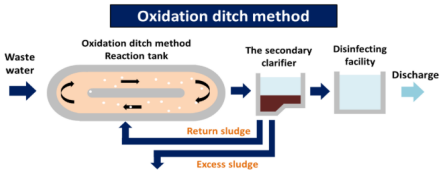


EPA Fact Sheet-2000

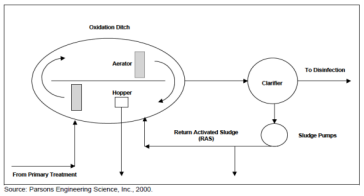
Primary settling prior to an oxidation ditch is sometimes practiced, but is not typical in this design. Tertiary filters may be required after clarification, depending on the effluent

Surface aerators, such as brush rotors, disc aerators, draft tube aerators, or fine bubble diffusers are used to circulate the mixed liquor.

nitrification will occur. Oxidation ditch effluent is usually settled in a separate secondary clarifier. An anaerobic tank may be added prior to the ditch to enhance biological phosphorus removal.

Long hydraulic retention time and complete mixing minimize the impact of a shock load or hydraulic surge.

EPA Fact Sheet-2000



Source: Parsons Engineering Science, Inc., 2000.

FIGURE 1 TYPICAL OXIDATION DITCH ACTIVATED SLUDGE SYSTEM

EPA Fact Sheet-2000

Design Parameters

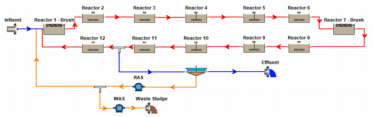
Screened wastewater enters the ditch, is aerated, and circulates at about 0.25 to 0.35 m/s (0.8 to 1.2 ft/s) to maintain the solids in suspension (Metcalf & Eddy, 1991). The RAS recycle ratio is from 75 to 150 percent, and the mixed liquor suspended solids (MLSS) concentration ranges from 1,500 to 5,000 mg/L (0.01 to 0.04 lbs/gal) (Metcalf & Eddy, 1991). The oxygen transfer efficiency of oxidation ditches ranges from 2.5 to 3.5 lb./Hp-hour (Baker Process, 1999).

Biowin Simulation Notes

A typical model flowsheet for an oxidation ditch
A circulation rate for mixed liquor must be selected when setting up this BioWin configuration.
Usually we think of this in terms of a recycle ratio; the ratio of flow rate in the ditch to the influent flow rate.
Usually a ditch is designed on the basis of a linear velocity of approximately 1 ft/sec (0.3 m/s).

Alpha Factor

α is the ratio of the overall mass transfer coefficient in process water to the overall mass transfer coefficient in clean water.
The global default αF is 0.5 and more typical for diffused aeration.
The αF should be set locally in the surface aerator reactor to a higher value **(e.g. 0.8 – 0.85)** to ensure accurate oxygen transfer modelling. Note that in BioWin 6, the default αF for surface aerator bioreactors is 0.8.



Legend	Given Info
	Assumptions
	Calculations

Characterization

Influent Wastewater Characteristics

BOD	250	mg/L
TSS	360	mg/L
TKN	55	mg/L

ADF	2.3	MGD
AWWF	5	MGD
PWWF	5.9	MGD
PHF	16.5	MGD

AWWF:ADF	2.17
PWWF:ADF	2.57
PHF:ADF	7.17

Industry practice often assumes PMF ≈ 1.5–2.5 × ADF		
PMF:ADF	2.5	
PMF	5.75	MGD

BioWin Model Influent

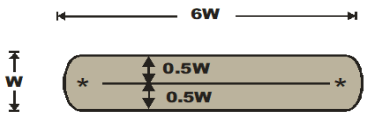
Flow	5.75
COD - Total mgCOD/L	500
N - Total Kjeldahl Nitrogen mgN/L	55
P - Total P mgP/L	6.5
S - Total S mgS/L	10
N - Nitrate mgN/L	0
pH	7.3
Alkalinity mgCaCO3/L	300
ISS Total mgISS/L	72
Metal soluble - Calcium mg/L	80
Metal soluble - Magnesium mg/L	15
Gas - Dissolved oxygen mg/L	0

BioWin Model WW Characteristics

Name	Default	Value
Fbs - Readily biodegradable (including A	0.16	0.07
Fvfa - Volatile fatty acids [g VFA COD/g c	0.15	0.3429
Fac - Acetate [gCOD/g of VFA COD]	1	1
Fxsp - Non-colloidal slowly biodegradable	0.75	0.9599
Fus - Unbiodegradable soluble [gCOD/	0.05	0.03
Fup - Unbiodegradable particulate [gC(	0.13	0.13
Fcel - Cellulose fraction of unbiodegradal	0.5	0.5
Fna - Ammonia [gNH3-N/gTKN]	0.66	0.48
Fnox - Particulate organic nitrogen [gN/	0.5	0.5
Fnus - Soluble unbiodegradable TKN [(	0.02	0.02
FupN - N:COD ratio for unbiodegradable	0.07	0.07
Fpo4 - Phosphate [gPO4-P/gTP]	0.5	0.5
FupP - P:COD ratio for unbiodegradable	0.022	0.022
Fsr - Reduced sulfur [H2S] [gS/gS]	0.15	0.15
FZbh - Ordinary heterotrophic COD fracti	0.02	0.02
FZbm - Methylotrophic COD fraction [g	1.00E-04	1.00E-04
FZao - Ammonia oxidizing COD fraction	1.00E-04	1.00E-04
FZno - Nitrite oxidizing COD fraction [g(	1.00E-04	1.00E-04
FZaao - Anaerobic ammonia oxidizing C(	1.00E-04	1.00E-04
FZppa - Phosphorus accumulating COD	1.00E-04	1.00E-04
FZpa - Propionic acetogenic COD fractio	1.00E-04	1.00E-04
FZam - Acetoclastic methanogenic COD	1.00E-04	1.00E-04
FZhm - Hydrogenotrophic methanogenic	1.00E-04	1.00E-04
FZso - Sulfur oxidizing COD fraction [g(	1.00E-04	1.00E-04
FZsrpa - Sulfur reducing propionic aceto(	1.00E-04	1.00E-04
FZsra - Sulfur reducing acetotrophic COI	1.00E-04	1.00E-04
FZsrh - Sulfur reducing hydrogenotrophic	1.00E-04	1.00E-04
FZe - Endogenous products COD fractio	0	0

Sizing

assume that we are designing a new ditch system, and we select the "length-to-width" ratio as 6:1 as



Assumptions

HRT	18	hr
Influent Flow	5.75	MGD
Depth	13	ft
Design Linear Velocity	1	ft/s

Volume, Area and Circulation

Ditch Volume	4.3	MG
Ditch Volume	576,497.37	ft3
Ditch Area	44,345.95	ft2
Width	85.97	ft
Width of channel	42.99	ft
Area for Flow	558.81	ft2
Flow in ditch	48,281,245.36	ft3/d
Flow in ditch	361.17	MGD
Recycle Ratio	62.81	

