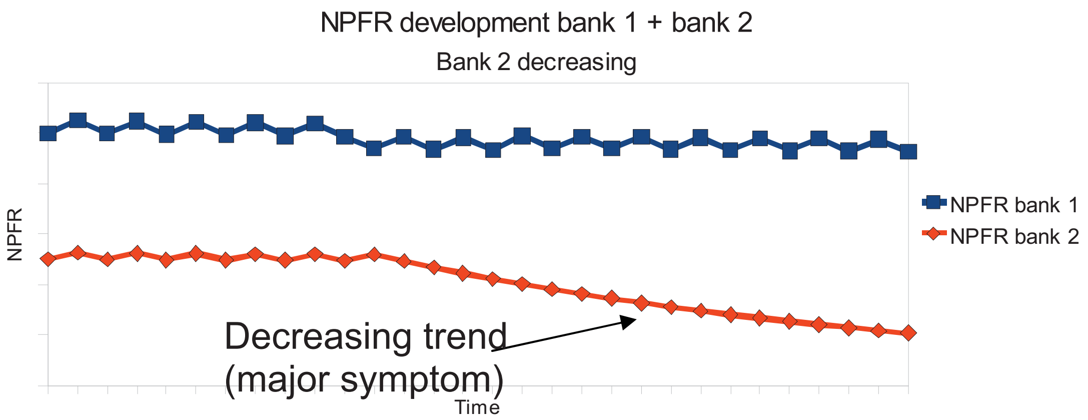
Case A: Normalized permeate flow rate (NPFR) decline – first bank

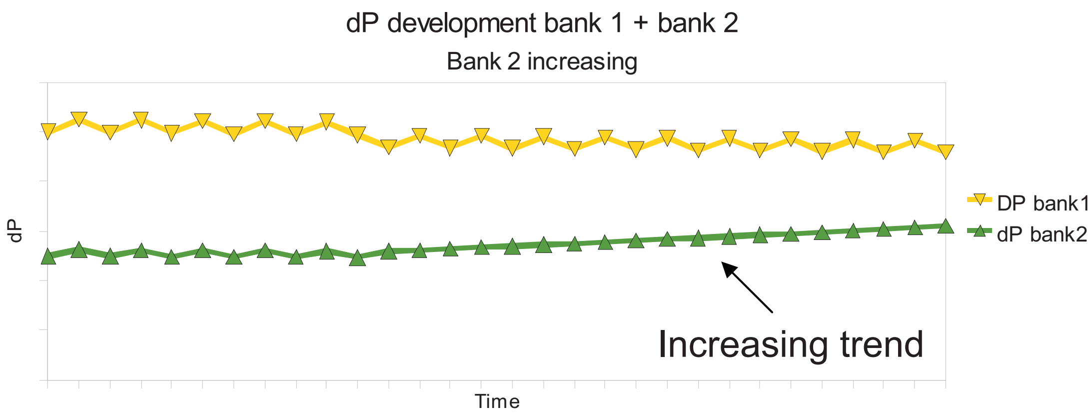




Potential causes	Countermeasures
• Change in feed water quality	Check operating parameters (recovery, flux). Optimize pre-treatment, check pre-filtration (perform any required adjustments)
• Fouling by metal hydroxides, inorganic colloids, organic or bacterial matter	Optimize pre-treatment, followed by appropriate CIP and / or sterilization
• Fouling by suspended particles	Chemical cleaning. Optimize pre-treatment, check pre-filtration equipment

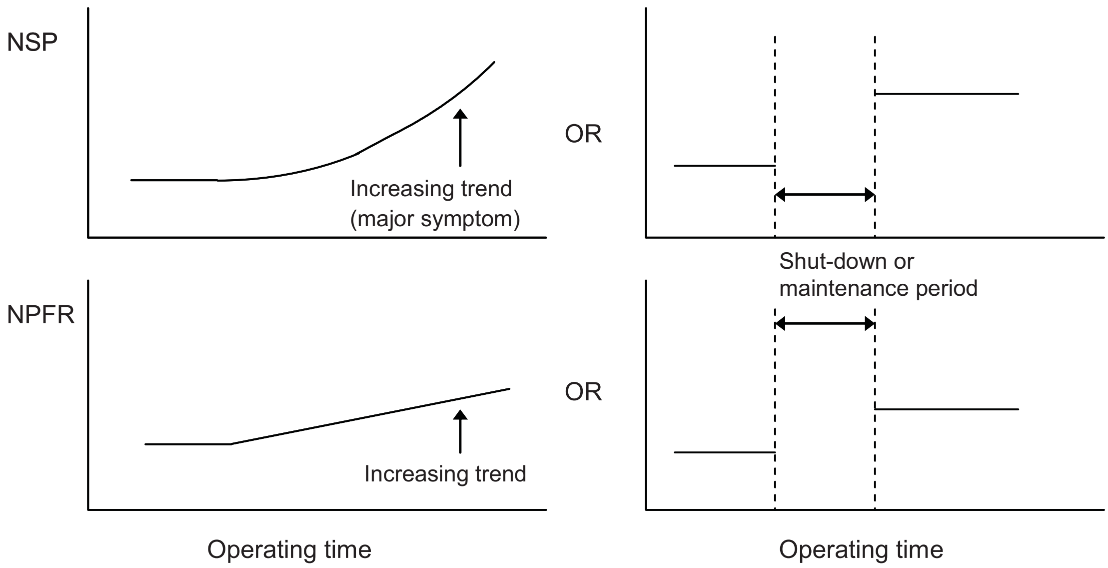
Case B: Normalized permeate flow rate (NPFR) decline – last bank





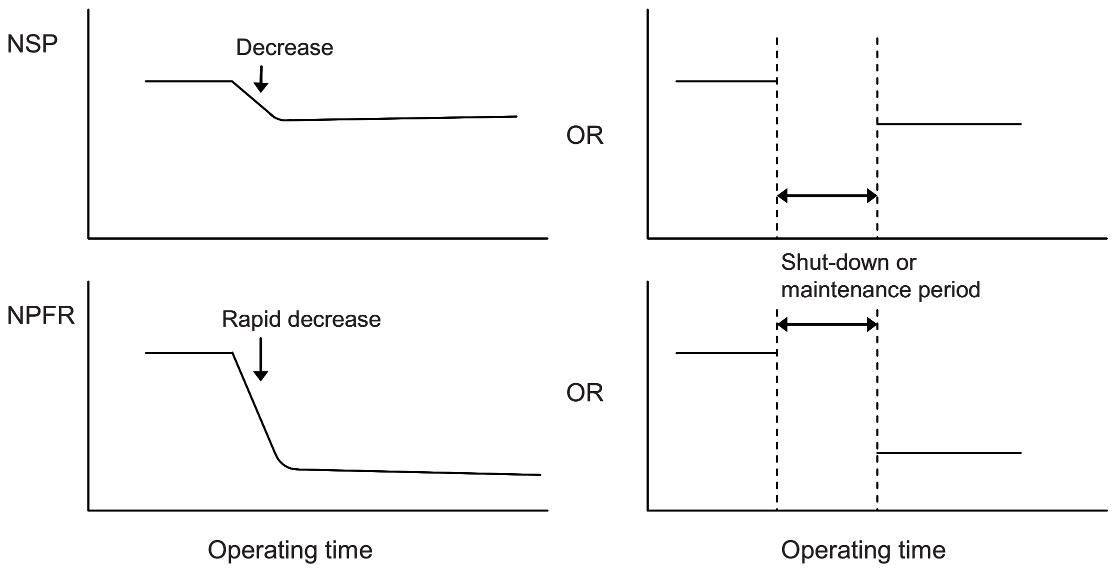
Potential causes	Countermeasures
• Change in feed water quality	Check operating parameters (recovery, flux). Optimize pre-treatment, especially the scale inhibitor injection system and dosage rate..
• Scaling in Bank 2 (precipitation of sparingly soluble salts	Check feed analysis for changes. Check scale inhibitor injection system and inhibitor dosage rate
• Fouling by metal hydroxides, inorganic colloids, organic or bacterial matter	Optimize pre-treatment, analyse the foulant followed by an appropriate CIP and / or sterilization procedure
• Fouling by suspended particles	Analyze precipitate, followed by appropriate chemical cleaning

Case C: Normalized Salt Passage (NSP) Increase–All Vessels



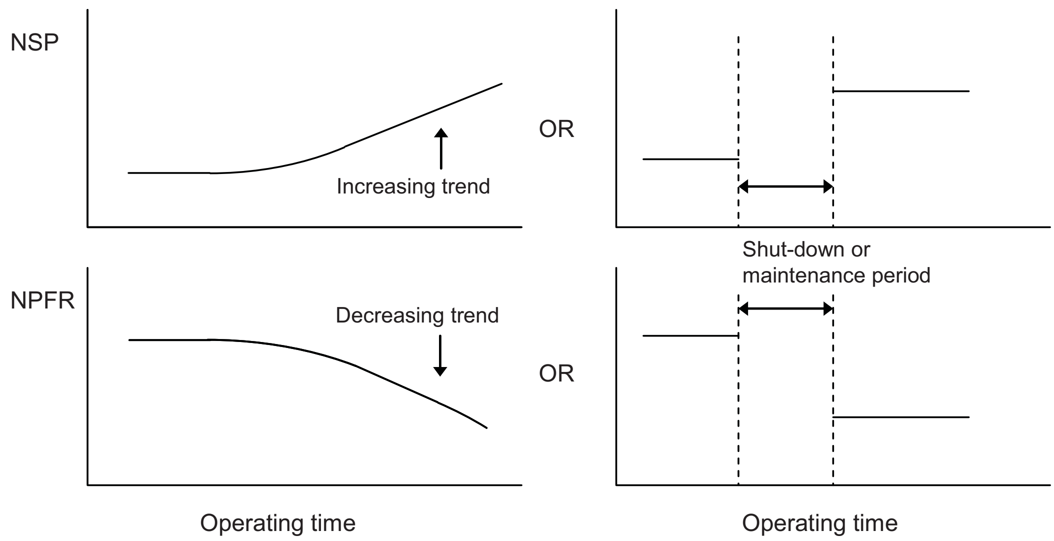
Potential causes	Countermeasures
● Membrane affected by exposure to oxidants, Use of non-compatible chemicals, System operation outside recommended design values.	Check, modify and/or optimize chemicals that come in contact with the membrane elements.. Check oxidant removal apparatus(if any) Check and adjust operating conditions according to recommendations of the membrane manufacturer.
● Mechanical damage due to scratch by particles such as precipitation of sparingly soluble salts.	Check pre-treatment, in particular regarding pH adjustment and / or dosing rate of scale inhibitors. Adjust system recovery with attention to limits given by feed water chemistry.

Case D: Normalized permeate flow rate (NPFR) decrease – all banks simultaneously



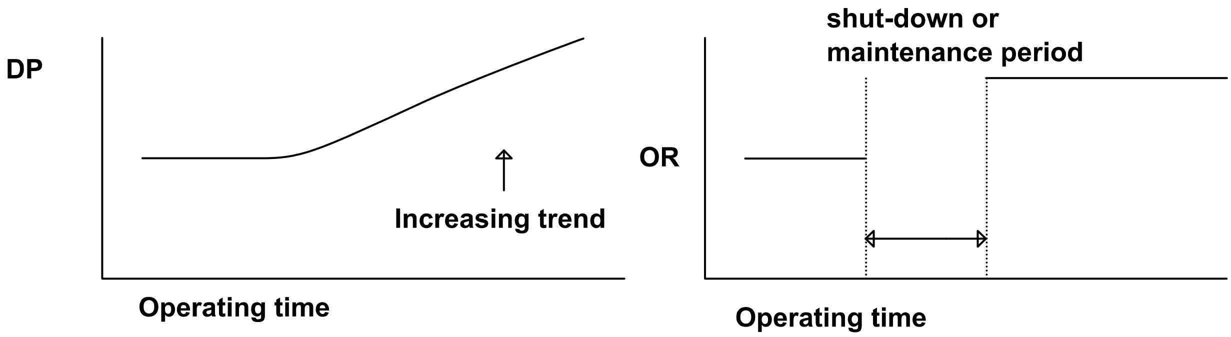
Potential causes	Countermeasures
• Initial stages of damage caused by exposure of non-compatible chemicals,	Check, modify and/or optimize chemicals coming in contact with the membranes. Check to make sure all chemicals are compatible with the installed membrane. Check and adjust operating conditions according to recommendations of the membrane manufacturer.

Case E: Normalized permeate flow rate (NPFR) decrease – all banks simultaneously, with variations for individual brine stages



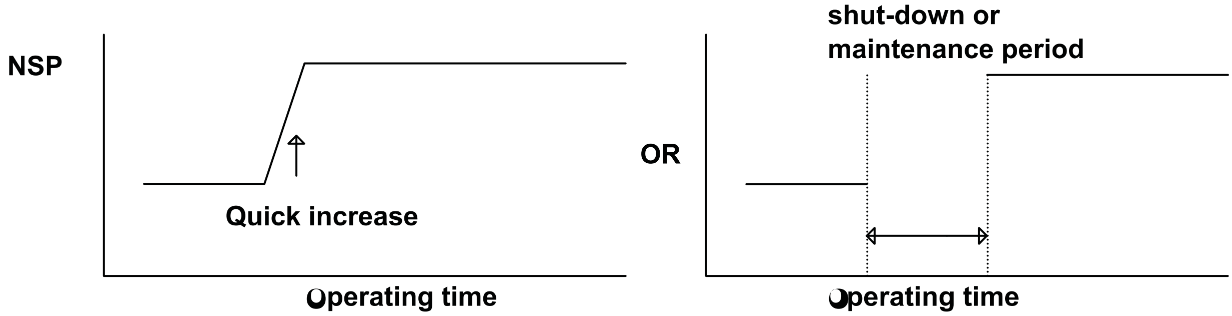
Potential causes	Countermeasures
• Excessive concentration polarization	Check and adjust operating conditions according to recommend guidelines. Make sure the minimum brine flow requirement has been maintained. Check the system's recovery rate to make sure it is within the system design specifications- if needed reduce the recovery Check pre-treatment chemical dosage and addition,. Check and replace brine seals if necessary

Case F: Differential pressure (DP) increase



Potential causes	Countermeasures
● Contamination by particulate matter or biogrowth	Refer to Case A and B. Check and improve pre-treatment, in particular for particle removal and carbon feed to system (TOC/DOC ratio)
● Excessive feed flow	Check feed flow rates for compliance with recommendations and latest trends

Case G: Normalized salt passage (NSP) Increase – individual vessels



Potential causes	Countermeasures
• Mechanical leakage due to O-ring seal damage excessive feed flow/pressure drop excessive permeate back pressure	Detect location of the leak in a particular vessel by probing the pressure vessel in question. Make sure permeate back pressure (permeate pressure minus feed/brine pressure) is less than 0.05 Mpa [7 psi] at all times especially during start-up and shut down.

Appendix E

Colorado River Municipal Water District Exception Request Letter

and

Texas Commission on Environmental Quality Exception Approval Letter

for operation outside normal operating conditions for the purpose of implementing this Protocol

Tuesday, December 02, 2014

Ms. Marlo Berg,
Technical Review and Oversight Team
Texas Commission on Environmental Quality
12100 Park 35 Circle, Bldg. F
Austin, Texas 78753

Subject: Colorado River Municipal Water District (PWS ID No. 1140038)
Raw Water Production Facility
Exception Request for Temporary Operating Conditions

Dear Ms. Berg,

As you are aware, the Colorado River Municipal Water District (CRMWD) is hosting a research project sponsored by the Texas Water Development Board (TWDB) and supported by the Texas Commission on Environmental Quality (TCEQ) at our Raw Water Production Facility (Facility) in Big Spring, TX. A team lead by Carollo Engineers, Inc. (Carollo) is performing this research study, which includes collection of a large number of samples for water quality analysis. The first sample event was conducted in July 2014.

As part of this study, Carollo is proposing to conduct membrane challenge testing on the reverse osmosis (RO) membranes of our Facility. The overall time-frame for this testing would be up to one work week (five days). This testing may involve the following deviations from our normal operations:

1) Temporary shut-downs of our Facility to allow for setup of test equipment.

2) Short term feed of MS-2 bacteriophage suspension ahead of the RO membranes (less than 15 minutes for each spike event, with no more than 10 spike events), in order to determine their ability to remove virus. While the MS-2 preparation is not formally NSF certified for use in drinking water, it is considered benign. Please refer to an email addressed to you from Eva Steinle-Darling with Carollo, dated October 24, 2014 with the attachment "Response to TCEQ Comments" for evidence supporting this statement.

3) Feed of an NSF-certified anti-scalant provided by Nalco, which includes a tracer molecule (Trasar(R) chemical) that will be tested in parallel with MS-2 samples to establish the tracer as a surrogate measure of virus removal.

4) Temporary substitution of existing RO membrane elements with identical, new Toray elements that have been artificially aged by exposure to an oxidant. The artificial aging process is currently underway off-site and is expected to result in elements whose sodium chloride rejection is between 75% and 80%. The artificially aged membranes will be operated for no more than a total of 36 hours. This time is necessary to equilibrate the membranes to operating conditions before testing is conducted.

5) Temporary operation with intentionally damaged RO element connection hardware, for example a cut o-ring, to determine that the Trasar(R) technology will alert operators to a breach within a short time. MS-2 bacteriophage will be dosed during operation with this damaged hardware to determine the actual magnitude of the integrity breach with respect to virus removal. Operation under these conditions would likely occur for only a few minutes (time to start up the RO skid, start Trasar(R) feed, start MS-2 feed, collect samples, and shut down). After testing is complete, the original membranes and connection hardware will be reinstalled and system operation under previous conditions will be confirmed.

Some of these proposed tests, in particular those listed under 4) and 5) above, have the potential to result in electrical conductivity readings in the RO permeate that exceed shut-down thresholds for our Facility per the operating conditions approved in a TCEQ letter dated April 11, 2013. Specifically, the testing may cause the Facility to not be able to meet Operation Requirement No. 1d., which states:

> *If conductivity or total dissolved solids levels of an RO unit's permeate increase by the larger of 20% or 40 microSiemens per centimeter (uS/cm) over the last reading then the RO unit must be removed from service, the problem repaired, and an acceptable conductivity or total dissolved solids achieved in the permeate before discharge to the CRMWD raw water pipeline can be resumed.*

Based on the importance of this research for future implementation of potable reuse projects and the fact that our Facility does not rely on the RO system for any pathogen removal (the acute concern for public health), CRMWD hereby submits an exception request to operate outside the limits of Operation Requirement No. 1d under the following conditions:

1) The total time in which the RO skid will operate after potentially exceeding the 20% relative increase in conductivity or the 40 uS/cm absolute threshold is expected to last only a few minutes and under no circumstances will exceed 48 hours;

2) The RO permeate conductivity will be returned to within 20% of the readings previously recorded after testing is complete; and

3) The dates for testing will be determined after approval of this exception request and communicated to TCEQ before testing begins.

We request approval by TCEQ to allow our Facility to operate under the aforementioned conditions to complete the testing proposed for the TWDB-funded research project. Please contact me if there are any questions or if there is any additional information that we can provide to assist you with your review.

Sincerely,

Cole Walker, PE

Bryan W. Shaw, Ph.D., P.E., *Chairman*
Toby Baker, *Commissioner*
Zak Covar, *Commissioner*
Richard A. Hyde, P.E., *Executive Director*

PWS_1140038_CO_20141229_Exception

Texas Commission on Environmental Quality

Protecting Texas by Reducing and Preventing Pollution

December 29, 2014

Mr. Cole Walker, PE
Colorado River Municipal Water District
400 East 24th Street
Big Spring, Texas 79721-0869

Subject: Revision to the Previously Granted Exception to Use Membrane-Treated Reclaimed Wastewater from the Big Spring Wastewater Treatment Plant as a Raw Water Source for Public Drinking Water Systems
Colorado River Municipal Water District - PWS ID No. 1140038
Howard County, Texas

CN602515967 ; RN105692891

Dear Mr. Walker:

The Texas Commission on Environmental Quality (TCEQ) received your December 2, 2014 letter requesting review and changes in some of the conditions described in the TCEQ's April 11, 2013 letter approving an innovative raw water source. The Colorado River Municipal Water District (CRMWD) Big Spring Regional Water Reclamation Project (reclamation facility) had requested an exception to the requirements for the raw water source. The exception request proposed the use of City of Big Spring Wastewater Treatment Plant (WWTP) effluent treated at the CRMWD reclamation facility by hollow fiber (HF) microfiltration (MF) membranes followed by reverse osmosis (RO) membranes to be used as a raw water source for the City of Big Spring (PWS ID 1140001), City of Snyder (PWS ID 2080001), City of Odessa (PWS ID 0680002), City of Stanton (1590001), and City of Midland (PWS ID 1650001) surface water treatment plants (SWTPs).

The Texas Water Development Board (TWDB) is sponsoring research at the CRMWD reclamation facility. To characterize the removal potential of the reverse osmosis (RO) membranes and the ability to measure the removal, the researcher will test the existing RO modules, artificially aged RO modules and intentionally damaged connection hardware. These modules and connection hardware will be tested for one week and may allow larger increases in total dissolved solids (TDS) or conductivity than allowed in condition 1d of TCEQ's April 11, 2013 approval letter.

"If conductivity or total dissolved solids levels of an RO unit's permeate increase by the larger of 20% or 40 microSiemens per centimeter (uS/cm) over the last reading than the RO unit must be removed from service, the problem repaired, and an acceptable conductivity or total dissolved solids achieve in the permeate before discharge to the CRMWD raw water pipeline can be resumed."

Because the facility does not rely on the RO modules for pathogen removal treatment credit and the short term nature of project, the TCEQ can **grant a temporary exception** to allow

CRMWD's reclamation facility to operate with TDS or conductivity increases greater than those listed in condition 1d of TCEQ's April 11, 2013 approval letter with the following conditions:

1. The TDS or conductivity condition is only suspended for the period of **one week** during the TWDB testing with artificially aged membrane modules or a damaged RO connector.
2. The temporary exception will expire after the testing is completed.
3. CRMWD will notify TCEQ via email the dates of the testing.
4. The facility must meet all of the other operational requirements found in #1 of the TCEQ April 11, 2013 letter especially the daily direct integrity testing and UV operations.

If you have any questions or need further assistance, please contact Ms. Marlo Wanielista Berg, P.E. of my staff at marlo.berg@tceq.texas.gov, or at (512) 239-6967.

Sincerely,

Gary Shaw, for

Joel Klumpp, Manager
Plan & Technical Review Section
Water Supply Division
Texas Commission on Environmental Quality

JPK/mew

cc: Mr. John Grant, General Manager, Colorado River Municipal Water District, PO Box 869, Big Spring, TX 79721- 0869
Mr. Jim R. Purcell, Colorado River Municipal Water District, PO Box 869, Big Spring, TX 79721- 0869

bcc: TCEQ Midland Regional Office – R7
Ms. Vera Poe, P.E., Team Leader, Utilities Technical Review Team – MC159
Mr. Gary Chauvin, Section Manager, Public Drinking Water Section - MC155
Ms. Jaya Zyman-Ponebshek, Assistant Director, Water Quality Division – MC145

Appendix C

Summary of TCEQ Data for Regulated Constituents

Table C.1 Results of Product Water Sampling Conducted by or on behalf of TCEQ - Inorganic Constituents

Sample Date	Alkalinity, Total (mg/L as CaCO3)	Hardness, Total (mg/L as CaCO3)	Conductance, Diluted (µmhos/cm)	pH, Field SU	Bicarbonate (mg/L)	Chloride (mg/L)	Nitrate (duplicates) (mg/L)		Nitrite (mg/L)	Sulfate (mg/L)	Solids, Total Dissolved (mg/L)
MCL or Action Level	--	--	--	--	--	300	10		1	300	1000
31-Jan-2013	6	< 2.5	40	5.5	7	7	0.26	0.26	0.02	< 1	18
20-Jun-2013	6	< 2.5	33	5.8	8	4	0.46	0.45	< 0.01	< 1	10
27-Feb-2014	5	< 2.5	44	5.5	6	6	0.67	0.71	< 0.01	2	28
19-May-2014	7	< 2.5	49	6.3	8	8	0.55	0.56	< 0.01	1	25
4-Sep-2014	12	< 2.5	132	5.2	14	25	2.83	2.98	0.02	2	85
15-Dec-2014	4	< 2.5	68	4.6	5	13	1.84	1.85	0.01	< 1	43
2-Feb-2015	7	< 2.5	57	5.6	8	10	1.44	1.41	< 0.01	< 1	29
22-Apr-2015	5	< 2.5	74	5.3	6	14	1.55	1.48	0.01	2	38
6-Aug-2015	8	< 2.5	89	6.0	9	16	2.12	2.12	0.01	2	45
27-Oct-2015	6	< 2.5	44	5.3	7	6	0.97	1.02	0.05	2	24
18-Feb-2016	< 20	4	71	5.4	<	8	1.22	1.46	NS	< 5	36
12-Apr-2016	< 20	2	68	5.1	<	8	1.41	1.26	0.052	< 5	< 10
1-Sep-2016	< 20	10	188	5.6	<	32	2.4	NS	NS	7	121
11-Oct-2016	< 20	3	90	5.8	<	12	1.49	1.60	0.014	< 5	32

Table C.2 Results of Product Water Sampling Conducted by or on behalf of TCEQ - Metals

Sample Date	Barium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Sodium (mg/L)	Zinc (mg/L)
MCL or Action Level	2	--	0.1	1.3	--	--	--	--	--	0.05	--	--
31-Jan-2013	< 0.0010	< 1.00	< 0.0100	0.0027	< 0.010	< 1.00	0.0032	< 0.0010	< 1.00	< 0.0030	6.82	0.0826
20-Jun-2013	< 0.0010	< 1.00	< 0.0100	0.0039	0.013	< 1.00	< 0.0010	< 0.0010	< 1.00	< 0.0030	6.38	0.0106
27-Feb-2014	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	< 0.0010	0.0046	< 1.00	< 0.0030	6.56	< 0.0050
19-May-2014	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	0.0012	< 0.0010	< 1.00	< 0.0030	8.32	< 0.0050
4-Sep-2014	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	0.0051	< 0.0010	1.21 | 1.26	0.0046	21.5	< 0.0050
15-Dec-2014	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	< 0.0010	< 0.0010	< 1.00	< 0.0030	11.5	< 0.0050
2-Feb-2015	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	< 0.0010	< 0.0010	< 1.00	< 0.0030	9.36	< 0.0050
22-Apr-2015	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	< 0.0010	< 0.0010	< 1.00	< 0.0030	12.1	< 0.0050
6-Aug-2015	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	0.0025	< 0.0010	< 1.00	< 0.0030	16.0	< 0.0050
27-Oct-2015	< 0.0010	< 1.00	< 0.0100	< 0.0020	< 0.010	< 1.00	0.0016	< 0.0010	< 1.00	< 0.0030	7.04	< 0.0050
18-Feb-2016	0.00074	0.87	0.00042	< 0.00040	< 0.0200	0.52	0.00043	< 0.00040	0.63	< 0.0010	9.94	0.0033
12-Apr-2016	< 0.00070	0.51	0.00058	0.0022	< 0.0200	0.27	< 0.00040	< 0.00040	0.50	< 0.0010	9.79	< 0.00200
1-Sep-2016	0.00230	2.17	0.00063	0.0007	< 0.0200	1.13	< 0.00040	< 0.00040	1.21	0.0011	26.7	< 0.00200
11-Oct-2016	0.00077	0.74	< 0.00040	0.0011	< 0.0200	0.40	< 0.00040	< 0.00040	0.78	0.0017	13.3	< 0.00200

Table C.3 Results of Product Water Sampling Conducted by or on behalf of TCEQ - Trihalomethanes and Other Selected Constituents

Sample Date	Bromodichloromethane (duplicates) (µg/L)		Bromoform (duplicates) (µg/L)		Chloroform (duplicates) (µg/L)		Dibromochloromethane (duplicates) (µg/L)		Total Trihalomethanes (duplicates) (µg/L)		Bromate (ug/L)	Pentachlorophenol (duplicates) (µg/L)		Endothall (ug/L)	2,3,7,8 TCDD/Dioxin (pg/L)	Pb-212 (pCi/L)	Ra-228 (pCi/L)
MCL or Action Level	--		--		--		--		80		10	1		100	30	--	5
31-Jan-2013	< 1.0	< 0.5	< 1.0	< 0.5	< 1.0	0.7	< 1.0	< 0.5	< 4.0	< 2.0	NS	< 0.04	< 0.04	NA	NA	2.4	ND
20-Jun-2013	4.7	5.5	< 1.0	< 0.5	2.6	2.9	< 1.0	0.5	7.3	8.9	ND	< 0.04	< 0.04	NA	NA		ND
27-Feb-2014	3.5	3.2	< 1.0	< 0.5	2.1	1.9	2	1.4	7.6	6.5	ND	< 0.04	< 0.04	ND	ND		ND
19-May-2014	5.0	3.4	< 1.0	< 0.5	3.4	3.2	1.5	1.6	9.9	8.2	ND	< 0.04	< 0.04	ND	ND		ND
4-Sep-2014	10.6	12.0	1.4	1.8	3	3.2	7.5	8.8	22.5	25.8		< 0.04	< 0.04	NA			ND
15-Dec-2014	6.1	5.0	< 1.0	0.7	10.4	11	3.7	2.9	20.2	19.6		< 0.04	< 0.04				ND
2-Feb-2015	3.3	3.3	< 1.0	< 0.5	1	1	2.7	2.3	7	6.6		0.07	< 0.04				ND
22-Apr-2015	4.1	2.8	< 1.0	< 0.5	2	1.5	3.3	1.9	9.4	6.2		< 0.04	< 0.04			no longer required	ND
6-Aug-2015	12.5	14.0	2	2.5	3.9	4.6	10.9	12	29.3	33.1	no longer required	< 0.04	< 0.04		no longer analyzed		ND
27-Oct-2015	12.1	7.0	< 1.0	< 0.5	11	8.7	3.5	1.6	26.6	17.3		< 0.04	< 0.04	no longer required			1.7
18-Feb-2016	7.0	6.4	< 1.0	1.7	10.5	8.9	4.4	3.1	21.8	20.1		< 0.03	< 0.04				ND
12-Apr-2016	6.2	5.4	< 1.0	1.6	2.1	1.9	3.4	2.2	11.7	11.0		< 0.03	< 0.04				ND
1-Sep-2016	10.5	11.8	4.8	7.9	2.4	2.2	11.9	17.6	29.6	39.4		NA	< 0.04				ND
11-Oct-2016	10.2	9.6	2.3	1.1	3.3	2.8	9.3	6.4	25.1	19.9		NA	< 0.04				ND

Appendix D

Collimated Beam Test Results Report by Trussell Technologies

Trussell
TECHNOLOGIES INC

Appendix D

Testing Water Quality in a Municipal Wastewater Effluent Treating to Drinking Water Standards

Additional Testing for UV Advanced Oxidation Process Verification: Collimated Beam Test Results

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December, 2016

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1 Executive Summary

This report focuses on the RWPF UV AOP system and the water chemistry and UV dose requirements to provide advanced oxidation. This report reviews both NDMA destruction and the destruction of 1,4-dioxane, neither of which is a regulatory requirement within Texas for potable water reuse. For some potable water reuse projects nationally and internationally, the regulatory authorities require an advanced oxidation process following treatment by RO, resulting in measurable destruction of a broad range of potential small and trace level pollutants. Providing removal of 1,4-dioxane correlates well to equal or greater removal of a broad range of other pollutants. Further, destruction of NDMA is often needed to reduce NDMA below certain standards, such as a 10 ng/L level that is regulated in other states.

Ultraviolet light (UV) photolysis and UV advanced oxidation process (AOP) bench-scale collimated beam (CB) testing was conducted with advanced treated reclaimed water from Colorado River Municipal Water District's Raw Water Purification Facility (RWPF). The facility's advanced treatment train includes microfiltration, RO, and UV/hydrogen peroxide (UV/H_2O_2) AOP. The UV reactors at the RWPF are low pressure UV (LPUV) reactors so the CB testing was conducted with LPUV lamps. It is believed that RO permeate is an ideal feed for a UV AOP because of its low levels of alkalinity and natural organic matter (NOM), which are scavengers of the hydroxyl radicals (•OH) that drive the UV/H_2O_2 AOP. UV photolysis of chloramines and N-Nitrosodimethylamine (NDMA) in the absence of oxidant was evaluated as a possible approach to evaluate dose delivery of the full-scale UV reactor, with chloramine potentially serving as a surrogate for NDMA removal by photolysis. Comparison of CB testing of NDMA destruction to a full-scale same day test of NDMA destruction was planned to establish a delivered UV dose. However, NDMA levels in the RO permeate were far too low to demonstrate accurate NDMA dose/response behavior, on the order of 1-log minimum. For this reason, the rest of the discussion in the Executive Summary will focus on 1,4-dioxane destruction testing.

The CB testing with 1,4 dioxane demonstrated that the UV/H_2O_2 AOP could remove 1,4 dioxane spiked into RWPF RO permeate to a log removal value (LRV) of 0.5-log, as shown in Table ES-1. While chemistry plays a large role in AOP performance, RO systems rely upon low dose chloramines to limit biofouling, and some chloramines will pass into the RO permeate. For this project, as noted during testing, the chloramine level in RO permeate was 0.93 mg/L. For this chloramine concentration, a UV dose of 1000 mJ/cm^2 was able to increase the LRV 1,4 dioxane to 0.49-log at a H_2O_2 dose of 3.5 mg/L, to 0.68-log for a H_2O_2 dose of 5.5 mg/L, and to 0.74-log to 1.15-log for a H_2O_2 dose of 10.1 mg/L. It will be shown later that chloramines scavenge •OH so the low chloramine level represents the ideal condition for future operation. This is born out by the testing results at an increased chloramine level that resulted in reduced destruction of 1,4 dioxane. At the high chloramine level of 2.9 mg/L, only the high H_2O_2 dose of 9.9 mg/L was able to just achieve the 0.5 LRV level for 1,4 dioxane at 0.54-log and only at the high UV dose of 1000 mJ/cm^2.

Table ES-1 - CB testing conditions where 0.5-log removal of 1,4-dioxane was achieved

UV Dose	UVT	Chloramine	H_2O_2	LRV 1,4 dioxane
1000	97.9%	0.93	3.5	0.49
1000	98.6%	0.93	5.5	0.68
650	97.9%	0.93	10.1	0.74
1000	97.9%	0.93	10.1	1.15
1000	96.8%	2.13	5.5	0.56
650	96.2%	2.13	10.1	0.53
1000	96.2%	2.13	10.1	0.78
1000	95.3%	2.9	9.9	0.54

[a]UV Dose in mJ/cm^2, H_2O_2 in mg/L, 1,4-dioxane in µg/L, LRV is log(C/C_0)

It should be noted that only the chloramine level of 0.93 mg/L represents the actual condition for the RO permeate shipped from the RWPF. The levels of 2.13 and 2.9 mg/L were achieved by spiking and are representative of doses used in other plants to control biofouling in the RO. Chloramine was removed to a greater extent than 1,4-dioxane in the CB testing, to a degree that cannot be fully explained as removal by UV photolysis. It was determined that the hydroxyl radical (•OH) scavenging rate has a significant impact on the ability of the UV/H_2O_2 AOP to reduce the target constituent, 1,4-dioxane. Total scavenging rate (TSR), $\sum_i (k_{\bullet OH,i}[\mathrm{S}_i])$, is a concept that has been introduced to the UV AOP field in recent years. $[\mathrm{S}_i]$ represents the molar concentration of a hydroxyl radical scavenging compound and $k_{\bullet OH,i}$ represents the 2nd order hydroxyl radical rate constant of the scavenging compound, a measure of the compound's ability to react with •OH. Essentially, any compound present in the water matrix could act as a •OH scavenger including the target compound(s), but most compounds will be present in such low concentrations or have such low $k_{\bullet OH}$ that they are insignificant. Hydroxyl radical scavenging was evaluated at H_2O_2 doses of 3, 5, and 10 mg/L. TSR results are presented in Table ES-2 at an H_2O_2 dose of 5 mg/L as a representative example, as the trends and magnitude of the numbers are similar for the other doses. The water quality in Table ES-2 is the water quality of the RO permeate shipped from the RWPF used in the bench testing. The top row in Table ES-2 shows the chloramine level for the scavenging calculations. The impact of chloramine on scavenging is seen most clearly by looking at column 2 (no chloramines present) compared to any of the other columns. For the most dramatic effect, column 2 with no chloramines will be compared to column 5 with the high level of chloramines (2.9 mg/L). In the absence of chloramines, NOM dominates •OH scavenging at 63.1% with H_2O_2 second ranked at 17.6%, bicarbonate at 13.6% and 1,4-dioxane at 4.2%. At the high chloramine level of 2.9 mg/L, chloramine dominates •OH scavenging at 87.7% with NOM at 7.8%, H_2O_2 at 2.2%, bicarbonate at 1.67% and 1,4-dioxane at 0.52%. This demonstrates the significance of chloramine on the TSR, with its 2nd order •OH rate constant of 2.8×10^9 (same as 1,4-dioxane, but with chloramine present at much higher concentration).

The TSR is also significant and shown in Table ES-2. The TSR in 1/s increases from 23,000 to 74,000 to 141,000 to 183,000 at chloramine levels in mg/L from 0 to 0.93 to 2.13 to 2.9. The increase in total scavenging rate from no chloramines to 2.9 mg/L chloramine represents a 712% increase. As shown in the report, the rate of removal by AOP is inversely proportional to total scavenging rate so these increases are significant and chloramine is clearly the dominant player for •OH radical scavenging for RO permeate. Strategies to reduce chloramines in RO permeate ahead of UV AOP may prove cost effective, as long as those strategies do not add in more scavengers that significantly impact the reduction in TSR by removing the chloramines.

The 1,4-dioxane removal data suggest a UV dose near 720 mJ/cm^2 and a H_2O_2 dose of 5 mg/L are required to reach LRV of 0.5-log for 1,4-dioxane. The UV dose of 720 mJ/cm^2 was demonstrated at a chloramine level of 0.93 mg/L and a UVT of 98.6%, which was the UVT observed in the RO permeate on the day of testing. Higher UV dose and/or H_2O_2 dose values will allow for greater removal.

Because it was not possible to evaluate the delivered dose for the full-scale reactor with NDMA destruction on the bench-scale reactor, a brief analysis was made of electrical energy dose (EED) for the full-scale reactor. The EED was determined to be 0.43 kWh/kgal. A comparison was made to the Orange County Groundwater Replenishment who are permitted to EED=0.23 kWh/kgal and have historically operated at 0.25 to 0.35 kWh/kgal and H_2O_2 dose of 3 mg/L. This suggests that the RWPF may have sufficient power to achieve 0.5-log 1,4-dioxane removal at H_2O_2 doses of 5 mg/L or lower, but it should be noted that all potable reuse systems and the experience at one facility is not guaranteed to transfer to another facility.

Table ES-2 - Total Scavenging Rate Results for UV Dose of 1000 mJ/cm2 and H2O2 dose of 5 mg/L. Fraction of total scavenging rate for key constituents that scavenge •OH.