Model Size Inputs

Number of Bioreactors	12	
Volume of each Bioreactor	0.36	MG
Width	42.99	ft
Depth	13	ft
Total Volume	4.3	MG

Recirculation

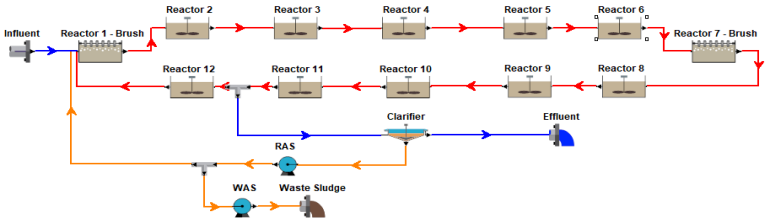
Recycle Ratio	62.81	
Rate in main	361.17	MGD

Oxidation Ditch Dimensions

Width	42.99	ft
Depth	13	ft
Volume	4.3	MG

Secondary Clarifier

Volume	0.6	MG
Depth	13	ft



Effluent Limts

Effluent Quality Targets

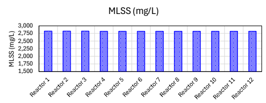
cBOD	30	mg/L
TSS	30	mg/L

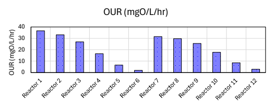
Influent

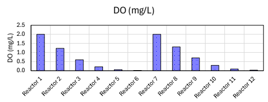
	Flow	COD	BOD	TSS	VSS	TKN	Ammonia	TP	OP	pH	Alkalinity	Temperature
	(MGD)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	
Model	5.75	500	245	343	271	55	26.4	6.5	3.25	7.3	300	20
Baseline	5.75		250	360		55						
	0%		-2%	-5%								

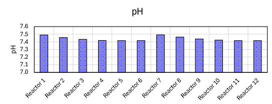
Oxidation Ditch Reactor Parameters

		MLSS	MLVSS	BOD	TKN	Ammonia	Nitrate	TP	OP	pH	Alkalinity	DO	OUR	Recirc.rate	Total air flow
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mgO/L/hr)		(ft3/min)
Aerobic	Reactor 1	2,823.49	1,935.10	780.65	164.964	0.781	1.645	53.745	2.906	7.489	200.366	2	36.545	62.78	165.06
Anoxic	Reactor 2	2,823.06	1,934.88	780.37	164.873	0.702	1.705	53.745	2.905	7.457	199.85	1.226	33.076		
Anoxic	Reactor 3	2,822.65	1,934.69	780.09	164.8	0.645	1.732	53.745	2.903	7.432	199.524	0.596	26.939		
Anoxic	Reactor 4	2,822.28	1,934.56	779.83	164.753	0.625	1.705	53.745	2.902	7.418	199.522	0.209	16.515		
Anoxic	Reactor 5	2,821.96	1,934.50	779.59	164.734	0.64	1.634	53.745	2.901	7.415	199.827	0.058	6.458		
Anoxic	Reactor 6	2,821.69	1,934.45	779.38	164.728	0.672	1.553	53.745	2.9	7.416	200.25	0.015	1.847		
Aerobic	Reactor 7	2,821.27	1,934.11	779.17	164.639	0.593	1.634	53.745	2.902	7.492	199.689	2	31.575		
Anoxic	Reactor 8	2,820.89	1,933.83	778.93	164.561	0.523	1.699	53.745	2.903	7.462	199.223	1.304	29.736		
Anoxic	Reactor 9	2,820.50	1,933.59	778.68	164.497	0.469	1.736	53.745	2.903	7.438	198.907	0.707	25.537		
Anoxic	Reactor 10	2,820.14	1,933.41	778.44	164.452	0.442	1.727	53.745	2.903	7.423	198.837	0.291	17.786		
Anoxic	Reactor 11	2,819.82	1,933.31	778.20	164.43	0.445	1.67	53.745	2.902	7.416	199.051	0.093	8.462		
Anoxic	Reactor 12	2,819.53	1,933.24	777.99	164.422	0.469	1.592	53.745	2.901	7.416	199.43	0.026	2.788		









Secondary Clarifier

		TSS Removal	BOD Removal	SOR	SLR	RAS:Influent	WAS:RAS
		(%)	(%)	(gal/ft2 d)	(lb/ft2 d)		
	Model	99.7%	99.6%	911.7	34.3	44%	5%
10state	CAS			1200	40		
10state	Extended Air			1000	35		

Final Effluent

	TSS	BOD	Ammonia
	(mg/L)	(mg/L)	(mg/L)
Model	9.0	3.2	0.45
Limit	30	30	

Model Output

Elements	Flow [mgd]	Temperature [	Alkalinity [mg(	pH []	Gas - Dissolve	BOD - Total C	BOD - Filtered	COD - Total [r	COD - Filtered	Total suspend	Volatile suspe	N - Total Kjeld
Influent	5.75	20	300	7.3	0	244.834	33.645	500	65.013	343.11	271.11	55
Reactor 1 - Brush	369.267	20	200.366	7.489	2	780.65	1.3	2,823.49	16.983	3,067.17	1,935.10	164.964
Reactor 2	369.267	20	199.85	7.457	1.226	780.37	1.274	2,823.06	16.945	3,066.97	1,934.88	164.873
Reactor 3	369.267	20	199.524	7.432	0.596	780.09	1.222	2,822.65	16.875	3,066.80	1,934.69	164.8
Reactor 4	369.267	20	199.522	7.418	0.209	779.83	1.123	2,822.28	16.74	3,066.68	1,934.56	164.753
Reactor 5	369.267	20	199.827	7.415	0.058	779.59	0.978	2,821.96	16.547	3,066.62	1,934.50	164.734
Reactor 6	369.267	20	200.25	7.416	0.015	779.38	0.836	2,821.69	16.359	3,066.58	1,934.45	164.728
Reactor 7 - Brush	369.267	20	199.689	7.492	2	779.17	0.983	2,821.27	16.515	3,066.25	1,934.11	164.639
Reactor 8	369.267	20	199.223	7.462	1.304	778.93	1.057	2,820.89	16.619	3,065.97	1,933.83	164.561
Reactor 9	369.267	20	198.907	7.438	0.707	778.68	1.074	2,820.50	16.648	3,065.74	1,933.59	164.497
Reactor 10	369.267	20	198.837	7.423	0.291	778.44	1.032	2,820.14	16.595	3,065.58	1,933.41	164.452
Reactor 11	369.267	20	199.051	7.416	0.093	778.20	0.929	2,819.82	16.461	3,065.48	1,933.31	164.43
Reactor 12	361	20	199.43	7.416	0.026	777.99	0.802	2,819.53	16.296	3,065.42	1,933.24	164.422
spside	361	20	199.051	7.416	0.093	778.20	0.929	2,819.82	16.461	3,065.48	1,933.31	164.43
spside (U)	8.267	20	199.051	7.416	0.093	778.20	0.929	2,819.82	16.461	3,065.48	1,933.31	164.43
Clarifier	5.625	20	199.051	7.416	0.093	3.213	0.929	24.701	16.461	9.01	5.683	2.64
Clarifier (U)	2.642	20	199.051	7.416	0.093	2,428.40	0.929	8,771.49	16.461	9,573.65	6,037.82	508.93
Effluent	5.625	20	199.051	7.416	0.093	3.213	0.929	24.701	16.461	9.01	5.683	2.64
WAS splitter	2.517	20	199.051	7.416	0.093	2,428.40	0.929	8,771.49	16.461	9,573.65	6,037.82	508.93
WAS splitter (U)	0.125	20	199.051	7.416	0.093	2,428.40	0.929	8,771.49	16.461	9,573.65	6,037.82	508.93
Waste Sludge	0.125	20	199.051	7.416	0.093	2,428.40	0.929	8,771.49	16.461	9,573.65	6,037.82	508.93

Elements	N - Ammonia [	N - Nitrate [mg	N - Nitrite [mg	P - Total P [m	P - Soluble PO	Liquid volume	Element HRT [h	OUR - Total [r	SOTE [%]	Solids loading	Surface overfl	Linear velocity	Air flow rate [f	Off gas flow rate (dry) [ft3/min (field)]
Influent	26.4	0	0	6.5	3.25	0	-----	-----	-----	-----	-----	-----	-----	-----
Reactor 1 - Brush	0.781	1.645	0.247	53.745	2.906	0.36	0.023	36.545	-----	-----	-----	-----	-----	80.67
Reactor 2	0.702	1.705	0.254	53.745	2.905	0.36	0.023	33.076	100	-----	-----	-----	0	0.652
Reactor 3	0.645	1.732	0.262	53.745	2.903	0.36	0.023	26.939	100	-----	-----	-----	0	0.691
Reactor 4	0.625	1.705	0.269	53.745	2.902	0.36	0.023	16.515	100	-----	-----	-----	0	0.721
Reactor 5	0.64	1.634	0.269	53.745	2.901	0.36	0.023	6.458	100	-----	-----	-----	0	0.741
Reactor 6	0.672	1.553	0.263	53.745	2.9	0.36	0.023	1.847	100	-----	-----	-----	0	0.753
Reactor 7 - Brush	0.593	1.634	0.259	53.745	2.902	0.36	0.023	31.575	-----	-----	-----	-----	-----	77.316
Reactor 8	0.523	1.699	0.252	53.745	2.903	0.36	0.023	29.736	100	-----	-----	-----	0	0.645
Reactor 9	0.469	1.736	0.247	53.745	2.903	0.36	0.023	25.537	100	-----	-----	-----	0	0.682
Reactor 10	0.442	1.727	0.247	53.745	2.903	0.36	0.023	17.786	100	-----	-----	-----	0	0.712
Reactor 11	0.445	1.67	0.246	53.745	2.902	0.36	0.023	8.462	100	-----	-----	-----	0	0.733
Reactor 12	0.469	1.592	0.241	53.745	2.901	0.36	0.02	2.788	100	-----	-----	-----	0	0.748
spside	0.445	1.67	0.246	53.745	2.902	0	-----	-----	-----	-----	-----	-----	-----	-----
spside (U)	0.445	1.67	0.246	53.745	2.902	0	-----	-----	-----	-----	-----	-----	-----	-----
Clarifier	0.445	1.67	0.246	3.051	2.902	0.6	1.742	-----	-----	34.277	911.69	-----	-----	-----
Clarifier (U)	0.445	1.67	0.246	161.688	2.902	0.6	-----	-----	-----	-----	-----	-----	-----	-----
Effluent	0.445	1.67	0.246	3.051	2.902	0	-----	-----	-----	-----	-----	-----	-----	-----
WAS splitter	0.445	1.67	0.246	161.688	2.902	0	-----	-----	-----	-----	-----	-----	-----	-----
WAS splitter (U)	0.445	1.67	0.246	161.688	2.902	0	-----	-----	-----	-----	-----	-----	-----	-----
Waste Sludge	0.445	1.67	0.246	161.688	2.902	0	-----	-----	-----	-----	-----	-----	-----	-----

Oxidation Ditch Dimensions		
Width	42.99	ft
Depth	13	ft
Volume	4.31	MG

Secondary Clarifier		
Volume	0.6	MG
Depth	13	ft

Oxidation Ditch Concrete Volume

Convert Volume to Cubic Feet

	4,312,500	gallons
	576,499	ft3

Estimate Total Length of Ditch

Area	558.81	ft2
Length	1,032	ft

Assuming the race-track shape consists of:
2 semicircular ends (combined = 1 full circle)
2 straight sections

Radius of the semicircles:
Width=2×Radius

Radius	21.5	ft
Circumference of full circle	135.0	ft

Length of straight sections :

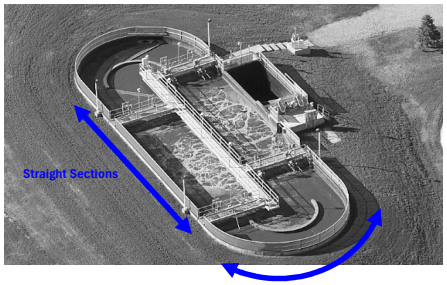
Straight length	896.61	ft
Each straight section	448.31	ft

Calculate Wall Surface Area

Straight walls	11,655.95	ft2
Curved walls (full circle perimeter × dep	1,755.6	ft2
Total wall surface area	13,411.50	ft2

Wall Concrete Volume

All Walls volume	15,647	ft3



Secondary Clarifier Concrete Volume

Convert Volume to Cubic Feet

	80,209	ft3

Estimate Diameter

r2	1,964	
r	44.32	ft
D	88.63	ft

Wall Surface Area

A-wall	3,620	ft2

Wall Volume

V-wall	4,223	ft3

Sloped Floor Geometry
model the sloped floor as a conical frustum (a cone with the top cut off), sloping from the outer edge down to the center.
Horizontal distance from center to wall: R=44.33 ft
Slope: 1:15 → for every 15 ft horizontal, 1 ft vertical
vertical drop from wall to center is 2.95 ft center of the clarifier is 2.95 ft deeper than the outer edge.