Chloramine Level (mg/L)	→	**0 0.93**		**2.13**	**2.9**
•OH Scavenger	**Concentration**	**Fraction of Total Scavenging Rate**			
Bicarbonate (mg/L)	22	13.6%	4.13%	2.18%	1.67%
Carbonate (mg/L)	0.042	1.5%	0.46%	0.24%	0.19%
NOM[a] (mg/L)	0.57	63.1%	19.2%	10.1%	7.8%
H_2O_2 (mg/L)	3	17.6%	5.4%	2.8%	2.2%
Chloramine	Not Applicable	**0.0%**	**69.5% 83.**	**9 % 87.**	**7 %**
1,4-dioxane[b] (µg/L)	30	4.2%	1.3%	0.68%	0.52%
TSR = Total Scavenging Rate = Summation {$k_{\cdot OH}$ x C (1/s)}					
TSR (1/s)	Not Applicable	**23,000 74,**	**000**	**141,000**	**183,000**
TSR %Increase from NH_2Cl=0	Not Applicable	-	228%	523%	712%

[a]After spiking with 1,4-dioxane. NOM=0.275 mg/L before spiking. Difference has small effect on TSR relative to chloramine.
[b]1,4-dioxane spiked at 30 µg/L.

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Nomenclature and List of Acronyms

•OH	Hydroxyl Radical(s)
$[S_i]$	Molar Concentration of •OH Scavenger, i
1,4-dioxane	1,4-dioxane
72AL75	UV reactor at the full-scale plant
A	Constant for predictive equation for 1,4-dioxane LRV
Alk.	Alkalinity (mg/L as $CaCO_3$)
AOP	Advanced Oxidation Process
ATSDR	Agency for Toxic Substances and Disease Registry
B	Constant for predictive equation for 1,4-dioxane LRV
C	Constant for predictive equation for 1,4-dioxane LRV
$CaCO_3$	Calcium Carbonate
CB	Collimated Beam
Cl_2	Chlorine
CO_3	Carbonate
D	Constant for predictive equation for 1,4-dioxane LRV
E_{avg}	Average irradiance measured in a collimated beam test (mW/cm^2)
EED	Electrical Energy Dose (kWh/kgal)
EPA	Environmental Protection Agency
Einstein	One Mole of Photons
FAT	Full Advanced Treatment
Fluence	Product of the average irradiance, E_{avg}, and the time of exposure, t, in a CB test (mJ/cm^2)
h	hours
H_2O_2	Hydrogen Peroxide concentration (mg/L)
HCO_3	Bicarbonate
$k_{\bullet OH,i}$	2nd order •OH rate constant of constituent, I (L/mole/s)
k_p	Photolysis coefficient, equal to $\varepsilon \times \Phi$ (L/Einstein/cm)
kgal	Kilogallon
kW	Kilowatts
L	Liters
LPUV	Low Pressure UV
LRV	Log Removal Value
MCL	Maximum Contaminant Level
mg	Milligrams
ng	Nanograms
NOM	Natural Organic Matter
NL	Notification Level

NDMA N-Nitrosodim ethylamine
NH_2Cl Chloram ine
NTP National Toxicology Program
NWRI National Water Research Institute
R^2 Statistical measure of the closeness of data to a fitted regression line
RWPF Raw Water Purification Facility
S_i Individual •OH scavenging compound
t Time of Exposure in a Collimated Beam Test (s)
T Tem perature (°C)
TOC Total Organic Carbon (mg/L)
Tot. Cl Total Chlorine (mg/L as Cl_2)
Tot. NH_3 Total Ammonia (mg/L)
TRI Toxics Release Inventory
TSR Total Scavenging Rate (1/s)
UV Ultrav iolet Light
UVA UV absorbance (1/cm)
UV AOP UV advanced oxidation process
UV dose Dose of ultraviolet light to achieve a LRV for a constituent (mJ/cm^2)
UV/H_2O_2 UV/Hydrogen Peroxide AOP
UVT UV Transmittance (%)
x Independent Variable in Regression Equations
y Dependent Variable in Regression Equations

Greek Letters

ε Molar Absorption Coefficient (L/mole/cm)
Φ Quantum Yield (mole of constituent transformed per Einstein of photons absorbed by constituent (mole/Einstein);
µg m icrograms

2 Introduction

In May 2013 the Colorado River Municipal Water District (CRMWD or the District) began augmenting raw water supplies with advanced treated reclaimed water at the Raw Water Production Facility (RWPF) in Big Spring Texas. The treatment train includes microfiltration, reverse osmosis, and ultraviolet light/UV advanced oxidation process (UV AOP) with hydrogen peroxide as the oxidant (UV/H_2O_2).

This report focuses on the RWPF UV AOP system and the water chemistry and UV dose requirements to provide advanced oxidation. This report reviews both NDMA destruction and the destruction of 1,4-dioxane, neither of which is a regulatory requirement within Texas for potable water reuse. For some potable water reuse projects nationally and internationally, the regulatory authorities require an advanced oxidation process following treatment by RO, resulting in measurable destruction of a broad range of potential small and trace level pollutants. Providing removal of 1,4-dioxane correlates well to equal or greater removal of a broad range of other pollutants. Further, destruction of NDMA is often needed to reduce NDMA below certain standards, such as a 10 ng/L level that is regulated in other states.

RO permeate was collected from the RWPF to test the impact of ultraviolet (UV) light dosed with hydrogen peroxide in the treatment train. RO permeate was collected from the RWPF and shipped to the Trussell Technologies Laboratory in Pasadena, CA. Bench-scale testing of UV photolysis and UV AOP were conducted in the Trussell Tech lab using a collimated beam (CB) apparatus.

UV photolysis is a process capable of destroying a chemical that readily absorbs UV light and is amenable to undergoing a chemical reaction that transforms it into sub-components. The photolysis coefficient, k_p, is a measure of the ability to remove or inactivate a chemical or microorganism by UV photolysis and is the product of the molar absorption coefficient, ε, and the quantum yield, Φ (Hokanson, Trussell, and Li, 2016). Advanced oxidation, in this case, is the result of a combination of ultraviolet light in the presence of an oxidant to generate hydroxyl radicals, resulting in destruction of trace organics such as 1,4-dioxane. A measure of the ability of an advanced oxidation process to destroy a given compound is the hydroxyl radical rate constant (see compilation in Buxton, et al., 1988). A more recent compilation of molar absorption coefficients, quantum yields, and hydroxyl radical rate constants is provided in Wols and Hofman-Caris (2012).

NDMA and chloramine are both amenable to removal by UV photolysis, and the removal of one can often be correlated to the removal of another. 1,4-dioxane and chloramine are both amenable to removal by UV AOP, this time due to the hydroxyl radical. Testing was conducted to demonstrate the removal of chloramine and NDMA with UV photolysis. Testing was also conducted with UV/H_2O_2 to demonstrate 1,4-dioxane log removal in the presence of a hydroxyl radical scavenger at varying levels (chloramine).

1.1, 2.2, 3.3 mg/L as Cl_2, (UVT of 98.6%, 97.3%, 95.7%)

For both UV photolysis and UV AOP CB testing, RO permeate samples were tested at three different UV exposures (300, 650, and 1000 mJ/cm^2), three different chloramine levels (in the range of 1 to 3 mg/L), and three different UV transmittances (in the range of 95% to 99%). For the UV/H_2O_2 AOP, testing was conducted at each of three specified H_2O_2 doses (3, 5, and 10 mg/L). The chloramine and UVT variation were included to assess how the presence of chloramines and UVT levels could affect performance of the UV AOP and for evaluation as surrogates.

The UV AOP portion of the report is broken down as follows: (1) Background; (2) Experimental Methods and Test Conditions; and (3) Results and Discussion.

3 Background

Background information on NDMA and NDMA removal based on past work is provided below.

3.1 NDMA

NDMA is a common byproduct formed during the disinfection of secondary treated wastewater. US EPA risk assessments report the carcinogenic risk level for NDMA as 0.69 ng/L in drinking water (EPA, 2001), based on a 1 x 10^{-6} cancer risk level (EPA, 2008) . A review of UCMR 2 data indicated that many utilities in Texas have found NDMA in their source water (http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/data.cfm).While some states have developed notification levels and health criteria for NDMA, no regulatory action has currently been taken in the State of Texas.

There are several known mechanisms of NDMA formation, however, there are numerous additional mechanistic possibilities. Several studies have shown NDMA formation due to the oxidation of dimethylamine (DMA) and dimethylsulfamide (DMS) (Andrzejewski et al., 2008; Schmidt and Brauch, 2008; von Gunten et al., 2010). Other studies have linked NDMA formation to the presence of polymers commonly used in wastewater treatment (Padhye et al., 2011). In 2001, NDMA formation was linked to the disinfection of water and sewage with chlorine. The results showed that the chlorination of water containing dimethylamine leads to the formation of byproducts, with 5% of the total byproducts formed being NDMA. A correlation of NDMA formation as a function of the ratio of chlorine, ammonia and dimethylamine was found as a potential indicator of NDMA concentrations. (Andrzejewski et al., 2004).

The primary process responsible for the formation of NDMA in water treatment is chloramination, which is generally used during disinfection or pretreatment of RO membranes. Chloramines are a proven method for minimizing biofouling of RO membranes, with implementation at both domestic and international facilities. NDMA formation can be mitigated in RO operation by utilizing preformed chloramines, while optimizing the pH to avoid dichloramine formation. The addition of preformed chloramines ahead of RO is currently in operation at the RWPF for biofouling reduction.

NDMA is poorly removed by RO membranes due to its small size and hydrophilic nature (Plumlee et al., 2008). To ensure the destruction of NDMA passing through the RO membranes at a full advanced treatment (FAT) plant, a high dose of UV is commonly applied as a final treatment step to ensure residual NDMA destruction. A UV dose commonly applied for NDMA destruction in a FAT facility is between 700 to 1100 mJ/cm^2. For reference, a UV dose of 50 mJ/cm^2 is recommended to inactivate 99.999% of poliovirus in RO permeate (NWRI, 2012), whereas the most resistant virus to UV, adenovirus, can be reduced by 6-log at a dose of 235 mJ/cm^2 (Gerba *et al.*, 2002).

3.2 1,4-dioxane

1,4-dioxane is a semi-volatile liquid, synthetic industrial chemical historically used as a solvent in products such as paints, lacquers, resins, waxes, and emulsions. It can also be found in the manufacturing process of personal care products and cosmetics. The wide-spread use and probably carcinogenic health effects of 1,4-dioxane make it a contaminant of concern. It has been found in groundwater at sites throughout the United States at concentrations ranging from 1 ppb to 109 ppb (ATSDR, 2005). From 1988 to 2011, the total annual environmental release of 1,4-dioxane reported by EPA's Toxics Release Inventory (TRI), ranged from 0.3 million to 1.3 million pounds, with approximately 0.9 million pounds released in 2011 alone (U.S. EPA, 2013b; NTP, 2011). Under the EPA's Guidelines for Carcinogen Risk Assessment (U.S. EPA, 2005; 2010; 2013), 1,4-dioxane is "likely to be carcinogenic to humans" by all routes of exposure, with evidentiary support from animal studies. State and Federal Maximum Contaminant Levels (MCL) have not been established for this constituent, however, the EPA has established and health advisory level of 0.35 µg/L based on a 1×10^{-6} carcinogenic risk assessment (US EPA 2012). Based on the EPA health advisory level, the State of California established a notification level (NL) of 1 µg/L. Several potable water reuse facilities have been effective at reducing the amount of 1,4-dioxane entering a wastewater treatment plant through source control programs and routine monitoring.

Equally important to all of the health concerns, and relevant to this analysis, 1,4-dioxane is a conservative advanced oxidation surrogate, with destruction of 1,4-dioxane correlating to greater reduction to a wide range of trace level organic chemicals. 1,4-dioxane has a low hydroxyl radical rate constant of 2.8×10^9 $M^{-1}s^{-1}$ (Crittenden et al., 2012) relative to many other trace organics amenable to removal by advanced oxidation. The majority of organic contaminants have a known hydroxyl radical rate constant at the same order of magnitude or higher (10^9 $M^{-1}s^{-1}$), meaning that 0.5-log removal of 1,4-dioxane corresponds to equal or greater removal of compounds with equal or greater hydroxyl radical rate constants. The California Title 22 regulations for Groundwater Replenishment (GRP) using recycled water (DDW, 2014) recognize this fact, requiring a demonstration of 0.5-log destruction of 1,4-dioxane using a UV AOP technology.

4 Experimental Methods and Test Conditions

Testing was conducted with a bench-scale collimated beam (CB) setup using low pressure UV lamps. A description of the CB apparatus, test methods and water quality characteristics during testing is provided below.

4.1 Collimated Beam Experiments

A CB apparatus (Figure 1) was used to perform the bench-scale UV irradiation tests to demonstrate removal of trace organic contaminants (TOrCs), including NDMA and 1,4-dioxane. The CB apparatus uses four 15 watt low-pressure high-output mercury lamps to produce light at a germicidal wavelength of close to monochromatic 254 nm. The CB apparatus also includes an adjustable platform and two stir plates to insure proper mixing during throughout the exposure time during testing. Samples were irradiated in 500 mL aliquots for water quality analyses. UV doses were calculated as the product of the incident UV intensity, the exposure time and a series of CB correction factors, including the reflection factor, Petri factor, water factor, and divergence factor associated with each CB experiment and lamp output.

Figure 1 – Collimated Beam Apparatus

4.2 General Water Quality Data

RO permeate samples were collected from the RWPF on February 9, 2015 and shipped to Trussell Technologies' laboratory in Pasadena, CA for CB testing. The RO permeate sample was treated by UV photolysis and advanced oxidation (UV/H_2O_2) and subsequently analyzed for NDMA and 1,4-dioxane destruction within three days. Table 1 shows data for the average water quality parameters tested. The RO permeate chloramine level was 1.1 mg/L and the UVT was high at 98.4%. Other facilities have more commonly dosed chloramine close to 2 mg/L or higher for effective control of biofouling in the RO membranes.

Table 1 – Water quality parameters analyzed for the RO permeate sample

Parameters Value	
Temperature (ºC)	16.8
pH 6.3	
Alkalinity (mg/L as $CaCO_3$) 18	
TOC (ppm)	0.275
UVA (cm^{-1}) 0.007	
UVT (% - calculated)	98.4
Total Cl (mg/L)	1.1
Total NH_3 (mg/L)	0.11
NDMA (ng/L)	5.4

5 Results and Discussion

The bench-scale CB results for chloramine, NDMA, and 1,4-dioxane destruction are discussed below. A log-removal value (LRV) predictive equation was developed for 1,4-dioxane destruction based on the CB results from this experiment and is presented below.

5.1 Chloramine Photolysis Results

During the NDMA photolysis degradation experiments, chloramine photolysis was evaluated in parallel to potentially develop a correlation between a NDMA LRV and a chloramine LRV. Three chloramine levels were dosed and tested for degradation using 3 UV doses. Each chloramine level corresponds to a specific UVT. When chloramine was spiked, the UVT was correspondingly reduced. A summary of the test conditions are found below:

- UV dose = 300, 650, 1000 mJ/cm^2
- Chloramine dose = 1.1, 2.2, 3.3 mg/L as Cl_2, (UVT of 98.6%, 97.3%, 95.7%)

The chloramine concentrations at each UV dose for the CB photolysis testing are shown in Table 2. A plot of all the data in Table 2 presented as LRVs is shown in Figure 2. The trendline associated with the plotted data demonstrates a tight correlation, as expected. It is also observed that the results lie on a single line due to the water factor and reflection factor incorporated into the CB testing, which accounts for the different UVT conditions. The chloramine destruction results will be discussed below for potential correlation with NDMA results.

Table 2 – Chloramine concentrations in RO permeate and after UV exposure for chloramine photolysis testing

UV dose (mJ/cm^2)	Chloramine (mg/L) 98.6% UVT	Chloramine (mg/L) 97.3% UVT	Chloramine (mg/L) 95.7% UVT
0	1.1	2.2	3.3
300	0.82	1.6	2.3
650	0.59	1.1	1.6
1000	0.40	0.79	1.1

5.2 NDMA Photolysis Results

NDMA destruction using UV photolysis in the absence of oxidant was tested, as the hydroxyl radical rate constant for NDMA is an order of magnitude lower than that for most other trace organics (10^8 vs. 10^9 $M^{-1}s^{-1}$) , and at a low concentration (ng/L level), hydroxyl radical degradation is not expected to play a significant role in NDMA destruction in the UV AOP testing. Chloramine levels also impact UV process efficiency, so three chloramine doses were tested at the bench-scale level during this phase, with UVT varying between 95.7% and 98.6%. For full-scale UV systems, the destruction of chloramines (online) potentially can be used to estimate both UV dose and NDMA destruction. The addition of chloramines reduces the UVT because it absorbs UV light at the same wavelength (254 nm).

Experimental conditions for NDMA CB testing are shown in Table 3. The initial chloramine level in the RO permeate received from the RWPF was 1.1 mg/L with a UVT of 98.6%. Spiking additional chloramines to achieve a concentration of 2.2 mg/L reduced the UVT to 97.3%. Spiking chloramines to 3.3 mg/L resulted in a reduced UVT of 95.7%.

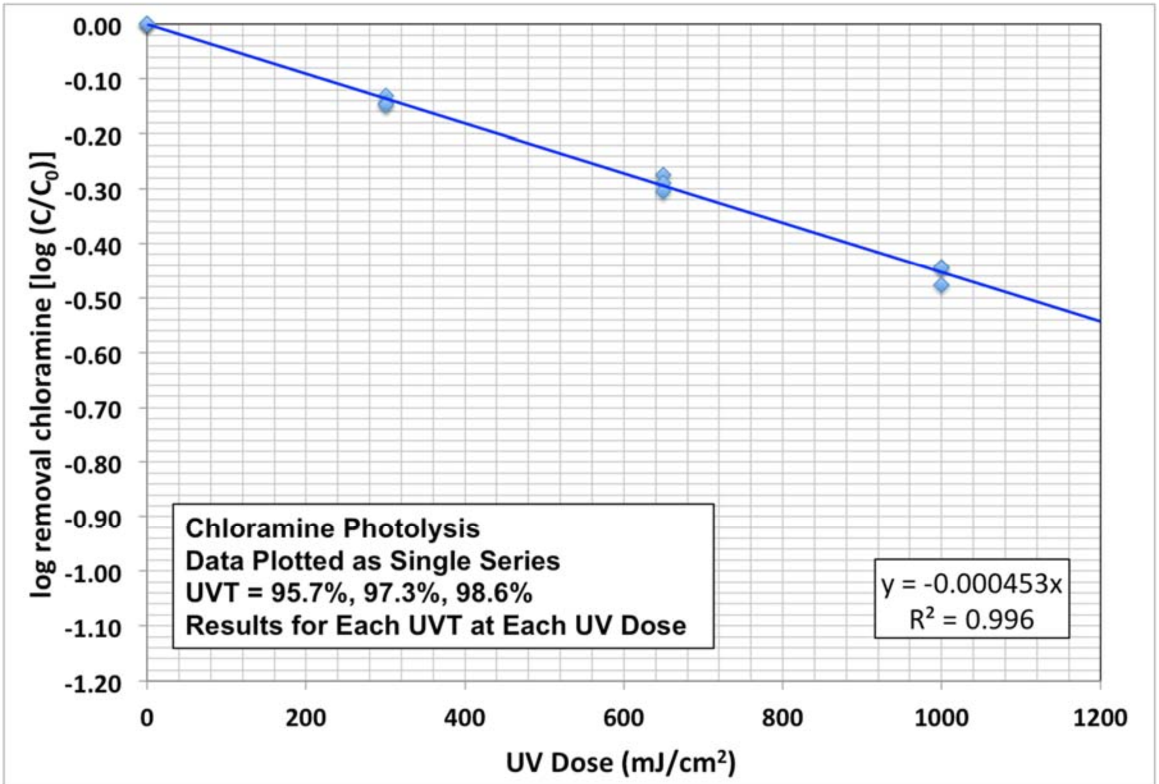

Figure 2 – Chloramine log-removal during NDMA destruction CB testing in RWPF RO Permeate

Table 3 – Experimental conditions for NDMA destruction CB testing

Total Chlorine (mg/L as Cl_2)	UVT (%)	UV Dose (mJ/cm^2)
1.1 (level in RO permeate)	98.6%	300
		650
		1000
2.2 (level after spiking)	97.3%	300
		650
		1000
3.3 (level after spiking)	95.7%	300
		650
		1000

As shown in Table 3, the inherent NDMA concentration in RWPF RO permeate ranged from 4.7 to 6.0 ng/L, approaching the method reporting limit of 2 ng/L. Table 4 shows the NDMA concentration before and after UV photolysis. Most NDMA results following UV photolysis were below the detection limit. While low NDMA levels are beneficial for plant operation, they did not allow for a clear evaluation of UV dose delivery nor correlation with chloramine destruction.