Volume of Sloped Floor (Conical Frustum)
sloped cone-shaped floor
V=1/3*πh(R1^2+R1R2+R2^2)
h=2.96 ft (vertical height of the slope)
R1=0 (center point)
R2=44.33 (outer radius)

	6,076	ft3

Total Concrete Volume

	10,299	ft3

Oxidation Ditch Base Slab Volume

Base slab area = total footprint of ditch

Straight section area

Area	19,271	ft2

Curved Section Area (Full Circle)

Area	1,451	ft2

Total Footprint Area

A-total	20,722	ft2

Base Slab Volume (with 2 ft thickness)

Base Volume	41,444	ft3

Total Concrete Volume

Total Concrete Volume	57,090	ft3

Secondary Clarifier Slab Volume

Clarifier Footprint Area

	6,170	ft2

Base Slab Volume (with 2 ft thickness)

Base Volume	12,340	ft3

Excavation Volume

Total tank depth: 13 ft
Above-ground portion: 3 ft
Below-ground portion: 10 ft
Excavation slope: 1 vertical : 2 horizontal
→ For every 10 ft depth, we extend 20 ft outward from the tank edge on all sides
So the excavation will form a trapezoidal cross-section around the tank, sloping outward from the base to the surface.

Total Footprint Area

A-bottom	20,722	ft2

Top footprint: tank footprint extended outward by 20 ft on all sides

Top Rectangle
Original rectangle: 448 ft × 42.99 ft
Add 20 ft on each side → new dimensions:

Length: 448 + 2×20	488.3	ft
Width: 42.99 + 2×20 = 82.99 ft	83.0	ft
A-top rectangle	40,522	ft2

Top Circle
Original radius: 21.495 ft
Add 20 ft → new radius 41.5 ft

A-top circle	5,409	ft2

Total Top Footprint

A-top	45,931	ft2

Excavation Volume (Trapezoidal Prism)
average area between top and bottom footprints, multiplied by depth
Vexcavation=((Atop+Abottom)/2)×depth

V-excavation	333,264	ft3

Excavation Volume

Clarifier depth: 13 ft
Above-ground portion: 3 ft
Below-ground portion: 10 ft
Excavation slope: 1 vertical : 2 horizontal
→ For every 10 ft depth, we extend 20 ft outward from the tank edge on all sides

Bottom radius = tank radius = 44.33 ft
Top radius = 44.33 + 20 = 64.33 ft
Excavation depth = 10 ft

Bottom Area (Clarifier Footprint)

A-bottom	6,170	ft2

Top Area (Excavation Footprint)

A-top	12,995	ft2

Average Area

A-Avg	9,583	ft2

Excavation Volume

V-excavation	95,826.88	ft3

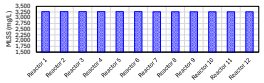
Influent

	Flow (MGD)	COD (mg/L)	BOD (mg/L)	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	Ammonia (mg/L)	TP (mg/L)	OP (mg/L)	pH	Alkalinity (mg/L)	Temperature
Model	5.75	500	240	340	271	55	26.4	6.5	3.25	7.3	300	20
Baseline	5.75		250	360		55						
	0%		-2%	-5%								

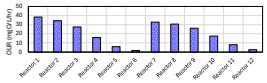
Oxidation Ditch Reactor Parameters

		MLSS (mg/L)	MLVSS (mg/L)	BOD (mg/L)	TKN (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	TP (mg/L)	OP (mg/L)	pH	Alkalinity (mg/L)	DO (mg/L)	OUR (mgO/L/hr)	Recirc rate	Total air flow
															(ft3/min)
Aeration	Reactor 1	3,265.22	2,238.85	832.54	188.649	0.72	0.799	61.446	3.123	7.493	203.19	2	38.269	62.78	172.69
Aeration	Reactor 2	3,264.77	2,238.61	832.24	188.554	0.637	0.858	61.446	3.123	7.459	202.644	1.196	34.39		
Aeration	Reactor 3	3,264.35	2,238.42	831.95	188.478	0.579	0.883	61.446	3.122	7.434	202.318	0.554	27.414		
Aeration	Reactor 4	3,263.96	2,238.25	831.68	188.433	0.562	0.851	61.446	3.121	7.421	202.351	0.183	15.873		
Aeration	Reactor 5	3,263.66	2,238.22	831.44	188.419	0.581	0.78	61.446	3.119	7.418	202.689	0.049	5.751		
Aeration	Reactor 6	3,263.38	2,238.13	831.22	188.411	0.616	0.703	61.446	3.118	7.42	203.129	0.012	1.557		
Aeration	Reactor 7	3,262.93	2,237.81	831.01	188.318	0.533	0.783	61.446	3.121	7.495	202.541	2	32.695		
Aeration	Reactor 8	3,262.53	2,237.50	830.76	188.238	0.461	0.846	61.446	3.123	7.493	202.06	1.283	30.645		
Aeration	Reactor 9	3,262.13	2,237.23	830.50	188.173	0.407	0.881	61.446	3.123	7.445	201.748	0.676	25.959		
Aeration	Reactor 10	3,261.78	2,237.07	830.24	188.13	0.381	0.868	61.446	3.123	7.425	201.705	0.297	17.495		
Aeration	Reactor 11	3,261.44	2,236.96	830.00	188.109	0.388	0.81	61.446	3.122	7.42	201.949	0.082	7.953		
Aeration	Reactor 12	3,261.16	2,236.89	829.78	188.102	0.415	0.754	61.446	3.122	7.42	202.346	0.022	2.469		

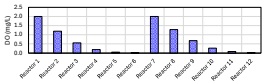
MLSS (mg/L)



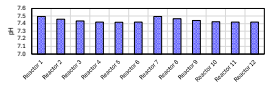
OUR (mgO/L/hr)



DO (mg/L)



pH



Secondary Clarifier

		TSS Removal (%)	BOD Removal (%)	SOR (gal/ft2 d)	SLR (lb/ft2 d)	RAS:Influent	WAS:RAS
	Model	99.7%	99.6%	609.0	40.9	44%	5%
Aeration	CAS			1200	40		
Aeration	Extended Air			1000	35		