For example, at the highest level of NDMA observed in the RO permeate (6 ng/L), when the treated water concentration is below detection, it can only be stated that >0.48-log removal was achieved at the UV dose tested (see UV doses 650 and 1000 mJ/cm^2). The level of NDMA removal potential is likely far greater than the measured 0.48-log at the UV doses tested based on previous work. It was not possible to correlate the bench-scale CB results to the full-scale NDMA destruction to determine the full-scale UV dose due to NDMA detection limit issues. However, the chloramine destruction work on the bench-scale does allow for the future determination of dose in the full-scale UV system.

Table 4 – NDMA concentrations in RO permeate and after UV exposure (log removals shown in parentheses)

UV Dose ($^{mJ/cm2}$)	NDMA (ng/L) 1.1 mg/L chloramine, 98.6% UVT	NDMA (ng/L) 2.2 mg/L chloramine, 97.3% UVT	NDMA (ng/L) 3.3 mg/L chloramine, 95.7% UVT
0	4.7 5.6 6.0		
300	<2* (>0.37-log)	2.8 (0.30-log)	4.3 (0.14-log)
650	<2* (>0.37-log)	<2* (>0.45-log)	<2* (>0.48-log)
1000	<2* (>0.37-log)	<2* (>0.45-log)	<2* (>0.48-log)

* Below method reporting limit of 2 ng/L

The NDMA concentration was anticipated to be on the order of 10 to 50 ng/L in the RO permeate shipped from the RWPF, based on work at potable reuse facilities. Previously published studies have shown that direct photolysis of NDMA is the best available technology for elevated levels of NDMA destruction (Aflaki et al., 2015; Sharpless and Linden, 2003). The efficiency of direct photolysis is dependent on the UVT of the water, with NDMA removal more efficient in a full-scale reactor with a higher UVT water. Examples of NDMA log removal measurements using UV photolysis or UV/H_2O_2 bench-scale CB testing are shown in Figure 3. Data from UV/H_2O_2 testing are shown, however, advanced oxidation is not expected to enhance NDMA removal significantly (Sharpless and Linden, 2003).

In these examples by Sharpless and Linden 2003, a synthetic natural water showed slower UV dose-based destruction kinetics than the RO permeate used in testing at the Los Angeles Department of Water and Power (LADWP) at their Tillman Water Reclamation Facility (Hokanson et al., 2011). The CB testing methodology corrects for UVT, therefore there must be another water quality or test condition accounting for the discrepancy in destruction kinetics.

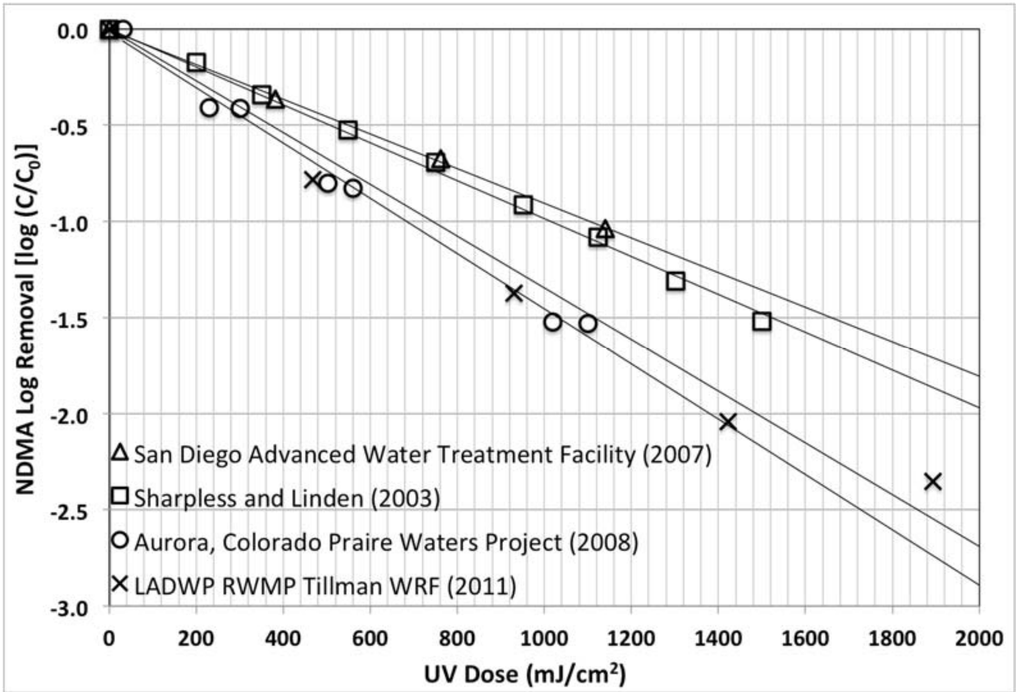

Figure 3 – Collimated Beam Bench Testing Results for NDMA Collected in different Studies (Sources of Data: City of San Diego, 2007; Sharpless and Linden, 2003; Swaim et al., 2008; Hokanson et al., 2011). The Colorado Prairie Waters Project in Aurora, Colorado is the only reference study that used hydrogen peroxide (5mg/L). The results shown for the other three studies used UV photolysis.

5.3 1,4-dioxane Advanced Oxidation Results

While NDMA can be readily reduced by photolysis alone, advanced oxidation through a process such as UV/H_2O_2 is necessary to degrade 1,4-dioxane, as 1,4-dioxane does not photolyze at 254 nm, the germicidal wavelength indicative in low pressure UV processes. The RO permeate sample was spiked with 30 µg of 1,4-dioxane before adding 3, 5 and 10 mg/L of H_2O_2 for the CB testing (H_2O_2 dose for the full-scale RWPF varies between 3 and 4 mg/L). As noted above for the NDMA testing, three different chloramine doses were used at the bench-scale during the 1,4-dioxane CB testing because chloramine levels impact process performance by absorbing UV light and by scavenging hydroxyl radicals at high concentrations. The RWPF RO permeate UVT varied between 95.3% and 98.6%, with corresponding chloramine level. Experimental conditions for 1,4-dioxane destruction CB testing are shown in Table 5. The initial chloramine level in the RO permeate sample from the RWPF on the day of 1,4-dioxane testing was 0.93 mg/L with a UVT of 97.9% to 98.6%. Spiking additional chloramine to achieve a concentration of 2.13 mg/L reduced the UVT to between 96.2% and 97.3% over testing. Spiking to 2.9 mg/L chloramine resulted in a UVT ranging from 95.3% to 96.2%. Experimental test conditions are summarized in Table 5.

Table 5 – CB test conditions for 1,4-dioxane

Chloramine (mg/L)	UV doses (mJ/cm^2)	Target H_2O_2 (mg/L)
0.93	300 – 650 – 1000	3 – 5 – 10
2.13	300 – 650 – 1000	3 – 5 – 10
2.9	300 – 650 – 1000	3 – 5 – 10

Table 6 shows CB test results for 1,4-dioxane including the feed conditions for each individual CB test. The organization of Table 6 is shown as three parts. The upper part of the table shows the results when a H_2O_2 dose of 3 mg/L was targeted (the feed H_2O_2 doses in the table are highlighted in light blue). There are three dose-response relationships shown in the upper part of the table. Each represents a different chloramine level (0.93, 2.13, 2.9, with feed chloramine levels highlighted in light green), with three UV doses tested at each chloramine level. For each chloramine level, the top row shown as UV dose equal to zero represents the feed levels of each parameter/constituent. From Table 6, it is observed that at a H_2O_2 dose of 3 mg/L, a chloramine level of 0.93 mg/L, and a UV doses of 650 mJ/cm^2, the log removal value (LRV) for 1,4-dioxane is 0.30-log, while the chloramine LRV is 0.55-log. The middle portion of Table 6 shows the results for a target H_2O_2 dose of 5 mg/L, with the general organization the same as for the top portion of the table, with only the H_2O_2 dose changing. By the same method, it is observed that at a H_2O_2 dose of 5 mg/L, a chloramine level of 0.93 mg/L, and a UV dose of 650 mJ/cm^2, the log removal value (LRV) for 1,4-dioxane is 0.45-log, while the chloramine LRV is 0.71-log. The same is true for the rest of the data shown in Table 6. The conditions (UV dose, H_2O_2 dose, chloramine dose) where 0.5-log removal 1,4-dioxane was achieved are highlighted in yellow, with conditions that nearly achieved 0.5-log removal shaded gray.

Based on the results shown in Table 6, trends can be evaluated and are shown in Figures 4 and 5. As a representative example, 1,4-dioxane LRV results are plotted versus UV dose for a single chloramine level of 0.93 and for the three hydrogen peroxide doses shown in Table 5. This result is presented in Figure 4. From Figure 4, it is observed that the expected trends hold with higher 1,4-dioxane LRVs at higher UV dose and higher H_2O_2 dose. Based on data in Table 6, similar plots could be prepared for chloramine levels of 2.13 mg/L and 2.9 mg/L, but the plot at 0.93 mg/L chloramine is deemed sufficient for discussing the relevant trends in this report given that all the other results are similar and shown in Table 6.

As another representative example, 1,4-dioxane LRV results are plotted versus UV dose for a single hydrogen peroxide dose of 5 mg/L and for the three chloramine levels shown in Table 5. This result is presented in Figure 5. It is observed that higher 1,4-dioxane LRVs are achieved at higher UV dose and lower feed chloramine level, with chloramine shown to interfere with UV AOP due to scavenging (shown below).

Table 6 – CB Test Results for 1,4-dioxane Compared to Chloraminea

UV Dose	UVT	Chloramine	H_2O_2	1,4-dioxane	LRV 1,4-dioxane	LRV NH_2Cl
0 97.9%		0.93	3.5	28	0	0
300 98.9%		0.53	3.4	20	-0.15	-0.24
650 99.1%		0.26	3.5	14	-0.30	-0.55
1000 99.3%		0.12	3.0	9.1	-0.49	-0.89
UV Dose	**UVT**	**Chloramine**	**H_2O_2**	**1,4-dioxane**	**LRV 1,4-dioxane**	**LRV NH_2Cl**
0 97.3%		2.13	3.2	28	0	0
300 97.7%		1.21	3.2	22	-0.10	-0.25
650 98.2%		0.22	3.1	16	-0.24	-0.99
1000 98.4%		0.51	3.0	13	-0.33	-0.62
UV Dose	**UVT**	**Chloramine**	**H_2O_2**	**1,4-dioxane**	**LRV 1,4-dioxane**	**LRV NH_2Cl**
0 96.2%		2.9	3.2	28	0	0
300 96.8%		1.9	3.1	22	-0.10	-0.18
650 97.3%		0.95	3.0	16	-0.24	-0.48
1000 97.9%		1.01	3.0	13	-0.33	-0.46
UV Dose	**UVT**	**Chloramine**	**H_2O_2**	**1,4-dioxane**	**LRV 1,4-dioxane**	**LRV NH_2Cl**
0 98.6%		0.93	5.5	28	0	0
300 98.4%		0.44	5.2	17	-0.22	-0.33
650 99.1%		0.18	5.0	10	-0.45	-0.71
1000 99.1%		0.07	4.7	5.8	-0.68	-1.12
UV Dose	**UVT**	**Chloramine**	**H_2O_2**	**1,4-dioxane**	**LRV 1,4-dioxane**	**LRV NH_2Cl**
0 96.8%		2.13	5.5	28	0	0
300 97.1%		1.13	5.3	18	-0.19	-0.28
650 97.7%		0.42	5.2	10	-0.45	-0.71
1000 98.2%		0.47	5.1	7.8	-0.56	-0.66

UV Dose	UVT	Chloramine	H_2O_2	1,4-dioxane	LRV 1,4-dioxane	LRV NH_2Cl
0 95.7%		2.9	5.0	28	0	0
300 96.8%		1.91	4.8	20	-0.15	-0.18
650 97.1%		0.84	4.7	16	-0.24	-0.54
1000 97.5%		0.98	4.3	12	-0.37	-0.47

UV Dose	UVT	Chloramine	H_2O_2	1,4-dioxane	LRV 1,4-dioxane	LRV NH_2Cl
0 97.9%		0.93	10.1	28	0	0
300 97.9%		0.21	9.5	11	-0.41	-0.65
650 98.2%		0.06	9.4	5.1	-0.74	-1.19
1000 97.9%		0.08	9.1	2.0	-1.15	-1.07

UV Dose	UVT	Chloramine	H_2O_2	1,4-dioxane	LRV 1,4-dioxane	LRV NH_2Cl
0 96.2%		2.13	10.1	28	0	0
300 97.1%		0.97	9.7	13	-0.33	-0.34
650 97.5%		0.12	9.3	8.3	-0.53	-1.25
1000 98.2%		0.39	8.9	4.6	-0.78	-0.74

UV Dose	UVT	Chloramine	H_2O_2	1,4-dioxane	LRV 1,4-dioxane	LRV NH_2Cl
0 95.3%		2.9	9.9	28	0	0
300 95.9%		1.8	8.9	22	-0.10	-0.21
650 96.6%		1.28	9.2	14	-0.30	-0.36
1000 97.3%		0.86	8.7	8.1	-0.54	-0.53

[a]UV Dose in mJ/cm^2, Chloramine in mg/L as Cl_2, H_2O_2 in mg/L, 1,4-dioxane in µg/L, LRV is log(C/C_0)

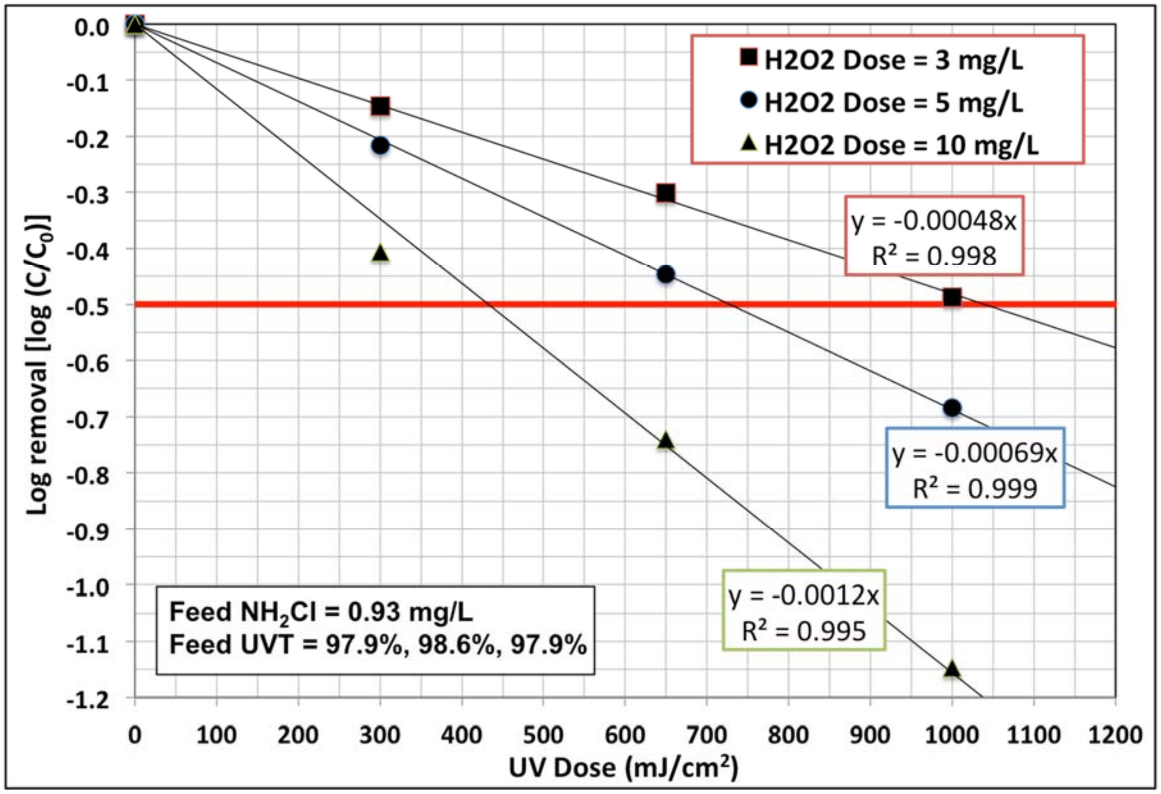

Figure 4 – Log removal of 1,4-dioxane at 0.93 mg/L chloramine at different H2O2 doses

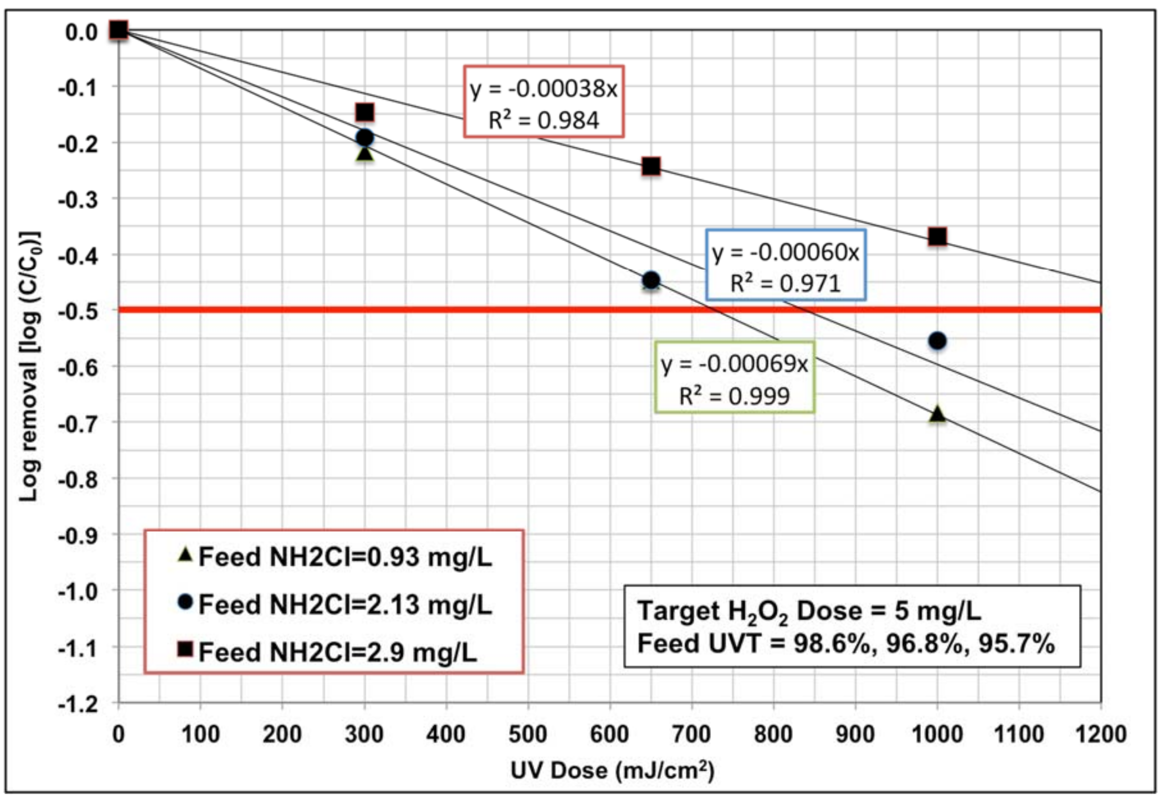

Figure 5 – Log removal of 1,4-dioxane at 5 mg/L H2O2 dose at different feed chloramine levels

The following observations are made based on Table 6 and informed by Figures 4 and 5:

- For 3 mg/L H_2O_2, UV AOP did not achieve 0.5-log 1,4-dioxane removal even at highest UV dose of 1000 mJ/cm^2 and the lowest chloramine dosage of 0.93 mg/L (highest UVT of ~98.6%).
- At 5 mg/L H_2O_2 and 0.93 mg/L chloramine (~98.6% UVT), UV AOP achieved 0.5-log 1,4-dioxane removal at an approximate UV dose of 720 mJ/cm^2.
- At 5 mg/L H_2O_2 and 2.9 mg/L chloramine (~95.3% UVT), UV AOP achieved 0.5-log 1,4-dioxane removal at an approximate UV dose of 1300 mJ/cm^2.