Final Effluent

	TSS (mg/L)	BOD (mg/L)	Ammonia (mg/L)
Model	10.5	3.3	0.39
Limit	30	30	

Mass Output

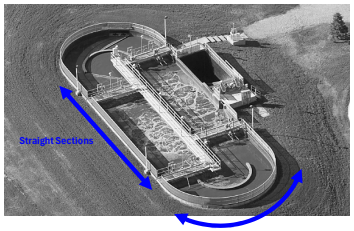
Elements	Flow [mgd]	Temperature [	Alkalinity [mg/[pH []	Gas - Dissolv	BOD - Total C	BOD - Filtered	COD - Total [	COD - Filtered	Total suspend	Volatile suspe	N - Total Kjeld	N - Ammonia [N - Nitrate [mg/L	N - Nitrite [mg/[	P - Total P [mg/	P - Soluble P	Liquid volume	Element HRT [hr	OUR - Total [mSOTE [%]	Solids loading	Surface overfl	Linear velocity	Air flow rate [f	Off gas flow rate (dry) [ft3/min (field)]
Influent	5.75	20	300	7.3	0	244.834	33.645	500	65.013	343.11	271.11	55	26.4	0	0	6.5	3.25	0 -----	-----	-----	-----	-----	-----	-----
Reactor 1 - Brush	369.371	20	203.19	7.493	2	832.54	1.258	3,265.22	16.983	3,608.77	2,238.85	188.649	0.72	0.799	0.198	61.446	3.123	0.36	0.023	38.269 -----	-----	-----	-----	-----	84.287
Reactor 2	369.371	20	202.644	7.459	1.196	832.24	1.235	3,264.77	16.952	3,608.55	2,238.61	188.554	0.637	0.858	0.21	61.446	3.123	0.36	0.023	34.39	100 -----	-----	-----	-----	0	0.672
Reactor 3	369.371	20	202.318	7.434	0.554	831.95	1.183	3,264.35	16.884	3,608.37	2,238.42	188.478	0.579	0.883	0.219	61.446	3.122	0.36	0.023	27.414	100 -----	-----	-----	-----	0	0.714
Reactor 4	369.371	20	202.351	7.421	0.183	831.68	1.074	3,263.96	16.745	3,608.25	2,238.29	188.433	0.562	0.851	0.224	61.446	3.121	0.36	0.023	15.873	100 -----	-----	-----	-----	0	0.745
Reactor 5	369.371	20	202.689	7.418	0.049	831.44	0.921	3,263.66	16.55	3,608.19	2,238.22	188.419	0.581	0.78	0.218	61.446	3.119	0.36	0.023	5.751	100 -----	-----	-----	-----	0	0.765
Reactor 6	369.371	20	203.129	7.42	0.012	831.23	0.777	3,263.39	16.389	3,608.14	2,238.17	188.411	0.616	0.703	0.207	61.446	3.118	0.36	0.023	1.557	100 -----	-----	-----	-----	0	0.78
Reactor 7 - Brush	369.371	20	202.541	7.495	2	831.01	0.644	3,262.93	16.52	3,607.78	2,237.81	188.318	0.533	0.783	0.207	61.446	3.121	0.36	0.023	32.693 -----	-----	-----	-----	-----	80.486
Reactor 8	369.371	20	202.06	7.465	1.283	830.76	1.025	3,262.53	16.638	3,607.49	2,237.50	188.238	0.461	0.846	0.204	61.446	3.123	0.36	0.023	30.641	100 -----	-----	-----	-----	0	0.665
Reactor 9	369.371	20	201.748	7.441	0.676	830.50	1.044	3,262.13	16.672	3,607.25	2,237.25	188.173	0.407	0.881	0.2	61.446	3.123	0.36	0.023	25.959	100 -----	-----	-----	-----	0	0.703
Reactor 10	369.371	20	201.705	7.425	0.267	830.24	0.996	3,261.76	16.617	3,607.07	2,237.07	188.13	0.381	0.868	0.198	61.446	3.123	0.36	0.023	17.495	100 -----	-----	-----	-----	0	0.735
Reactor 11	369.371	20	201.949	7.42	0.082	830.00	0.883	3,261.44	16.48	3,606.96	2,236.96	188.109	0.388	0.81	0.193	61.446	3.122	0.36	0.023	7.952	100 -----	-----	-----	-----	0	0.755
Reactor 12	361	20	202.346	7.42	0.022	829.78	0.752	3,261.16	16.318	3,606.91	2,236.89	188.102	0.415	0.734	0.183	61.446	3.122	0.36	0.02	2.462	100 -----	-----	-----	-----	0	0.775
spside	361	20	201.949	7.42	0.082	830.00	0.883	3,261.44	16.48	3,606.96	2,236.96	188.109	0.388	0.81	0.193	61.446	3.122	0 -----	-----	-----	-----	-----	-----	-----	-----	-----
spside (U)	8.371	20	201.949	7.42	0.082	830.00	0.883	3,261.44	16.48	3,606.96	2,236.96	188.109	0.388	0.81	0.193	61.446	3.122	0 -----	-----	-----	-----	-----	-----	-----	-----	-----
Clarifier	5.729	20	201.949	7.42	0.082	3.306	0.883	25.962	16.48	10.54	6.537	2.624	0.388	0.81	0.193	3.293	3.122	0.6	1.72 -----	-----	40.84	928.57 -----	-----	-----	-----
Clarifier (U)	2.642	20	201.949	7.42	0.082	2,622.89	0.883	10,278.35	16.48	11,406.72	7,074.18	590.38	0.388	0.81	0.193	187.567	3.122	0.6 -----	-----	-----	-----	-----	-----	-----	-----	-----
Effluent	5.729	20	201.949	7.42	0.082	3.306	0.883	25.962	16.48	10.54	6.537	2.624	0.388	0.81	0.193	3.293	3.122	0 -----	-----	-----	-----	-----	-----	-----	-----	-----
WAS splitter	2.517	20	201.949	7.42	0.082	2,622.89	0.883	10,278.35	16.48	11,406.72	7,074.18	590.38	0.388	0.81	0.193	187.567	3.122	0 -----	-----	-----	-----	-----	-----	-----	-----	-----
WAS splitter (U)	0.125	20	201.949	7.42	0.082	2,622.89	0.883	10,278.35	16.48	11,406.72	7,074.18	590.38	0.388	0.81	0.193	187.567	3.122	0 -----	-----	-----	-----	-----	-----	-----	-----	-----
Thickener	0.104	20	201.949	7.42	0.082	830.17	0.883	2,479.33	16.48	2,737.61	1,697.80	143.27	0.388	0.81	0.193	47.399	3.122	0.052	11.978 -----	-----	-----	17.121	149.88 -----	-----	-----
Thickener (U)	0.021	20	201.949	7.42	0.082	12,586.52	0.883	49,273.44	16.48	54,752.24	33,956.07	2,825.91	0.388	0.81	0.193	888.45	3.122	0.052 -----	-----	-----	-----	-----	-----	-----	-----	-----
Anaerobic Digestion	0.021	35	3,759.19	7.162	0	2,906.14	91.059	35,381.06	226.026	43,904.69	24,164.37	2,825.90	960.26	0	0	888.45	302.47	0.42	483.84 -----	-----	-----	-----	-----	-----	-----	-----	14.319
Digested Sludge	0.021	20	3,755.96	7.254	0	2,906.14	91.059	35,381.06	226.026	43,904.69	24,164.37	2,825.90	960.26	0	0	888.45	302.47	0 -----	-----	-----	-----	-----	-----	-----	-----	-----