To the last two bullet points, the H_2O_2 dose is the same and the UVT varies from approximately 95.3% to 98.6%. As mentioned above, the CB test normalizes for UVT with the water factor and the reflection factor. There must be other factors at play to explain the increase in the 1,4-dioxane LRV with the increase in UVT. The chloramine in the water was present initially in the RO permeate at levels near 1 mg/L and later increased to approximately 3 mg/L, resulting in a decrease of UVT from 98.6% to 95.3%, The chloramines themselves were hypothesized to be the cause of the trend of decreasing 1,4-dioxane LRV with decreasing UVT. This was not the case for UVT photolysis of chloramine where LRV of chloramine did not change with increasing UVT (see Figure 2).

In the presence of the oxidant, H_2O_2, hydroxyl radicals (•OH) are formed and represent another potential mechanism for the removal of chloramine via scavenging of hydroxyl radicals that would otherwise be present for the removal of 1,4-dioxane. The LRV of chloramine is shown in Table 6 in addition to the LRV of 1,4-dioxane discussed earlier. By plotting log removal of chloramine in the presence of •OH as a function of UV dose using all the chloramine LRV data in Table 6 and showing the results along with the chloramine LRV data for photolysis alone shown in Figure 2, it is possible to assess the amenability of chloramine for removal by •OH. This comparison is shown in Figure 6. From Figure 6, it is clear there is significant removal of chloramine beyond the level measured for UV photolysis alone (Figure 2). This suggests an •OH mechanism. A plot of LRV of chloramine (y-axis) vs. LRV of 1,4-dioxane (x-axis) using all the LRV data in Table 6 is shown in Figure 7. It is demonstrated in Figure 7 that the data points are consistently above the identity line, meaning that chloramine was consistently removed to a greater extent than 1,4-dioxane in the CB testing with UV/H_2O_2.

The results have shown that an •OH mechanism may be a significant factor in the removal of chloramine and may be the reason that the 1,4-dioxane results differ with UVT. In recent years, there has been much work that considers the scavenging of •OH in a broad mix of waters (e.g. Hokanson and Trussell, 2006) and in effluent organic matter from wastewater treatment plants (e.g. Rosario-Ortiz, Wert, and Snyder, 2010). The work of Wols and Hofman-Caris (2012) presents a kinetic model for UV photolysis and AOP based on the work of others (e.g. Glaze, Lay, and Kang, 1995; Crittenden et al., 1999; Bolton and Stefan, 2002; Bolton and Linden, 2003) and a tremendous database of molar extinction coefficient, quantum yield, and 2nd order hydroxyl radical rate constant for more than 100 trace organics. This type of kinetic modeling has recently been used to evaluate the removal of 16 trace organics for ten different wastewaters using various oxidation processes including UV/H_2O_2 (Lee et al., 2016).

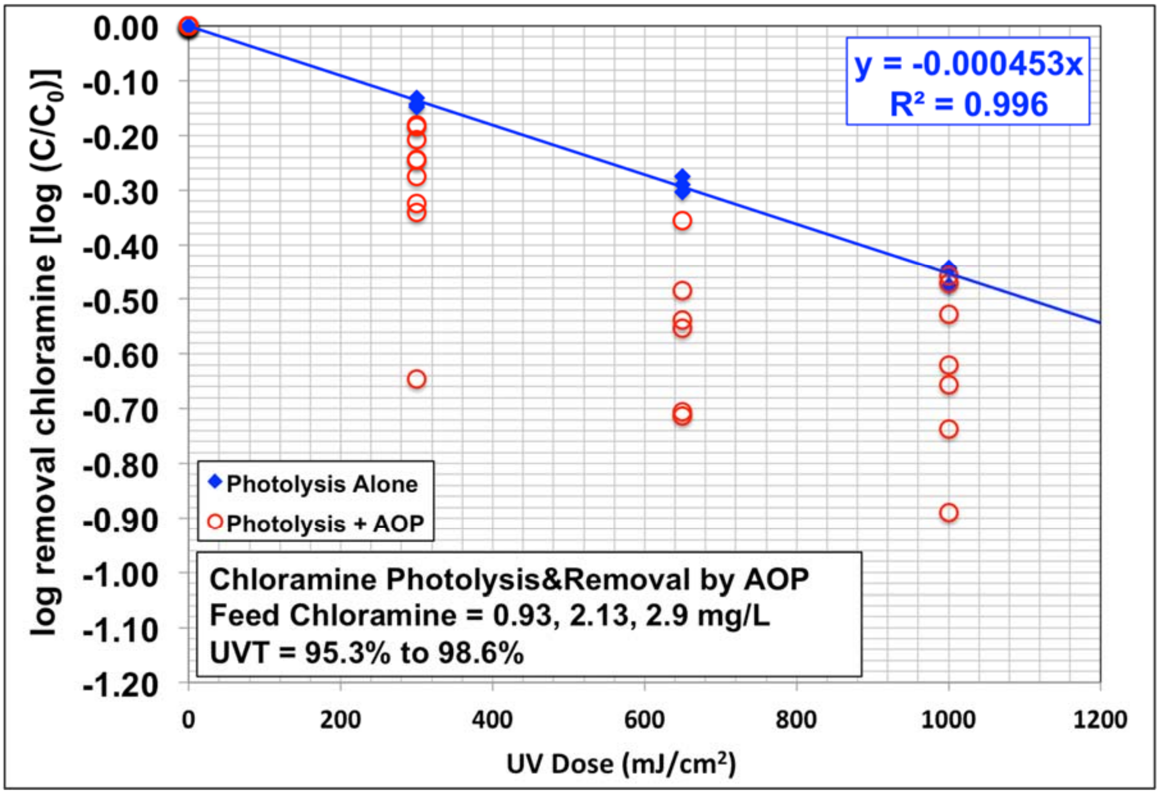

Figure 6 – Log removal of chloramine by photolysis alone (blue diamonds) and by UV photolysis and AOP at H2O2 doses of 3, 5, and 10 mg/L

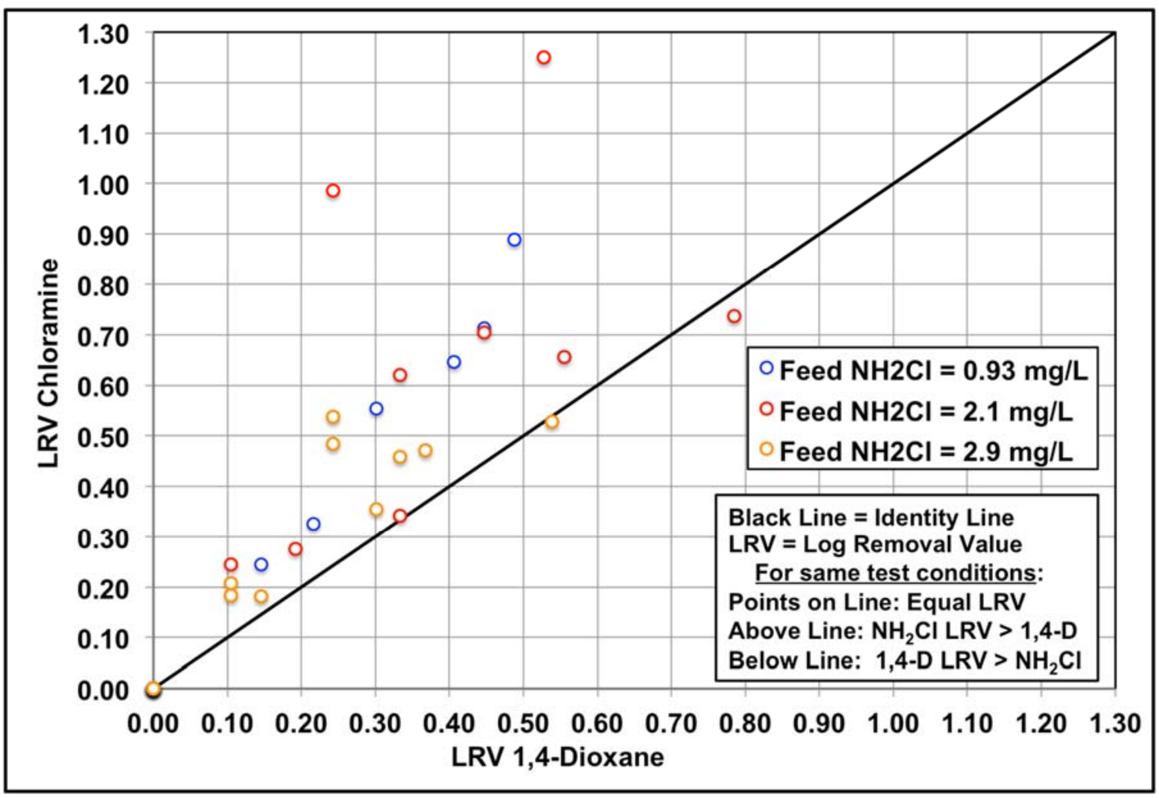

Figure 7 – Comparison of LRV of Chloramine vs. 1,4-dioxane at varying H2O2 and UVT

One important component of these kinetic models in the literature above is the evaluation of the impact of hydroxyl radical scavenging. For this project, the impact of hydroxyl radical scavenging will be considered using the following equation for •OH scavenging rate, or total scavenging rate (TSR). The $k_{\bullet OH}$ term represents the second order hydroxyl radical rate constant (L/mole/s). $[S_i]$ represents the molar concentration of an individual scavenger. The TSR represents the summation of hydroxyl radical rate constant times molar concentration of constituent. The values of the constituents shown in Equation 1 for the CRMWD RWPF project are summarized in Table 7. It is notable that the 2nd order •OH rate constant for chloramine reported in the literature (Johnson et al., 2002) is identical to the 2nd order •OH rate constant for 1,4-dioxane.

$$\sum_i \left(k_{\bullet OH,i}[\mathrm{S}_i]\right) = \left\{\begin{matrix} k_{\bullet OH,\mathrm{HCO_3}}[\mathrm{HCO_3}] + k_{\bullet OH,\mathrm{CO_3}}[\mathrm{CO_3}] + k_{\bullet OH,\mathrm{NOM}}[\mathrm{NOM}] \\ + k_{\bullet OH,\mathrm{H_2O_2}}[\mathrm{H_2O_2}] + k_{\bullet OH,\mathrm{NH_2Cl}}[\mathrm{NH_2Cl}] \\ + k_{\bullet OH,\mathrm{NDMA}}[\mathrm{NDMA}] + k_{\bullet OH,\text{1,4-dioxane}}[\text{1,4-dioxane}] \end{matrix}\right\} \quad \text{Equation 1}$$

Table 7 – Parameters needed for Scavenging Rate Calculations

•OH Scavenger	$k_{\bullet OH}$ (L/mole/s)	Scavenger Concentration (mg/L)
Bicarbonate, HCO_3 (mg/L)	8.50×10^6 22	
Carbonate, CO_3 (mg/L)	3.90×10^8 0.042	
NOM (mg/L)	3.00×10^8 0.57	
Hydrogen Peroxide, H_2O_2 (mg/L)	2.70×10^7	3, 5, 10
Chloramine, NH_2Cl (mg/L)	2.80×10^9	0, 0.93, 2.13, 2.9
1,4-dioxane (µg/L)	2.80×10^9 30	

Based on the parameters in Table 7 and Equation 1, calculations were made for •OH scavenging rate and for fraction of total scavenging rate (TSR) contributed by a given constituent. These calculations were made at the four chloramine levels shown in Table 7 (0 is added with the other three levels) at each of the 3 H_2O_2 doses being evaluated. The scavenging rate results are summarized in Table 8. The results are quite significant.

Here some important points on •OH scavenging rate from Table 8:

- Looking at the second column where chloramine equals zero, TSR ranged from 21,000 to 26,500 1/s with H_2O_2 varying from 3 to 10 mg/L. With chloramine equal to zero, NOM dominated the •OH scavenging rate determination, with the TSR at much lower levels than when chloramine is present.
- Looking at the fifth column where chloramine equals 2.9 mg/L, TSR ranged from 182,000 to 187,000 1/s with H_2O_2 varying from 3 to 10 mg/L.

- The first two bullet points demonstrate the strong impact of chloramine on TSR. The TSR increases by a factor of over 600% when chloramine increases from zero to 2.9 mg/L. They also demonstrate that H_2O_2 has a much lesser impact on TSR as TSR increases by 26% at the lower H_2O_2 dose but by only 2.7% at the high H_2O_2 dose.
- The importance of chloramine is also shown by the fraction of TSR represented by chloramine for each condition in Table 8. At H_2O_2 = 3 mg/L, chloramine fraction of TSR varied from 71.1% to 88.5% with chloramine varying from 0.93 to 2.9 mg/L. At H_2O_2 = 5 mg/L, chloramine fraction of TSR varied from 69.5% to 87.7% with chloramine varying from 0.93 to 2.9 mg/L. At H_2O_2 = 10 mg/L, chloramine fraction of TSR varied from 66.0% to 85.8% with chloramine varying from 0.93 to 2.9 mg/L.
- Even with the very small decrease in chloramine fraction of TSR as H_2O_2 varied from 3 to 10 mg/L, it is important to recognize that the TSR still increased in each case.

The simplified steady state model assuming a steady-state concentration of hydroxyl radical and that hydrogen peroxide concentration and total scavenging rate remain constant can be solved analytically for a CB apparatus as presented by Wols and Hofman-Caris (2012) based on the kinetic modeling literature shown above. The advanced oxidation portion of their kinetic model is shown below:

$$\begin{Bmatrix}\text{log removal}\\ \text{by AOP}\end{Bmatrix} = -\left\{\frac{2\times k_{p,\mathrm{H_2O_2}}\times[\mathrm{H_2O_2}]\times\text{UV Dose}}{471{,}527}\right\}\times\left(\frac{k_{\bullet OH,target}}{\sum_i k_{\bullet OH,i}[S_i]}\right) \quad \text{Equation 2}$$

The advanced oxidation process is facilitated by the photolysis of hydrogen peroxide, which generates hydroxyl radicals. The term, $k_{p,\mathrm{H_2O_2}}$, in Equation 2 represents the photolysis coefficient, discussed earlier, and equal to 9.8 L/Einstein/cm (an Einstein is a mole of photons). The term, $k_{\bullet OH,target}$, represents the hydroxyl radical rate constant of the target compound, 1,4-dioxane. The hydrogen peroxide dose and the UV dose appear in the numerator of Equation 2 while the TSR appears in the denominator. Therefore, the dramatic increases in TSR observed are likely to have a dramatic impact on removal of a target constituent by UV AOP. This explains why the 1,4-dioxane removal by CB was not identical for different UVT values. The scavenging of hydroxyl radicals predominantly by chloramine resulted in lower removal of 1,4-dioxane than would have been observed if chloramine were absent. This is borne out by the results presented earlier in Table 6 and Figures 6 and 7 that demonstrated chloramine removal by UV AOP in addition to photolysis and the greater removal observed for chloramine compared to 1,4-dioxane. The results suggest that removal of chloramines from the RO prior to UV AOP may offer cost savings for potable reuse projects if the approach is viable from an engineering perspective.

Table 8 – Summary of Scavenging Rate Calculation Results

H_2O_2 = 3 mg/L					
•OH Scavenger	**Concentration**	**Fraction of Total Scavenging Rate**			
Chloramine (mg/L)	→	0 0.93		2.13	2.9
Bicarbonate (mg/L)	22	14.6%	4.23%	2.20%	1.69%
Carbonate (mg/L)	0.042	1.6%	0.47%	0.25%	0.19%
NOM (mg/L)	0.57	67.9%	19.6%	10.2%	7.8%
H_2O_2 (mg/L)	3	11.3%	3.3%	1.7%	1.3%
Chloramine (mg/L)	Not Applicable	0.0%	71.1%	84.9%	88.5%
1-4-dioxane (µg/L)	30	4.5%	1.3%	0.69%	0.52%
TSR = Total Scavenging Rate = Summation {$k_{\bullet OH}$ x C (1/s)}					
TSR (1/s)	Not Applicable	21,000	72,600	139,000	182,000
TSR %Increase from NH2Cl=0	Not Applicable	-	246%	562%	767%
H_2O_2 = 5 mg/L					
•OH Scavenger	**Concentration**	**Fraction of Total Scavenging Rate**			
Chloramine (mg/L)	→	0 0.93		2.13	2.9
Bicarbonate (mg/L)	22	13.6%	4.13%	2.18%	1.67%
Carbonate (mg/L)	0.042	1.5%	0.46%	0.24%	0.19%
NOM (mg/L)	0.57	63.1%	19.2%	10.1%	7.8%
H_2O_2 (mg/L)	3	17.6%	5.4%	2.8%	2.2%
Chloramine (mg/L)	Not Applicable	0.0%	69.5%	83.9%	87.7%
1-4-dioxane (µg/L)	30	4.2%	1.3%	0.68%	0.52%
TSR = Total Scavenging Rate = Summation {$k_{\bullet OH}$ x C (1/s)}					
TSR (1/s)	Not Applicable	22,600	74,100	141,000	183,000
TSR %Increase from NH2Cl=0	Not Applicable	-	228%	524%	710%

H_2O_2 = 10 mg/L					
•OH Scavenger	**Concentration**	**Fraction of Total Scavenging Rate**			
Chloramine (mg/L)	→	0 0.93		2.13	2.9
Bicarbonate (mg/L)	22	11.5%	3.9%	2.1%	1.6%
Carbonate (mg/L)	0.042	1.3%	0.44%	0.24%	0.18%
NOM (mg/L)	0.57	53.7%	18.2%	9.9%	7.6%
H_2O_2 (mg/L)	3	29.9%	10.2%	5.5%	4.2%
Chloramine (mg/L)	Not Applicable	0.0%	66.0%	81.6%	85.8%
1-4-dioxane (µg/L)	30	3.6%	1.2%	0.66%	0.51%
TSR = Total Scavenging Rate = Summation {$k_{\bullet OH}$ x C (1/s)}					
TSR (1/s)	Not Applicable	26,600	78,100	145,000	187,000
TSR %Increase from NH2Cl=0	Not Applicable	-	194%	446%	604%

5.4 Development of predictive equations for log removal value (LRV) for 1,4-dioxane

Development of a predictive equation(s) for the target compound(s) based on experimental data is a useful tool for regulators and engineers. Bench scale data were analyzed to develop Equation 3 to determine the log removal value (LRV) for 1,4-dioxane. For 1,4-dioxane removal, chloramine concentration, UV dose and hydrogen peroxide concentration were used in developing the predictive equation by regression analysis. Table 9 lists the coefficients used to evaluate Equation 3. Table 10 shows the UVA, UV dose, chloramine and H_2O_2 concentration ranges tested during CB testing. Because the NDMA concentration was really low in the RO permeate and removals below detection were achieved for all but two test conditions during CB testing, no predictive equation was developed for NDMA.

$$\boldsymbol{LRV = A + B * NH_2Cl + C * UV\ Fluence + D * [H_2O_2]} \qquad \text{Equation 3}$$

Where

- LRV = Log removal value of target analyte 1,4-dioxane
- UV dose = UV dose applied to the sample (mJ/cm^2)
- NH_2Cl = Chloramine concentration (mg/L)
- H_2O_2 = Hydrogen peroxide concentration (mg/L)

Table 9 – Coefficients used in Predictive Equation for LRV 1,4-dioxane (Equation 3)

Coefficient 1,4-dioxane	
A	-0.000891
B	0.138
C	-0.00058
D	-0.0441

Table 10 – Validated ranges for Predictive Equation for LRV 1,4-dioxane (Equation 3)

Analyte	UVT (%)	UV Dose (mJ/cm^2)	H_2O_2 (mg/L)
1,4-dioxane	95.3 – 98.6	300 – 1000	3 – 10

Figure 8 shows measured and predicted LRV for 1,4-dioxane calculated using Equation 3 with the coefficients listed in Table 9. Figure 9 shows measured LRV versus calculated residuals for 1,4-dioxane. In the case of 1,4-dioxane removal, the R^2 of 0.86, indicates how statistically close the data is to the fitted regression line. Some degree of inaccuracy could be attributed to determining LRV from small measured values close to the detection limit and to the fact that the tested parameter ranges were not sufficiently wide to allow for the linear regression analysis to produce a statistically significant dependence on all of them. It is also possible that a degree of inaccuracy for 1,4-dioxane could be attributed to analytical laboratory error in performing trace analyses without a sufficient number of replicates. That said, the 1,4-dioxane LRV equation is a useful tool to calculate LRV for Big Spring RO permeate given the dependence on multiple parameters including UV Dose, UVT, and hydrogen peroxide dose and justifying the lower R^2 value, which is not unreasonable.