Oxidation Ditch Dimensions		
Width	42.99	ft
Depth	13	ft
Volume	4.31	MG

Secondary Clarifier		
Volume	0.6	MG
Depth	13	ft

Thickener		
Volume	0.6	MG
Depth	13	ft

Anaerbic Digestion		
Area	2,245	ft2
Depth	25	ft
Volume	0.42	MG



Oxidation Ditch Concrete Volume

Convert Volume to Cubic Feet

4,312,500 gallons
576,499 ft3

Estimate Total Length of Ditch

Area 558.81 ft2
Length 1,032 ft

Assuming the race-track shape consists of:
2 semicircular ends (combined = 1 full circle)
2 straight sections

Radius of the semicircles:
Width=2×Radius

Radius 21.5 ft
Circumference of full circle 135.0 ft

Length of straight sections :

Straight length 896.61 ft
Each straight section 448.31 ft

Calculate Wall Surface Area

Straight walls 11,655.95 ft2
Curved walls (full circle perimeter × dep 1,755.6 ft2
Total wall surface area 13,411.50 ft2

Wall Concrete Volume

All Walls volume 15,647 ft3

Secondary Clarifier Concrete Volume

Convert Volume to Cubic Feet

80,209 ft3

Estimate Diameter

r2 1,964
r 44.32 ft
D 88.63 ft

Wall Surface Area

A-wall 3,620 ft2

Wall Volume

V-wall 4,223 ft3

Sloped Floor Geometry
model the sloped floor as a conical frustum (a cone with the top cut off), sloping from the outer edge down to the center.
Horizontal distance from center to wall: R=44.33 ft
Slope: 1:15 → for every 15 ft horizontal, 1 ft vertical
vertical drop from wall to center is 2.95 ft center of the clarifier is 2.95 ft deeper than the outer edge.

Volume of Sloped Floor (Conical Frustum)
sloped cone-shaped floor
V=1/3*π(R1^2+R1R2+R2^2)
h=2.96 ft (vertical height of the slope)
R1=0 (center point)
R2=44.33 (outer radius)

6,076 ft3

Total Concrete Volume

10,299 ft3

Thickener

Convert Volume to Cubic Feet

80,209 ft3

Estimate Diameter

r2 1,964
r 44.32 ft
D 88.63 ft

Wall Surface Area

A-wall 3,620 ft2

Wall Volume

V-wall 4,223 ft3

Sloped Floor Geometry
model the sloped floor as a conical frustum (a cone with the top cut off), sloping from the outer edge down to the center.
Horizontal distance from center to wall: R=44.33 ft
Slope: 1:15 → for every 15 ft horizontal, 1 ft vertical
vertical drop from wall to center is 2.95 ft center of the clarifier is 2.95 ft deeper than the outer edge.

Volume of Sloped Floor (Conical Frustum)
sloped cone-shaped floor
V=1/3*π(R1^2+R1R2+R2^2)
h=2.96 ft (vertical height of the slope)
R1=0 (center point)
R2=44.33 (outer radius)

6,076 ft3

Total Concrete Volume

10,299 ft3

Anaerobic Digester

Convert Volume to Cubic Feet

56,146 ft3

Estimate Diameter

r2 715
r 26.74 ft
D 53.47 ft

Wall Surface Area

A-wall 4,200 ft2

Wall Volume

V-wall 4,900 ft3

Roof Slab Volume
Assuming a flat circular roof with 1 ft thickness

A-roof 2,246 ft2
V-roof 2,246 ft3

Total Concrete Volume

7,146 ft3

Oxidation Ditch Base Slab Volume

Base slab area = total footprint of ditch

Straight section area

Area 19,271 ft2

Curved Section Area (Full Circle)

Area 1,451 ft2

Total Footprint Area

A-total 20,722 ft2

Base Slab Volume (with 2 ft thickness)

Base Volume 41,444 ft3

Total Concrete Volume

Total Concrete Volume 57,090 ft3

Secondary Clarifier Slab Volume

Clarifier Footprint Area

6,170 ft2

Base Slab Volume (with 2 ft thickness)

Base Volume 12,340 ft3

Secondary Clarifier Slab Volume

Clarifier Footprint Area

6,170 ft2

Base Slab Volume (with 2 ft thickness)

Base Volume 12,340 ft3

AD Slab Volume

AD Footprint Area

2,246 ft2

Base Slab Volume (with 2 ft thickness)

Base Volume 4,492 ft3

Excavation Volume

Total tank depth: 13 ft
Above-ground portion: 3 ft
Below-ground portion: 10 ft
Excavation slope: 1 vertical : 2 horizontal
→ For every 10 ft depth, we extend 20 ft outward from the tank edge on all sides
So the excavation will form a trapezoidal cross-section around the tank, sloping outward from the base to the surface.

Total Footprint Area

A-bottom 20,722 ft2

Top footprint: tank footprint extended outward by 20 ft on all sides

Top Rectangle
Original rectangle: 448 ft × 42.99 ft
Add 20 ft on each side → new dimensions:
Length: 448 + 2×20 488.3 ft
Width: 42.99 + 2×20 = 82.99 ft 83.0 ft

A-top rectangle 40,522 ft2

Top Circle
Original radius: 21.495 ft
Add 20 ft → new radius 41.5 ft

A-top circle 5,409 ft2

Total Top Footprint

A-top 45,931 ft2

Excavation Volume (Trapezoidal Prism)
average area between top and bottom footprints, multiplied by depth
Vexcavation=((Atop+Abottom)/2)×depth

V-excavation 333,264 ft3

Excavation Volume

Clarifier depth: 13 ft
Above-ground portion: 3 ft
Below-ground portion: 10 ft
Excavation slope: 1 vertical : 2 horizontal
→ For every 10 ft depth, we extend 20 ft outward from the tank edge on all sides

Bottom radius = tank radius = 44.33 ft
Top radius = 44.33 + 20 = 64.33 ft
Excavation depth = 10 ft

Bottom Area (Clarifier Footprint)

A-bottom 6,170 ft2

Top Area (Excavation Footprint)

A-top 12,995 ft2

Average Area

A-Avg 9,583 ft2

Excavation Volume

V-excavation 95,826.88 ft3

Excavation Volume

Clarifier depth: 13 ft
Above-ground portion: 3 ft
Below-ground portion: 10 ft
Excavation slope: 1 vertical : 2 horizontal
→ For every 10 ft depth, we extend 20 ft outward from the tank edge on all sides

Bottom radius = tank radius = 44.33 ft
Top radius = 44.33 + 20 = 64.33 ft
Excavation depth = 10 ft

Bottom Area (Clarifier Footprint)

A-bottom 6,170 ft2

Top Area (Excavation Footprint)

A-top 12,995 ft2

Average Area

A-Avg 9,583 ft2

Excavation Volume

V-excavation 95,826.88 ft3

Excavation Volume

for a 25 ft deep, 0.42 MG digester, it's much more typical to build it above ground on a reinforced concrete slab.

Table 1. Permittee Information

Permittee	City of Arcata
Name of Facility	Wastewater Treatment Facility
Facility Address	600 South G Street Arcata, CA 95521 Humboldt County
Type of Facility	Publicly Owned Treatment Works (POTW)
Facility Design Flow	2.3 million gallons per day (mgd) (average dry weather design flow) 5.8 mgd (average wet weather design flow) 5.9 mgd (peak wet weather design flow) 16.5 mgd (wet weather Q_{max})

Table 2. Discharge Locations

Discharge Point	Effluent Description	Discharge Point Latitude (North)	Discharge Point Longitude (West)	Receiving Water
001	Equivalent to secondary treated wastewater	40° 51' 18"	124° 5' 26"	Humboldt Bay
002	Secondary treated wastewater	40° 51' 29"	124° 5' 31"	Arcata Marsh Wildlife Sanctuary
003	Secondary treated wastewater	40° 51' 40"	124° 5' 37"	Brackish Marsh, Humboldt Bay

Table 5. Effluent Limitations – Discharge Point 001 (After Completion of Phase One of the Upgrade Project)

Parameter	Units	Effluent Limitations[1]				
		Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
Biochemical Oxygen Demand 5-day @ 20°C (BOD_5)	mg/L	38	57	--	--	--
Total Suspended Solids (TSS)	mg/L	32	48	--	--	--
pH	standard units	--	--	--	6.0	8.5
Cyanide, Total (as CN)	µg/L	0.43	--	1.0	--	--
TCDD-Equivalents	µg/L	1.4×10^{-8}	--	3.3×10^{-8}	--	--
[redacted]					--	--
Settleable Solids	ml/L	0.1	--	0.2	--	--

Table Notes:
1. See Definitions in Attachment A and Compliance Determination discussion in section VII of this Order.
2. The Ammonia Impact Ratio (AIR) is calculated as the ratio of the ammonia concentration in the effluent and the applicable ammonia standard (AMEL and MDEL). Attachment H is a PDF example of the calculator that will be sent to the Permittee to determine compliance with the AMEL/MDEL AIR. For each of the applicable ammonia standards, Attachment G includes two tables that provide the variable AMEL and MDEL ammonia standards used in calculating the AIR. The AIR is the ammonia effluent limit and must be reported in the self-monitoring reports in addition to ammonia, pH, salinity and temperature values. Monitoring for ammonia, pH, salinity and temperature must be conducted concurrently in order for the AIR to be calculated properly. Compliance determination will be based on the receiving water data and ammonia effluent data taken on the same day.
3. See sections VII.L and VII.M of this Order regarding compliance with each AIR effluent limitation.

Table 6. Effluent Limitations – Discharge Point 003 (After Completion of Phase One of the Upgrade Project)

Parameter	Units	Effluent Limitations[1]				
		Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
Biochemical Oxygen Demand 5-day @ 20°C (BOD_5)	mg/L	30	45	--	--	--
Total Suspended Solids (TSS)	mg/L	30	45	--	--	--
pH	standard units	--	--	--	6.0	8.5
Copper, Total Recoverable	µg/L	3.3	--	5.3	--	--
Cyanide, Total (as CN)	µg/L	0.43	--	1.0	--	--
TCDD-Equivalents	µg/L	1.4×10^{-8}	--	3.3×10^{-8}	--	--
[redacted]					--	--
Settleable Solids	ml/L	0.1	--	0.2	--	--

Table Notes:
1. See Definitions in Attachment A and Compliance Determination discussion in section VII of this Order.
2. The Ammonia Impact Ratio (AIR) is calculated as the ratio of the ammonia concentration in the effluent and the applicable ammonia standard (AMEL and MDEL). Attachment H is a PDF example of the calculator that will be sent to the Permittee to determine compliance with the AMEL/MDEL AIR. For each of the applicable ammonia standards, Attachment G includes two tables that provide the variable AMEL and MDEL ammonia standards used in calculating the AIR. The AIR is the ammonia effluent limit and must be reported in the self-monitoring reports in addition to ammonia, pH, salinity and temperature values. Monitoring for ammonia, pH, salinity and temperature must be conducted concurrently in order for the AIR to be calculated properly. Compliance determination will be based on the receiving water data and ammonia effluent data taken on the same day.
3. See sections VII.L and VII.M of this Order regarding compliance with each AIR effluent limitation.

Table 7. Effluent Limitations – Discharge Point 002 (After Completion of Phase Two of the Upgrade Project)

Parameter	Units	Effluent Limitations[1]				
		Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
[redacted]				--	--	--
				--	--	--
pH	standard units	--	--	--	6.0	8.5

Table Notes:
1. See Definitions in Attachment A and Compliance Determination discussion in section VII of this Order.

C. Average Monthly Effluent Limitation (AMEL)

If the average (or when applicable, the median determined by subsection B, above, for multiple sample data) of daily discharges over a calendar month exceeds the AMEL for a given parameter, this will represent a single violation, though the Permittee will be considered out of compliance

for each day of that month for that parameter (e.g., resulting in 31 days of noncompliance in a 31-day month). If only a single sample is taken during the calendar month and the analytical result for that sample exceeds the AMEL, the Permittee will be considered out of compliance for that calendar month. The Permittee will only be considered out of compliance for days when the discharge occurs. If there are ND or DNQ results for a specific constituent in a calendar month, the Permittee shall calculate the median of all sample results within that month for compliance determination with the AMEL as described in section VII.B, above.

D. Average Weekly Effluent Limitation (AWEL)

If the average (or when applicable, the median determined by subsection B, above, for multiple sample data) of daily discharges over a calendar week exceeds the AWEL for a given parameter, this will represent a single violation, though the Permittee will be considered out of compliance for each day of that week for that parameter, resulting in 7 days of non-compliance. If only a single sample is taken during the calendar week and the analytical result for that sample exceeds the AWEL, the Permittee will be considered out of compliance for that calendar week. The Permittee will only be considered out of compliance for days when the discharge occurs. If there are ND or DNQ results for a specific constituent in a calendar week, the Permittee shall calculate the median of all sample results within that week for compliance determination with the AWEL as described in section VII.B, above.

E. Maximum Daily Effluent Limitation (MDEL)

If a daily discharge (or when applicable, the median determined by subsection B, above, for multiple sample data of a daily discharge) exceeds the MDEL for a given parameter, the Permittee will be considered out of compliance for that parameter for that 1 day only within the reporting period.

F. Instantaneous Minimum Effluent Limitation

If the analytical result of a single grab sample is lower than the instantaneous minimum effluent limitation for a parameter, the Permittee will be considered out of compliance for that parameter for that single sample. Noncompliance for each sample will be considered separately (e.g., the results of two grab samples taken within a calendar day that both are lower than the instantaneous minimum effluent limitation would result in two instances of noncompliance with the instantaneous minimum effluent limitation).