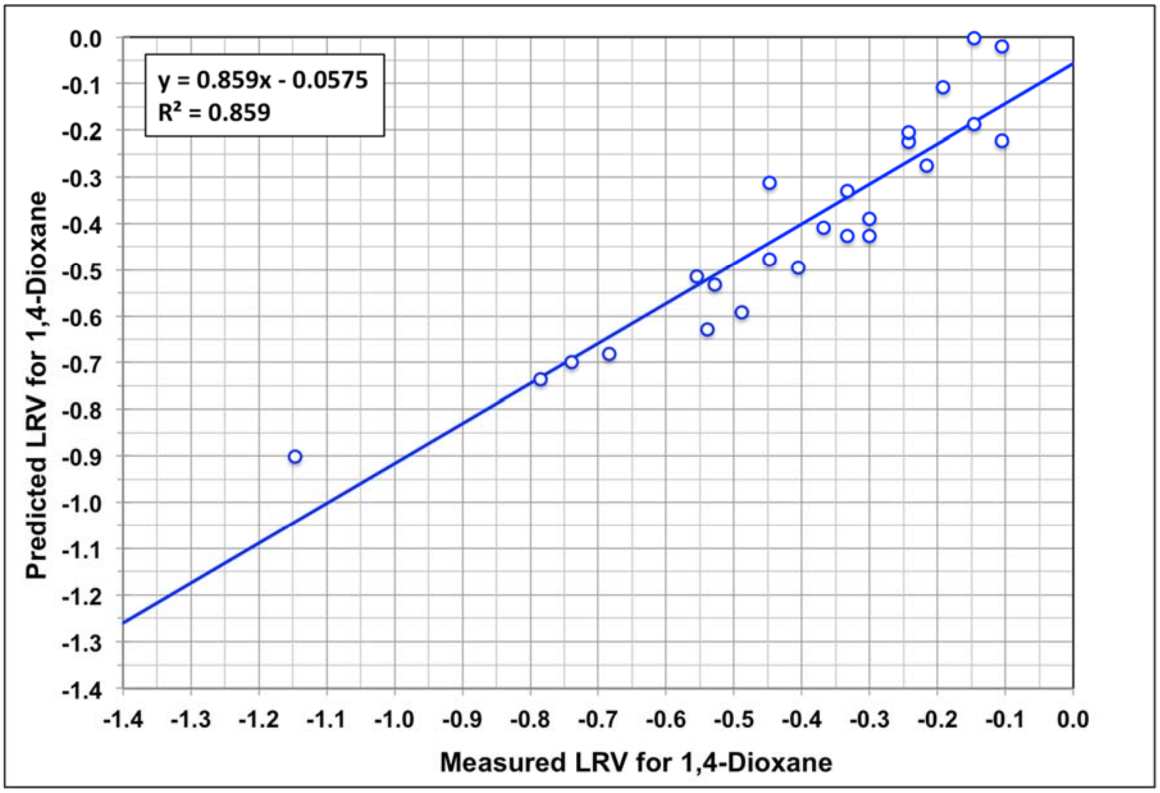

Figure 8 – Predicted and measured LRV for 1,4-dioxane

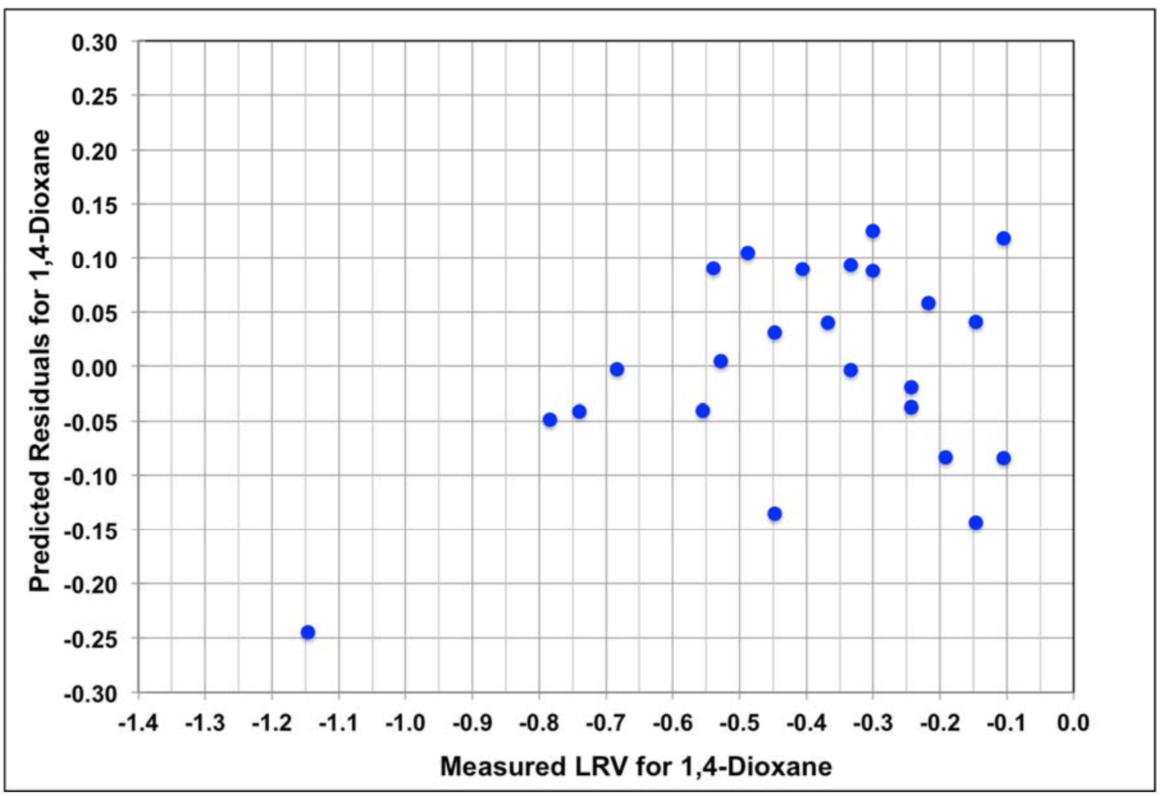

Figure 9 – Predicted residuals and measured LRV for 1,4-dioxane

6 Conclusions

A brief summary of each portion of the results are summarized below along with a brief discussion of implications for the full-scale CRMWD RWPF.

6.1 UV Photolysis of Chloramines

The goals of the CB experiments were to verify UV/AOP performance, demonstrating removal of NDMA and 1,4-dioxane under different test conditions for the particular RWPF RO permeate water quality. Testing for chloramines and NDMA were conducted in the absence of oxidant at varying UV dose and varying UV transmittance. The chloramine results were promising and showed a single linear result for CB data collected at three UVT levels ranging from 95.3% to 98.6%. This represents removal by UV photolysis alone in the absence of hydroxyl radical. As discussed below, it was not possible to correlate the CB chloramine results with the NDMA CB results. Because of the lack of NDMA data to correlate, it is noted that the CB chloramine LRV of 0.41-log at 910 mJ/cm^2 is similar to a CB chloramine LRV of 0.38-log at the same UV dose (Hokanson et al., 2011) for another potable reuse testing project with RO permeate collected from the RO feed to the pilot AOP system at the Los Angeles Bureau of Sanitation Donald C. Tillman Water Reclamation Facility as a part of the City of Los Angeles Recycled Water Master Plan project conducted in conjunction with the Los Angeles Department of Water and Power (LADWP). CB testing at Tillman WRF was also conducted with chloramine in the absence of oxidant.

The RWPF could calculate the UV dose delivered through the simple measurement of chloramine destruction across the UV without the H_2O_2 in operation. The CWMWD staff would then use Figure 2 to estimate dose delivery under the tested conditions (flow, UVT, reactor power setting).

6.2 UV Photolysis of NDMA

The levels of NDMA in the RO permeate ranged from 4.7 to 6.0 ng/L, far less than the levels expected based on similar projects. RO permeate NDMA levels were insufficient to either demonstrate removals above detection with the exception of two very low UV doses or to reduce NDMA to any significant degree. The outcome of the NDMA CB testing is achievement of LRVs of “>0.48-log”. These removals are far lower than the levels approaching or exceeding 1.0-log that would be anticipated for the RWPF UV system. The absence of NDMA in the feed also eliminated the possibility of comparing bench-scale NDMA results to full-scale reactor results and determining a delivered dose.

6.3 Removal of 1,4-dioxane by UV AOP

The 1,4-dioxane data was collected at three UV dose levels, three UVT levels, and three hydrogen peroxide doses. Counter intuitively, decreasing 1,4-dioxane removal was observed with decreasing UVT. CB testing for UV photolysis normalizes for UVT such that data collected at different UVTs overlay each other as was shown for chloramines undergoing UV photolysis alone. As discussed above, it is likely that the variations in the dose-response curve for UV/H_2O_2 are due to the advanced oxidation process that is proceeding at the same time as UV photolysis reactions when oxidant is present. The dramatic effect on 1,4-dioxane removal in the presence of hydroxyl radical is likely due to the presence of hydroxyl radical scavenger(s) at significant levels. The •OH scavengers compete with 1,4-dioxane for the hydroxyl radical, as 1,4-dioxane does not photolyze and is removed by the hydroxyl radical alone.

The presence of hydroxyl radical scavengers will reduce the ability of the UV AOP to remove 1,4-dioxane and other trace level pollutants. As discussed, above, chloramines absorb UV light and are amenable to removal by photolysis. At the same time, it was demonstrated above that chloramine has a tremendous capability to scavenge hydroxyl radicals in UV AOP processes treating RO permeate. This is especially true because while 1,4-dioxane and chloramine have the same 2nd order hydroxyl radical rate constant, the chloramine is present at much higher levels, resulting in a much greater impact on •OH scavenging rate. At a H_2O_2 dose of 5 mg/L, the total •OH scavenging rate increased from 23,000 1/s to 74, 000 1/s to 187,000 1/s at chloramine levels of 0 to 0.93 mg/L to 2.9 mg/L. This represents a 228 percent increase in TSR compared to 0 mg/L chloramine at 0.93 mg/L and a 712 percent increase in TSR at 2.9 mg/L. Given that removal of the target compound, 1,4-dioxane, by UV AOP is inversely proportional to the total •OH scavenging rate as shown above, the impact of the presence of chloramines on the LRV of 1,4-dioxane is significant. It was also demonstrated that removal of chloramine was significantly greater than removal of 1,4-dioxane for the conditions tested.

The results showed 3 mg/L H_2O_2 would require greater than 1000 mJ/cm^2 UV dose to achieve 0.5-log 1,4-dioxane removal. The 1,4-dioxane removal data suggest a UV dose near 720 mJ/cm^2 and a H_2O_2 dose of 5 mg/L are required to reach LRV of 0.5-log for 1,4-dioxane. The UV dose of 720 mJ/cm^2 was demonstrated at a chloramine level of 0.93 mg/L and a UVT of 98.6%, which was the UVT observed in the RO permeate on the day of testing. If the UVT is lower, then a UV dose higher than 720 mJ/cm^2 or a hydrogen peroxide dose greater than 5 mg/L may be required to meet 0.5-log 1,4-dioxane removal.

Note that 0.5 log removal of 1,4-dioxane is not a permit requirement. If it becomes a permit requirement in the future, then a combination of greater than 5 mg/L H_2O_2 dose and/or a UV dose greater than 720 mJ/cm^2 would be needed. As listed above, the dose delivery of the full-scale reactor can be determined by chloramine destruction, allowing for the engineering team to find the optimum balance of UV light and H_2O_2 dose to meet treatment targets.

6.4 Brief Discussion of Implications for Full-Scale

The electrical energy dose (EED), which is a measure of UV lamp power divided by UV AOP feed flow, can be used as a metric to consider whether the two UV reactors on site have sufficient power to photolyze H_2O_2 and generate the hydroxyl radicals needed to drive the UV AOP. It is noted that the maximum EED that can be delivered by the two Trojan 72AL75 reactors is 0.43 kWh/kgal. The permitted EED for Orange County (CA) Water District's Groundwater Replenishment System is 0.23 kWh/kgal at a 3 mg/L H_2O_2 dose and they historically have operated at EED's ranging from 0.25 to 0.35 kWh/kgal. Some plants like the Water Replenishment District's Leo J. Vander Lans Advanced Water Treatment Facility operate at significantly higher EED levels, but such plants typically have NDMA levels as high as 1-2 orders of magnitude higher at times than what has been observed at the RWPF to date. It is likely the two reactors at the plant have the power to reduce 1,4-dioxane to a LRV of 0.5-log at 5 mg/L H_2O_2 or even lower. The dose delivery can be better determined through chloramine destruction studies on the full-scale system.

7 References

Anbar 1996 1,4-dioxane ($1.1x10^9$)

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Appendix E

Results from Off-Site RO Challenge and Tracer Testing

MS-2 Results (IEH-BioVir) for Off-Site Trasar Testing

Notes	SampleNumber	CustomerSampleNumber	Permeate Location	Result (PFU/mL)
Test 1 Standard RO Operation, nothing out of service or damaged	151187-001	Perm-1A-0721	Stage 1	<1
	151187-002	Perm-1B-0721	Stage 1	<1
	151187-003	Perm-1C-0721	Stage 1	<1
	151187-004	Inf-1A-0721		3.30E+06
	151187-005	Inf-1B-0721		2.80E+06
	151187-006	Inf-1C-0721		2.20E+06
	151187-007	Conc-1-0721		1.20E+06
	151187-008	Perm-2A-0721	Combined	<1
	151187-009	Perm-2B-0721	Combined	<1
	151187-010	Perm-2C-0721	Combined	<1
	151187-011	Inf-2A-0721		3.30E+06
	151187-012	Inf-2B-0721		4.30E+06
	151187-013	Inf-2C-0721		4.20E+06
	151187-014	Conc-2-0721		2.30E+07
Test 2 Standard RO Operation, nothing out of service or damaged	151281-001	Perm-1A-0722	Stage 1	<1
	151281-002	Perm-1B-0722	Stage 1	<1
	151281-003	Perm-1C-0722	Stage 1	<1
	151281-004	Inf-1A-0722		1.00E+06
	151281-005	Inf-1B-0722		8.00E+05
	151281-006	Inf-1C-0722		7.00E+05
	151281-007	Conc-1-0722		1.00E+06
	151281-008	Perm-2A-0722	Combined	<1
	151281-009	Perm-2B-0722	Combined	<1
	151281-010	Perm-2C-0722	Combined	<1
	151281-011	Inf-2A-0722		1.30E+06
	151281-012	Inf-2B-0722		9.00E+05
	151281-013	Inf-2C-0722		1.80E+06
	151281-014	Conc-2-0722		2.00E+06
Test 3 O-ring damaged (cut)	151281-015	Perm-3A-0722	Stage 1	1.80E+05
	151281-016	Perm-3B-0722	Stage 1	1.90E+05
	151281-017	Perm-3C-0722	Stage 1	1.80E+05
	151281-018	Inf-3A-0722		1.20E+06
	151281-019	Inf-3B-0722		2.40E+06
	151281-020	Inf-3C-0722		3.00E+06
	151281-021	Conc-3-0722		3.00E+06
	151281-022	Perm-4A-0722	Stage 1	1.90E+05
	151281-023	Perm-4B-0722	Stage 1	2.20E+05
	151281-024	Perm-4C-0722	Stage 1	1.60E+05
	151281-025	Inf-4A-0722		1.50E+06
	151281-026	Inf-4B-0722		1.00E+06
	151281-027	Inf-4C-0722		1.50E+06
	151281-028	Conc-4-0722		3.00E+06
Test 4 Oxidized RO Membranes	151282-001	Perm-1A-0723	Stage 1	<1
	151282-002	Perm-1B-0723	Stage 1	<1
	151282-003	Perm-1C-0723	Stage 1	<1
	151282-004	Inf-1A-0723		3.40E+06
	151282-005	Inf-1B-0723		6.10E+06
	151282-006	Inf-1C-0723		4.20E+06
	151282-007	Conc-1-0723		1.00E+07
	151282-008	Perm-2A-0723	Stage 1	<1
	151282-009	Perm-2B-0723	Stage 1	<1
	151282-010	Perm-2C-0723	Stage 1	<1
	151282-011	Inf-2A-0723		5.80E+06
	151282-012	Inf-2B-0723		5.10E+06
	151282-013	Inf-2C-0723		5.20E+06
	151282-014	Conc-2-0723		1.80E+07

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

REPORT NO.: 150175
PAGE NO.: 1 of 6
CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: 1602 Bacteriophage **Method: EPA 1602 (821-R-01-029)**

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-001	**MF Source A**	**RWPF - Big Spring Influent**	**Bacteriophage, Male Specific**	**6**	**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 9:30:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: 2/11/2015 Analysis Start Time: 1455
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-001	**MF Source A**	**RWPF - Big Spring Influent**	**Bacteriophage, Somatic**		**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 9:30:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: Analysis Start Time:
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-002	**MF Source B**	**RWPF - Big Spring Influent**	**Bacteriophage, Male Specific**	**6**	**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 9:30:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: 2/11/2015 Analysis Start Time: 1455
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-002	**MF Source B**	**RWPF - Big Spring Influent**	**Bacteriophage, Somatic**		**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 9:30:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: Analysis Start Time:
Analyst: KTucker Analysis End: 2/12/2015

Comment

REPORT NO.: 150175

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: 1602 Bacteriophage **Method: EPA 1602 (821-R-01-029)**

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-003	**MF Source C**	**RWPF - Big Spring Influent**	**Bacteriophage, Male Specific**	**10**	**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 9:30:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: 2/11/2015 Analysis Start Time: 1455
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-003	**MF Source C**	**RWPF - Big Spring Influent**	**Bacteriophage, Somatic**		**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 9:30:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: Analysis Start Time:
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-004	**RO Feed A**	**RWPF - Big Spring RO Feed**	**Bacteriophage, Male Specific**	**6**	**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 10:00:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: 2/11/2015 Analysis Start Time: 1455
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-004	**RO Feed A**	**RWPF - Big Spring RO Feed**	**Bacteriophage, Somatic**		**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 10:00:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: Analysis Start Time:
Analyst: KTucker Analysis End: 2/12/2015

Comment

REPORT NO.:	150175
PAGE NO.:	3 of 6
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: 1602 Bacteriophage **Method: EPA 1602 (821-R-01-029)**

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-005	**RO Feed B**	**RWPF - Big Spring RO Feed**	**Bacteriophage, Male Specific**	**12**	**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 10:00:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: 2/11/2015 Analysis Start Time: 1455
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-005	**RO Feed B**	**RWPF - Big Spring RO Feed**	**Bacteriophage, Somatic**		**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 10:00:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: Analysis Start Time:
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-006	**RO Feed C**	**RWPF - Big Spring RO Feed**	**Bacteriophage, Male Specific**	**7**	**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 10:00:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: 2/11/2015 Analysis Start Time: 1455
Analyst: KTucker Analysis End: 2/12/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
150175-006	**RO Feed C**	**RWPF - Big Spring RO Feed**	**Bacteriophage, Somatic**		**pfu/100 mL**

Collector: Scott Evan Milles CollectDate: 2/10/2015 CollectTime: 10:00:00 AM
ReceiveDate 2/11/2015 9:30:00 AM Matrix: Waste Water, treated Temp 3.0 C
Volume: 500 mL Analysis Start Date: Analysis Start Time:
Analyst: KTucker Analysis End: 2/12/2015

Comment

REPORT NO.:	150175
PAGE NO.:	6 of 6
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

3/25/2015

Date:

Richard E Danielson

Signature

Quality Checked LBarriga

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

REPORT NO.: 151187

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-001	**Perm-1A-0721**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:27:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-002	**Perm-1B-0721**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:28:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-003	**Perm-1C-0721**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:29:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-004	**Inf-1A-0721**		**Bacteriophage, Male Specific**	**3.3e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:32:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-005	**Inf-1B-0721**		**Bacteriophage, Male Specific**	**2.8e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:33:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-006	**Inf-1C-0721**		**Bacteriophage, Male Specific**	**2.2e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:34:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-007	**Conc-1-0721**		**Bacteriophage, Male Specific**	**1.2e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 3:37:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 30 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment Rec'd. leaking w/crack in bottle w/aprox. 30 mL volume. Client notified.

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-008	**Perm-2A-0721**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:10:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-009	**Perm-2B-0721**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:12:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

REPORT NO.: 151187

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-010	**Perm-2C-0721**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:12:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-011	**Inf-2A-0721**		**Bacteriophage, Male Specific**	**3.3e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:16:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-012	**Inf-2B-0721**		**Bacteriophage, Male Specific**	**4.3e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:18:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-013	**Inf-2C-0721**		**Bacteriophage, Male Specific**	**4.2e6**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:19:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151187-014	**Conc-2-0721**		**Bacteriophage, Male Specific**	**2.3e7**	**PFU/mL**

Collector: John Sutherland CollectDate: 7/21/2015 CollectTime: 4:22:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 4.8C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1137
Analyst: JTruscott Analysis End: 7/24/2015

Comment

REPORT NO.:	151187
PAGE NO.:	4 of 4
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

8/14/2015

Date:

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

SAMPLE DATA SHEET
BACTERIOPHAGE ANALYSIS
1-800-GIARDIA (442-7342)

CAR010K
1187-1-14
4.8°C

COMPANY OR UTILITY:	**DATE OF SAMPLING:**
Carollo Engineers	7/21/2015
NAME OF SAMPLER: J. Sutherland	**MATRIX:** (1) RO Permeate (2) UF Filtered WWTP Effluent (3) RO Concentrate

	SAMPLE ID#	TIME	VOLUME	TREATMENT	EXPECTED CONCENTRATION PER SAMPLE (pfu per mL)	ANALYSIS/METHOD
1	PERM-1A-0721	15:27	100mL	STS	10 to 100	MS-2 Phage
2	PERM-1B-0721	15:28			"	
3	PERM-1C-0721	15:29			"	
4	INF-1A-0721	15:32			10^7	
5	INF-1B-0721	15:33			"	
6	INF-1C-0721	15:34			"	
* 7	CONC-1-0721	15:37			10^8	
8	PERM-2A-0721	16:10			10 to 100	
9	PERM-2B-0721	16:12			"	
10	PERM-2C-0721	16:12			"	
11	INF-2A-0721	16:16			10^7	
12	INF-2B-0721	16:18			"	
13	INF-2C-0721	16:19			"	
14	CONC-2-0721	16:22			10^8	

SIGNATURE: [signature]		**DATE:** 7/21/2015
RECEIVED:	Jmc	**DATE:** 7/23/15 08:20

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, BENICIA CALIFORNIA 94510 Ced up

F:\Shipping+Receiving\Phage Date Sheet.wpd

receptn note: * #7 rec'd leaking w/crack in btl. = aprox 30-40 mL volume rec'd. Jmc

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

REPORT NO.: 151281

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200
Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: Bacteriophage Male-Specific **Method: Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-001	**Perm-1A-0722**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 9:48:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1005
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-002	**Perm-1B-0722**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 9:49:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1005
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-003	**Perm-1C-0722**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 9:50:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1005
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-004	**Inf-1A-0722**		**Bacteriophage, Male Specific**	**1.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 9:55:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-005	**Inf-1B-0722**		**Bacteriophage, Male Specific**	**8.0e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 9:58:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-006	**Inf-1C-0722**		**Bacteriophage, Male Specific**	**7.0e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 9:59:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-007	**Conc-1-0722**		**Bacteriophage, Male Specific**	**1.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:06:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-008	**Perm-2A-0722**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:36:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1005
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-009	**Perm-2B-0722**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:38:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1005
Analyst: KTucker Analysis End: 7/27/2015

Comment

REPORT NO.: 151281

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: Bacteriophage Male-Specific **Method: Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-010	**Perm-2C-0722**		**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:40:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1005
Analyst: KTucker Analysis End: 7/27/2015

Comment

151281-011	**Inf-2A-0722**		**Bacteriophage, Male Specific**	**1.3e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:43:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

151281-012	**Inf-2B-0722**		**Bacteriophage, Male Specific**	**9.0e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:44:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

151281-013	**Inf-2C-0722**		**Bacteriophage, Male Specific**	**1.8e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:45:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 10 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. w/lid open and aprox. 10 mL volume remaining in sample btl. Client notified.

151281-014	**Conc-2-0722**		**Bacteriophage, Male Specific**	**2.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 10:49:00 AM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

REPORT NO.:	151281
PAGE NO.:	4 of 7
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: Bacteriophage Male-Specific **Method: Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-015	**Perm-3A-0722**		**Bacteriophage, Male Specific**	**1.8e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:22:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-016	**Perm-3B-0722**		**Bacteriophage, Male Specific**	**1.9e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:23:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-017	**Perm-3C-0722**		**Bacteriophage, Male Specific**	**1.8e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:24:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-018	**Inf-3A-0722**		**Bacteriophage, Male Specific**	**1.2e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:27:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp N/A
Volume: Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. empty. Client notified. NWP.

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-019	**Inf-3B-0722**		**Bacteriophage, Male Specific**	**2.4e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:28:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

REPORT NO.: 151281

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-020	**Inf-3C-0722**		**Bacteriophage, Male Specific**	**3.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:29:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-021	**Conc-3-0722**		**Bacteriophage, Male Specific**	**3.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:33:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-022	**Perm-4A-0722**		**Bacteriophage, Male Specific**	**1.9e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:38:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Samples #22-28 rec'd. in non-provided Idexx btls. Client notified not good for MS2 sampling.

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-023	**Perm-4B-0722**		**Bacteriophage, Male Specific**	**2.2e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:39:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. in non-supplied Idexx btl.

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-024	**Perm-4C-0722**		**Bacteriophage, Male Specific**	**1.6e5**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:40:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. in non-provided Idexx btl.

REPORT NO.:	151281
PAGE NO.:	6 of 7
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-025	**Inf-4A-0722**		**Bacteriophage, Male Specific**	**1.5e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:42:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. in non-provided Idexx btl.

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-026	**Inf-4B-0722**		**Bacteriophage, Male Specific**	**1.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:43:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. in non-provided Idexx btl.

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-027	**Inf-4C-0722**		**Bacteriophage, Male Specific**	**1.5e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:44:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. in non-provided Idexx btl.

BioVir #	Sample ID	Site	Analyte	Result	Units
151281-028	**Conc-4-0722**		**Bacteriophage, Male Specific**	**3.0e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/22/2015 CollectTime: 3:46:00 PM
ReceiveDate 7/23/2015 9:20:00 AM Matrix: Waste Water, treated Temp 9.9C
Volume: 100 mL Analysis Start Date: 7/23/2015 Analysis Start Time: 1300
Analyst: KTucker Analysis End: 7/27/2015

Comment Rec'd. in non-provided Idexx btl.

REPORT NO.:	151281
PAGE NO.:	7 of 7
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200
	Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

8/14/2015

Date:

Richard E Danielson

Signature

Quality Checked EMoran

BioVir LABORATORIES ®

SAMPLE DATA SHEET
BACTERIOPHAGE ANALYSIS
1-800-GIARDIA (442-7342)

CAR010K
1281-1-14
9.9°C

COMPANY OR UTILITY:	DATE OF SAMPLING:
Carollo Engineers, Inc.	7/22/2015
NAME OF SAMPLER:	MATRIX: (1) Ro Permeate (2) UF Filtered WWTP Eff. (3) RO Concentrate
Justin Sutherland	

	SAMPLE ID#	TIME	VOLUME	TREATMENT	EXPECTED CONCENTRATION PER SAMPLE (pfu per mL)	ANALYSIS/METHOD
1	PERM-1A-0722	9:48	100ml	STS	100 - 1000	MS-2 Phage
2	PERM-1B-0722	9:49			"	
3	PERM-1C-0722	9:50			"	
4	INF-1A-0722	9:55			$10^6 - 10^7$	
5	INF-1B-0722	9:58			"	
6	INF-1C-0722	9:59			"	
7	CONC-1-0722	10:06			$10^7 - 10^8$	
8	PERM-2A-0722	10:36			~~100-1000~~ 10^3-10^4	
9	PERM-2B-0722	10:38			"	
10	PERM-2C-0722	10:40			"	
11	INF-2A-0722	10:43			$10^6 - 10^7$	
12	INF-2B-0722	10:44			"	
13	INF-2C-0722	10:45	10ml		"	
14	CONC-2-0722	10:49			$10^7 - 10^8$	

SIGNATURE: [signature]	DATE: 7/22/2015
RECEIVED: JMC	DATE: 7/23/15 0920

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, BENICIA CALIFORNIA 94510
F:\Shipping+Receiving\Phage Date Sheet.wpd

#13 recd w/lid opened & aprox 10 mL volume recd ~ JMC

fed ey GEJ

1/2

BioVir LABORATORIES ®

SAMPLE DATA SHEET
BACTERIOPHAGE ANALYSIS
1-800-GIARDIA (442-7342)

CAR010K
1281-15-28
9.9°C

COMPANY OR UTILITY: Carollo Engineers, Inc.	**DATE OF SAMPLING:** 7/22/2015
NAME OF SAMPLER: Justin Sutherland	**MATRIX:** ① RO Permeate ② UF Filtered WWTP Eff. ③ RO Concentrate

	SAMPLE ID#	TIME	VOLUME	TREATMENT	EXPECTED CONCENTRATION PER SAMPLE (pfu per mL)	ANALYSIS/METHOD
15	PERM-3A-0722	15:22	100 mL	STS	~~100-1000~~ 10^3-10^4	MS-2 Phage
16	PERM-3B-0722	15:23			"	
17	PERM-3C-0722	15:24			"	
18	INF-3A-0722	15:27			10^6 - 10^7	
19	INF-3B-0722	15:28			"	
20	INF-3C-0722	15:29			"	
21	CONC-3-0722	15:33			10^7 - 10^8	
22	PERM-4A-0722	15:38			~~100 - 1000~~ 10^3-10^4	
23	PERM-4B-0722	15:39			"	
24	PERM-4C-0722	15:40			"	
25	INF-4A-0722	15:42			10^6 - 10^7	
26	INF-4B-0722	15:43			"	
27	INF-4C-0722	15:44			"	
28	CONC-4-0722	15:46			10^7 - 10^8	

SIGNATURE: [signature]	**DATE:** 7/22/2015
RECEIVED: JMC	**DATE:** 7/23/15 09:20

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, BENICIA CALIFORNIA 94510

F:\Shipping+Receiving\Phage Date Sheet.wpd

#18 rec'd empty - JMC 7/23/15

#22-28 Rec'd in Idexx btls - not supplied by BioVir - JMC

2/2

BioVir Laboratories

EPA ID# 01401, CA-ELAP #179

685 Stone Road, Unit 6 • Benicia, CA 94510 • (707) 747-5906 • 1-800-GIARDIA • FAX (707) 747-1751 • WEB: www.biovir.com

REPORT NO.: 151282

CLIENT: Carollo Engineers, Inc

ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759

CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-001	**Perm-1A-0723**	**None Given**	**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:48:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-002	**Perm-1B-0723**	**None Given**	**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:49:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-003	**Perm-1C-0723**	**None Given**	**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:50:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-004	**Inf-1A-0723**	**None Given**	**Bacteriophage, Male Specific**	**3.4e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:52:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment

REPORT NO.: 151282

CLIENT: Carollo Engineers, Inc
ADDRESS 8911 Capital of Texas Hwy North, Suite 2200

Austin, TX 78759
CLIENT NO CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-005	**Inf-1B-0723**	**None Given**	**Bacteriophage, Male Specific**	**6.1e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:53:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-006	**Inf-1C-0723**	**None Given**	**Bacteriophage, Male Specific**	**4.2e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:54:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. Idexx btl. Cracked & leaking. Client notified-Idexx not good for MS2 sampling.

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-007	**Conc-1-0723**	**None Given**	**Bacteriophage, Male Specific**	**1.0e7**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 1:58:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. samples #6-14 in non-supplied Idexx btl. Client notified not good for MS2 sampling

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-008	**Perm-2A-0723**	**None Given**	**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:13:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. in Idexx btl. Client notified.

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-009	**Perm-2B-0723**	**None Given**	**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:14:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. in Idexx btl. Client notified.

REPORT NO.:	151282
PAGE NO.:	3 of 4
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

Test: **Bacteriophage Male-Specific** **Method:** **Adams 1959**

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-010	**Perm-2C-0723**	**None Given**	**Bacteriophage, Male Specific**	**<1**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:15:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. in Idexx btl. Client notified.

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-011	**Inf-2A-0723**	**None Given**	**Bacteriophage, Male Specific**	**5.8e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:16:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. in Idexx btl. Client notified.

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-012	**Inf-2B-0723**	**None Given**	**Bacteriophage, Male Specific**	**5.1e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:17:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. Idexx btl. Cracked & leaking. Client notified Idexx not good for MS2 sampling.

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-013	**Inf-2C-0723**	**None Given**	**Bacteriophage, Male Specific**	**5.2e6**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:18:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. in Idexx btl. Client notified.

BioVir #	Sample ID	Site	Analyte	Result	Units
151282-014	**Conc-2-0723**	**None Given**	**Bacteriophage, Male Specific**	**1.8e7**	**PFU/mL**

Collector: J. Sutherland CollectDate: 7/23/2015 CollectTime: 2:20:00 PM
ReceiveDate 7/24/2015 9:17:00 AM Matrix: Waste Water, treated Temp 9.0C
Volume: 100 mL Analysis Start Date: 7/24/2015 Analysis Start Time: 1105
Analyst: KTucker Analysis End: 7/31/2015

Comment Rec'd. in Idexx btl. Client notified.

REPORT NO.:	151282
PAGE NO.:	4 of 4
CLIENT:	Carollo Engineers, Inc
ADDRESS	8911 Capital of Texas Hwy North, Suite 2200 Austin, TX 78759
CLIENT NO	CAR010K **CLIENT PO:** N/A

ASSAY RESULTS:

SAMPLE EVALUATION PERFORMANCE CRITERIA: The precise rates of recovery of organisms from environmental samples cannot be determined. B ioVir Laboratories has analyzed your sample(s) in accordance with the method described with each analyte above, however, due to inherent limitations of these methods organisms may avoid detection. For additional information regarding the limitations of the method(s) referred to above please call us at 1-800-GIARDIA.
COMPANY IS NOT AN INSURER: BioVir Laboratories is not an insurer or guarantor of the quality and/or purity of water, wastewater, biosolid or other material from which the sample was taken. BioVir offers no express or implied warranties whatsoever concerning the quality or purity of any water, wastewater, biosolid or other material which is ultimately consumed, distributed, applied or disposed.
MAINTENANCE OF RECORDS: BioVir Laboratories, Inc. shall maintain records pertaining to the historical reconstruction of client's data for a minimum of five years from the date of issuance of the final report. Records m ay be destroyed after that date unless a written client's request for records transfer is received by BioVir which requests otherwise. Records transfer or storage charges may apply after the 5 year period. THIS REPORT SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF BIOVIR LABORATORIES, INC.

8/14/2015

Date:

Richard E Danielson

Signature

Quality Checked EMoran

1282-1-14
CAR010K
9.0°C

SAMPLE DATA SHEET
BACTERIOPHAGE ANALYSIS
1-800-GIARDIA (442-7342)

BioVir Laboratories

COMPANY OR UTILITY: Carollo Engineers, Inc.	**DATE OF SAMPLING:** 7/23/2015
NAME OF SAMPLER: Justin Sutherland	**MATRIX:** ① RO Permeate ② UF Filtered WWTP Eff. ③ RO Concentrate

	SAMPLE ID#	TIME	VOLUME	TREATMENT	EXPECTED CONCENTRATION PER SAMPLE (pfu per mL)	ANALYSIS/METHOD
①	PERM-1A-0723	13:48	100ml	STS	$10^3 - 10^4$	MS-2 Phage
②	PERM-1B-0723	13:49			"	
③	PERM-1C-0723	13:50			"	
④	INF-1A-0723	13:52			$10^6 - 10^7$	
⑤	INF-1B-0723	13:53			"	
* I ⑥	INF-1C-0723	13:54			"	
~~7~~	~~INF-~~				this line — VOID	
7 ~~8~~	CONC-1-0723	13:58			$10^7 - 10^8$	
I ⑧	PERM-2A-0723	14:13			$10^3 - 10^4$	
I ⑨	PERM-2B-0723	14:14			"	
I ⑩	PERM-2C-0723	14:15			"	
I ⑪	INF-2A-0723	14:16			$10^6 - 10^7$	
* I ⑫	INF-2B-0723	14:17			"	
I ⑬	INF-2C-0723	14:18			"	
I ⑭	CONC-2-0723	14:20			$10^7 - 10^8$	

SIGNATURE:	**DATE:** 7/23/2015
RECEIVED:	**DATE:** 7/24/15

09:17
fedex

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, BENICIA CALIFORNIA 94510

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I - Idexx btls. - non-BioVir supplied jmc
* recd leaking #6 & 12 - jmc

Appendix F

Carollo Responses to TWDB and TCEQ Comments

Carollo Responses to

TWDB and TCEQ Comments on

"Final Report and DPR Monitoring Guidance' testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards"
TWDB Contract NO. 1348321632

Comments are organized in the order provided in the letter dated October 27, 2016 from Robert Mace of the Texas Water Development Board to Hisham "Hutch" Musallam of Carollo Engineers, Inc. Carollo's responses are provided in ***bold and italics*** below each comment.

TWDB Comments

General Comments:

1. Great job on the draft final report!

   Thank you!

2. Please consider modifying the title of the report to "Direct Potable Reuse Monitoring: Testing Water Quality in Municipal Wastewater Effluent Treated to Drinking Water Standards".

   Changed

3. Please use the same report title on the cover page and title page.

   Changed

4. Please correct the TWDB contract number in the footer to 1348321632. See page 2-5, 6, 11-14, and other pages.

   Changed

5. Please do not use acronyms in headings and titles. Please revise the report where applicable. For example, the heading for Chapter 5, Section 6.2, Appendix B and D, Figure 2.2, Figure 4.11 - 4.13, and Figure 4.16 - 4.19.

   Changed in most cases. NDMA is usually referred to by its acronym, so an exception was made for it.

6. Please do not use acronyms in the executive summary.

   Some acronyms were replaced. The remaining acronyms in the executive summary are defined at their first use and are commonly used.

7. Please limit the use of acronyms in the report to minimum because sentences may be unclear to the non-technical reader. If an acronym will be used, please spell out the word

when used for the first time. For example: *Both Backwash water from MF and CIP waste from RO are returned to the WWTP, and RO concentrate is discharged to Beal's Creek.*

Acronyms are defined at first use. Acronyms that are not commonly used will be spelled out in certain sentences to improve readability.

8. Please review and correct report for consistency when using acronyms and defining them. At times an acronym is used, but was not spell out. Other times the word is spell out and abbreviated, but the acronym is not used or had already been abbreviated.

   Acronyms are defined at first use. Once an acronym has been defined, we will usually use the acronym throughout the rest of the report. In cases where the acronym has not been used for a while, we redefine it to refresh the reader's memory. In certain cases, we spell out an acronym after it has been defined to improve readability.

9. Please add figure captions to the various photo images. Please see page 8, 10, 14, 27, and others.

   The photos in question are not figures. They are provided to break up the visual monotony, but they are not given in-text references. All photos are captioned with descriptions.

10. Please add periods at the end of captions and capitalize only the first letter and any proper names.

    Done

11. Please update all the items pending (highlighted in yellow) for the final report.

    Done

12. Please consider when comparing data and regulatory requirements to compare first with Texas Commission of Environmentally Quality requirements and then nationally.
    Done

13. Please define acronyms in the key of figures and in the notes section of tables.

    Done. Selected acronyms are used in figure captions to improve readability.

14. Please add any missing references and format references according to Exhibit D Guidelines for Authors Submitting Contract Reports to the Texas Water Development Board.

    We are not aware of any missing references. Word cross-referencing errors have been corrected.

15. Please add a discussion to address "permitting analysis of reverse osmosis brine discharge" per Task 3 of the Scope of Work.
    Done

16. Please submit the "Texas-specific version of the Integrated Treatment Train Toolbox for Potable Reuse (IT^3PR)" per Task 3 of the Scope of Work.
    This is being submitted.

17. Please append the final test protocol and Carollo's responses to TWDB and TCEQ comments as an appendix in the final report.

Final test protocol appended as Appendix B. This document (Appendix F) constitutes Carollo's responses to TWDB and TCEQ comments.

<u>Specific Comments</u>:

1. Page 1. Third paragraph, third sentence: Please add “of” after the word “number”.

   Done

2. Page 2. Bullet 3: Please remove “let”.

   Done

3. Page 2. Looking Ahead Section: Please consider adding language on any monitoring recommendations for direct potable reuse facilities.

   Added a paragraph at the end of this section. Added the same paragraph to the end of Chapter 6.

4. Page 3. Fourth paragraph, first sentence: Please use “TWDB” when referring to the agency and “the Board” when referring to our three-member governing body.

   Changed definition in question.

5. Page 3. Section 1.2, first and second sentence: Please replace “the Development Board” with “TWDB”.

   Done

6. Page 4. Section 1.3, Second bullet: Please remove “Innovative Water Technologies”.

   Done

7. Page 4. Section 1.3, Second bullet, sub-bullet one: Please replace “Team Lead and Project Manager” with “Contract Manager, Innovative Water Technologies”.

   Done

8. Page 4. Section 1.3, Second bullet, sub-bullet two: Please replace “Division Director” with “Director, Conservation and Innovative Water Technologies”.

   Done

9. Page 5. Section 2, third paragraph, second sentence: Please delete “(AFY)” and add hyphens to “acre-foot per year” and “million-gallon- per day”.

   It is important to define AFY, as it is a common unit and this is its first appearance. These definitions are already hyphenated.

10. Page 6. Figure 2.1: Please consider adding “Water Supply” before “System”.

    It is already clearly called a Water District.

11. Page 7. Figure 2.2: Please add a reference to the figure within the text and add a period at the end of the caption. Please lowercase the first letter in facilities and involved. Please consider removing “15 MG” from the callout box, since capacity is not provide for each plant or reservoir.

Added in-text reference to Figure 2.2 in first paragraph of Section 2. Caption changed.

12. Page 8. First paragraph, first sentence: Please avoid using too many acronyms within one sentence which would make it unclear for the reader.

    These acronyms have all been defined and are used in the bullets preceding this sentence.

13. Page 8. Section 2.2, fourth sentence: Please spell out "gfd".

    Done

14. Page 9. Figure 2.3: Please consider spelling out acronyms since a figure is standalone.

    These are already defined in the text and are commonly used.

15. Page 10. Third paragraph, first sentence: Please spell out NWRI and clarify the sentence. It is unclear what "Trojan" means and if the UVT ranges provided are validation results or benchmark values.

    NWRI spelled out as National Water Research Institute. Trojan clarified in this and above paragraph as Trojan Technologies. The paragraph references the NWRI validation windows for UVT and flow. A clarification was added.

16. Page 11. First paragraph, second sentence: Please correct the sentence to "…described in Title 30 of the Texas Administrative Code (TAC), Chapter 210 (Use of Reclaimed Water) and Chapter 321 Subchapter P (Reclaimed Water Production Facilities)."

    Done

17. Page 11. First paragraph, third sentence: Please modify the sentence to "the Title 2 of Texas Water Code (TWC) §11.402 governing bed and bank permits and TWC §11.406 governing return flows."

    Done

18. Page 11. First paragraph, fourth sentence: Please add reference to 30 TAC §210.33 in the sentence where it seems appropriate.

    Inserted as "The regulations governing indirect reuse in 30 TAC §210.33 do not include water quality requirements."

19. Page 11. Second paragraph, first sentence: Please replace "30 TAC 290" with "30 TAC §290.42(g)".

    Done

20. Page 11. Fifth paragraph, last sentence: Please modify the sentence to clarify that this is not specific TWDB recommendation. The Direct Potable Reuse Resource Document states the following:

    In many cases, a selected treatment scheme will meet the requirements of both sets of targets. To obtain project approval, the TCEQ targets (as discussed in Section 3.3.1.2) must be achieved. However, a PWS may want to confirm that the WRRF 11-02 targets can also be achieved to help provide additional justification to the public or stakeholders that the project meets recommendations developed by a national team of experts in potable water reuse.

Modified to "These standards are suggested by the Texas Water Development Board DPR Resource Document as a way to provide additional justification to the public or stakeholders that the project meets recommendations developed by a national team of experts in potable water reuse (APAI, 2015)."

21. Page 11. Last paragraph: Please clarify how the second alternative mentioned differs from guidance in the Direct Potable Reuse Resource Document. Please modify sentence as necessary. The Direct Potable Reuse Resource Document states the following:

    The baseline log removal targets are considered a starting point for the TCEQ approval process and may be revised based on data collected from the wastewater effluent in question. The primary difference between the WRRF 11-02 and TCEQ approach is the starting point for counting log reductions. The TCEQ approach uses wastewater treatment plant effluent as the starting point, whereas the WRRF 11-02 approach uses the raw wastewater as the starting point. Additionally, TCEQ uses site-specific wastewater treatment plant effluent concentrations to evaluate the need for additional log removal requirements above the baseline targets and does not consider a specific log removal target for total coliform[22].

    This section was rewritten in response to the request in Comment #22 below. The specific reference to a "second alternative" is no longer in the text.

22. Page 12. First paragraph: Please consider moving the paragraph up before the NWRI treatment target removal paragraph to discuss TCEQ regulations first and then national.

    Done.

23. Page 12. First paragraph, second sentence: Please specify what are “drinking water validation standards” and clarify if the “validation requirements for reuse projects” are for potable use.

    Specified as "drinking water validation standards in 30 TAC §290(F)," and "for potable reuse projects."

24. Page 12. First paragraph, third sentence: Please replace “differenced” with “differences”.

    Done

25. Page 12. First paragraph, last sentence: Please consider deleting the sentence because there may be no need to compare stringency. Otherwise please consider expanding on the sentence to justify the statement.

    The preceding two paragraphs justify the statement.

26. Page 12. Section 3.1, third sentence: Please consider moving the paragraph up, specifically after the second sentence in the second paragraph.

    It is already in the first paragraph of the section.

27. Page 13. Table 3.1, Trasar® Testing: Please consider changing “see Note 3.” to “none[3]” for each sample event.

    It would be misleading to say "none" since Trasar Testing was conducted.

28. Page 14. First paragraph, second sentence: Please replace “15 million gallon (MG)” with “15 million-gallon”.

Done

29. Page 14. Third paragraph, second sentence: Please add a comma between Ventura and California and delete “(TC)”.

    Done

30. Page 15. Figure 3.1: Please move the figure after Table 3.1. Please modify the note to state “…changed from 25% to 50%”.

    Moved. This note modification does not agree with the figure, which states the blend was at <20% of total flow, not 25%.

31. Page 16. Figure 3.2: Please move figure after Table 3.1. Please consider adding arrow symbol and labeling it as sample location.

    Moved. The arrow symbol is already described as a sample location in the caption.

32. Page 17. Seventh paragraph, second sentence: Please add the U.S. Geological Survey 2002 study to the reference section.

    The USGS 2002 study is referenced as the Kolpin et al. 2002 study.

33. Page 17. Seventh paragraph: Please change “US” to “U.S.”.

    Done

34. Page 28. First paragraph: Please remove the extra paragraph space.

    Done

35. Page 29. Figure 4.6: Please consider adjusting the x-axis to be less cluttered.

    It is showing specific sample dates, some of which are referred to in the text.

36. Page 30. Fifth paragraph, last sentence. Please consider providing the actual UV dose at the Raw Water Production Facility.

    The actual dose is described in section 4.6.3.

37. Page 31. Eighth paragraph, last sentence: Please consider adding what is the implication to carrying a negative surface charge at a neutral pH.

    The following sentence was added "Its repulsion by a negatively charged RO membrane surface would therefore be expected to be similar to that of other viruses. Page 32.

38. Section 4.5.3: Please use one definition for EEM. Is it emission excitation matrices or excitation-emission matrix?

    Changed to excitation-emission.

39. Page 33. Third paragraph, first sentence: Please fix the error message for the in-text citation.

    Word cross-referencing errors have been fixed throughout.

40. Page 35. Third paragraph, second sentence: Please fix the error message for the in-text citation and add the figure number.

Word cross-referencing errors have been fixed throughout.

41. Page 37. Section 4.5.3.3: Please consider adding language to address why facilities should conduct this preliminary or advance analysis and how it is applicable.

    The following text was added to the bottom of this section: "The analysis conducted here indicates that while a good correlation between EEM data and DBP FP data can be achieved, it requires a larger training dataset. This may lend itself to an in-depth characterization of an existing effluent proposed for a DPR project, but that it may not be a good tool for ongoing monitoring at DPR facilities."

42. Page 41. Section 4.6: Please consider adding language to define surrogate and indicator.

    Added to first paragraph of Section 4.5: Indicator organisms and chemicals are generally harmless constituents whose presence is correlated with the presence of organisms and chemicals of health concern.

    Added to first paragraph of Section 4.6: Surrogates are parameters that are not generally of health concern, but that are used to test the efficacy of treatment processes.

43. Page 42. Third paragraph: Please add a space between the second and third paragraph.

    Done.

44. Page 51. Section 5: Please consider adding a list of ongoing research projects on operations, maintenance, and monitoring for DPR projects.

    The reader is referred to the work of the Water Environment and Reuse Foundation, which is sponsoring several projects on those topics.

45. Page 51. Third paragraph: Please consider modifying sentence. Is the process control and monitoring discussion includes all ongoing research or limited to key projects?

    The sentence was modified to narrow the subject to "process control and monitoring for direct potable reuse projects"

46. Appendix C. Please correct the order and renumber the pages because the table of contents and list of figures, tables, and acronyms is located after executive summary.

    This report has been reformatted completely.

Texas Commission on Environmental Quality Comments

<u>General Comments</u>:

- Page 33 and 35. Please correct Microsoft word lists errors.

  Done

<u>Specific Comments:</u>

2.5 DPR Regulatory Summary

- Page 11. First paragraph: Change Division 30 of the TAC to Title 30 of the TAC.

  Changed

- Page 12. Second to last sentence: Please change "differenced" to "differences".

  Changed

4.1 Chemical Constituents: Health based criteria and Measured Concentrations

- I like that the report used the amount of sucralose in a soda as a real world comparison.

  Thank you!

4.4.4 Evaluation of Results

- The LT2 EPA Bin calculations are run on a rolling 12 month average for Crypto. From the EPA guidance document - "For PWSs that collect at least 24 samples, but not more than 47 samples, during the required monitoring period, the Cryptosporidium bin concentration is equal to the highest arithmetic mean of all sample concentrations in any 12 consecutive months in the monitoring period." This still puts the WWTP effluent in a Bin 4, but you may want to do the 12 consecutive month method to follow the rule. Also, for LT2, per EPA, any non-detect is replaced with a zero when doing the averages.

  Changed to "Based on the results of the influent water testing conducted at the RWPF, which had a maximum arithmetic mean Cryptosporidium concentration of 12.6 oocysts/L for any twelve consecutive months in the monitoring period, the filtered effluent from the City of Big Spring's WWTP would be classified as a Bin 4 source water."

  We have been replacing non-detects with zeros in averages.

- Is there any way to further stress that No C or G were found in samples past the MF? People love looking at graphs and can skip the text for the graphs. Readers may see the graphs and wonder if the C and G were removed by the treatment.

  Statements confirming this result in several locations were bolded and italicized for emphasis.

4.4.5 Comparison to Goal Concentrations.

- CRMWD RWPF was the first facility to be part of a DPR project. At that time we didn't count log credits, but looked at the treatments provided and deemed there to be enough

Crypto and Giardia credits. The virus treatment was the limiting factor, so we put a log inactivation requirement of 4-log viral on their system. We still require tests and shut downs based on using the unit processes as if they were gaining log removal and inactivation credits. For example, the DIT was set based on a 4.0-log removal. When I compare plants and their treatment credits, I conservatively give the RWPF a rating of 10, 10, 4 (C, G, V) and the whole treatment scheme (including the downstream PWS) a rating of 13, 13, 8 (C, G, V). So it may be better to compare the found Crypto and Giardia concentrations in the WWTP effluent to the treatment, not the base line. To break it down; 4 log C & G from MF, 6 log from UV (2 in series each verified at 3-log and operated at much higher doses then needed), 3 log for conventional treatment at downstream PWSs (plus the 4 log viral at the downstream PWS). You do this in the document, but I thought it would help to provide how TCEQ sees it so it's not a supposition on your part, but comparing it to how TCEQ looks at it. This may also help with the paragraph on pathogens in 6.1.

Some significant rearrangements were made in response to this comment. The more detailed discussion referenced in this comment was moved into the introductory section on permitting (Section 2.5), with emphasis on the Texas approach.

As discussed on 11/8, the wording was revised to avoid any potential implication that the facility is not meeting pathogen standards.

4.6.1 Particle Size Distribution Testing

- The yellow highlight should be 4-log removal for protozoa. It is listed in item number 4 of the October 30, 2015 update of the CRMWD list of conditions. I believe it's item number 4 in all of the lists of conditions. I tried not to renumber the list.

  Changed. Thanks for confirming.

4.6.2.3 Summary of RO Challenge Testing Results

- Page 46. First paragraph, last sentence: The document references Figure 4.13, where I believe it should reference Figure 4.16.

  Correct, changed.

4.6.2.4 Conclusions from RO Challenge Testing

- Please add a bit more discussion about Trasar and address the following questions.
  - If a PWS was to dose Trasar at a level to show 6-log viral removal on a continuous basis, what are the costs?
  - Will it cause issues with the RO equipment or discharge equipment or permits?
  - Lastly you discuss cost savings for design and operation. Are you referring to having systems basically not install some treatment because they are getting viral credit for RO? That is one of my big fears. Oh, I'll skip UVAOP because I'll get my C, G, V from the RO! The document does seem to show the RO did the heavy lifting on the CECs (except for NDMA and maybe TTHMs) so maybe that's the point.

  In Texas and in other states, Nalco is pursuing additional demonstration work so regulators can approve the technology as an integrity monitor. As discussed in our call

on 11/8, the benefits of the technology will be worded carefully to avoid reference to lower levels of treatment if this technology is used.

4.6.3.3 Chloramines Residual

- All I can say is really – 1,200 mJ/cm2?!?. That's not what I would have expected.

  Yup. The process was presumably was sized based on the CA model at the time to achieve 1.2-log NDMA removal and 0.5 log 1,4-dioxane removal. A UV dose in that range is necessary to meet those targets.

5.2 Monitoring Requirements

- Please correct Marlo's last name to Wanielista Berg.

  Corrected, with apologies!

Appendix C:

- A substantially higher flux in a UVFit (used for chemical destruction) versus a UVSwift (used for pathogen inactivation) reactor is possible if the contact time with the UV is relatively longer and the distance from the UV source is relatively shorter; the report does not contain the data to show how the higher flux estimate was obtained but it appears likely it is accurate. Please add how the flux estimate was obtained.

  The UV dose is an order of magnitude higher for UV oxidation than for UV disinfection. The details of how this was achieved are presented in the appendix and are more important for UV disinfection than for UV oxidation.

- The presence of hydroxyl radicals is likely the overwhelming driver of the observed chloramine decay; therefore, the possibility to scale up the collimated beam tests does appear to have technical merit for the specific application cited (a UVFit reactor used for the purpose of chemical destruction). Please address in the report.

  As is stated in the report, it is the photolysis of chloramine that we believe has the most potential for scale up of dose delivery. The presence of •OH will drive chloramine decay as stated (•OH rate constant=2.8x10^9 L/mole/cm, which is relatively low). The presence of hydrogen peroxide to generate •OH will complicate matters by adding another mechanism for chloramine removal and by competing with hydrogen peroxide for UV light, with chloramine more efficient at absorption of UV light.

Carollo Response to Draft Protocol - TCEQ Comments

Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards

TWDB Contract # 1348321632

General Comments

1. Please see pdf document for the specific comments.

Specific Comments

1. Page 6, last paragraph: The validation study was with the lower range UVT analyzer so we had to use it on full scale. We believe a new validation study would be needed to use a different sensor. If they are going to do that, we would suggest using the EPA guidance manual for UV testing and performing the test using UVTs and flows seen at this plant.

A text update clarifies that we are not proposing to do a full additional validation study as RWPF does not require additional credits.

2. Page 7, Item 2: Turbidity is also used as a trigger for the DIT testing.

This was updated in the text.

3. Page 8, Figure 3: Need to give them the file so it doesn't look wavy in the report.

We did not get the file but have improved the graphic.

4. Page 9, Section 1.3: The draft edited version that Carollo provided is great. Please use that reviewed version in the final protocol.

We incorporated the draft edited version provided to TCEQ via email.

5. Page 10, second paragraph, third bullet: Please ensure the method used for E. *Coli* is the counts and not the method that gives presence and absence.

It is. The July 2014 results are quantitative. No further changes are proposed.

6. Page 15, Section 2.3.3.2: For the Trasar testing method, have the membrane vendor completed a challenge test and developed a QCRV? We will need both items (challenge test and DIT method) to approve the "credits".

RWPF does not need additional credits. Therefore, while the protocol does include a membrane challenge test and an offline discussion of what would be required to obtain credit for reverse osmosis membranes at other facilities is warranted, no further changes to the protocol are proposed at this time.

7. Page 21, Table 2: For the “UV/AOP Final Product” column, zero tests will be completed for *Norovirus & Entervirus* because you do not expect any virus after UV. Is this correct?

Yes, that is correct. July 2014 results also corroborate this assumption. No further changes are proposed.

8. Page 23, Section 4.2.1: Please provide the source document that shows the MS2 Bacteriophage is not a human pathogen.

9. Page 25, Section 4.3: For the Trasar compound, please provide the NSF certification (or link to the website) showing ANSI/NSF 60 certification.

10. Page 25, Section 4.3.1: Please provide more information about the failure challenge test, I was under the impression that it would be onducted on a single element in an off-line setting. But others are concerned that you are proposing to compromise one of the active elements at CRMWD's facility. Please provide more information about the challenge testing. Please address where it will be conducted, on which equipment, and what will happen to the water produced by the test.

Questions 8,9, and 10 were addressed in an email transmitted to Marlo Wanielista Berg at the TCEQ, with cc to Erika Mancha at the TWDB via electronic mail on October 29, 2014. A copy of the attachment to this email is appended to this response. In this attachment, questions 8, 9, and 10 are referred to as questions 1, 2, and 3, respectively.