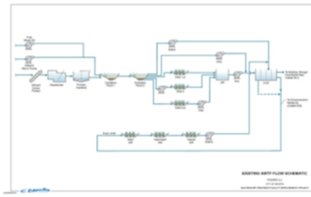
If the Permittee monitors pH continuously, pursuant to 40 C.F.R. section 401.17, the Permittee shall be in compliance with the pH limitation specified herein provided that both of the following conditions are satisfied: (1) the total sum of time during which the pH values are outside the required range of pH values shall not exceed 7 hours and 26 minutes in any calendar month; and (2) no individual excursion from the range of pH values shall exceed 60 minutes.

G. Instantaneous Maximum Effluent Limitation

If the analytical result of a single grab sample is higher than the instantaneous maximum effluent limitation for a parameter, the Permittee will be considered out of compliance for that parameter for that single sample. Noncompliance for each sample will be considered separately (e.g., the results of two grab samples taken within a calendar day that both exceed the instantaneous maximum effluent limitation would result in two instances of noncompliance with the instantaneous maximum effluent limitation).

[redacted]

Effluent Concentration Allowance (ECA)
A value derived from the water quality criterion/objective, dilution credit, and ambient background concentration that is used, in conjunction with the coefficient of variation for the effluent monitoring data, to calculate a long-term average (LTA) discharge concentration. The ECA has the same meaning as wasteload allocation (WLA) as used in U.S. EPA guidance (Technical Support Document For Water Quality-based Toxics Control, March 1991, second printing, EPA/505/2-90-001).



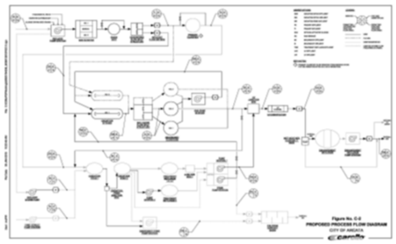


Table E-3. Effluent Monitoring – Monitoring L[redacted]

Parameter	Units	Sample Type	Minimum Sampling Frequency	Required Analytical Test Method
Flow[1]	Mgd	Meter	Continuous	--
Biochemical Oxygen Demand 5-day @ 20°C (BOD_5)	mg/L	24-hr Composite	Weekly[2]	Part 136[3]
Fecal Coliform Bacteria	MPN/100 mL	Grab	Weekly[2,4]	Part 136[3]
Enterococci Bacteria[12]	CFU/100 mL	Grab	Weekly[2,4]	Part 136[3]
pH	standard units	Grab	Daily[5,6]	Part 136[3]
Total Suspended Solids (TSS)	mg/L	24-hr Composite	Weekly[2]	Part 136[3]
Cyanide, Total (as CN)	µg/L	Grab	Monthly[7,8]	Part 136[3]
TCDD Equivalents[9]	µg/L	Grab	Quarterly[7,8]	Part 136[3]
[redacted]				Part 136[3]
Chlorine, Total Residual[10]	mg/L	Meter	Continuous	Part 136[3]
Nitrate Nitrogen, Total (as N)	mg/L	Grab	Quarterly[8]	Part 136[3]
Phosphorus, Total (as P)	mg/L	Grab	Quarterly[8]	Part 136[3]
Settleable Solids	ml/L	Grab	Daily[6]	Part 136[3]
Temperature	°C	Grab	Daily	
Acute Toxicity[11]	% Survival, Pas or Fail, and % Effect	Grab	Annually[8]	See Section V Below
Chronic Toxicity[11]	Pass or Fail, and % Effect	Grab	Quarterly[8]	See Section V Below

Table E-5. Effluent Monitoring – Monitoring Location EFF-003

Parameter	Units	Sample Type	Minimum Sampling Frequency	Required Analytical Test Method
Flow[1]	Mgd	Meter	Continuous	--
pH	standard units	Grab	Daily[3,4]	Part 136[2]
Biochemical Oxygen Demand 5-day @ 20°C (BOD_5)[12]	mg/L	24-hr Composite	Weekly[3]	Part 136[2]
Total Suspended Solids (TSS)[12]	mg/L	24-hr Composite	Weekly[3]	Part 136[2]
Fecal Coliform Bacteria	MPN/100 mL	Grab	Weekly[3,13]	Part 136[2]
Copper, Total Recoverable	µg/L	Grab	Monthly[5,6]	Part 136[2]
Cyanide, Total (as CN)	µg/L	Grab	Monthly[5]	Part 136[2]
TCDD Equivalents[7]	µg/L	Grab	Quarterly	Part 136[2]
Ammonia Nitrogen, Total (as N)	mg/L	Grab	Monthly[4,5]	Part 136[2]
Hardness, Total (as $CaCO_3$)	mg/L	Grab	Monthly[6]	Part 136[2]
Nitrate Nitrogen, Total (as N)	mg/L	Grab	Quarterly	Part 136[2]
Phosphorus, Total (as P)	mg/L	Grab	Quarterly	Part 136[2]
Settleable Solids	ml/L	Grab	Daily[2]	Part 136[2]

[1] The Permittee will start monitoring for constituents listed in Table E-5 once discharge from Discharge Point 003 commences.

Parameter	Units	Sample Type	Minimum Sampling Frequency	Required Analytical Test Method
CTR Priority Pollutants[8]	µg/L	24-hr Composite[9]	Twice per permit term[10]	Part 136[2]
Acute Toxicity[11]	% Survival, Pass or Fail, and % Effect	Grab	Annually	See Section V Below
Chronic Toxicity[11]	Pass or Fail, and % Effect	Grab	Quarterly	See Section V Below

Steps for caculation

Step 1: To calculate the effluent limits, an effluent concentration allowance (ECA) is calculated for each pollutant found to have reasonable potential using the following equation, which takes into account dilution and background concentrations:

$ECA = C + D (C - B)$,

Where:

C = the applicable water quality criterion (adjusted for effluent hardness and expressed as the total recoverable metal, if necessary)

D = dilution credit (here D= 0, as the discharge does not qualify for a dilution credit)

B = background concentration

Here, no credit for dilution is allowed, which results in the ECA being equal to the applicable criterion (ECA = C).

Step 2: For each ECA based on an aquatic life criterion/objective (copper, cyanide, and ammonia), the long-term average discharge condition (LTA) is determined by multiplying the ECA by a factor (multiplier), which adjusts the ECA to account for effluent variability. The multiplier depends on the coefficient of variation (CV) of the data set and whether it is an acute or chronic criterion/objective. Table 1 of the SIP provides pre-calculated values for the multipliers based on the values of the CV. When the data set contains less than 10 sample results, or when 80 percent or more of the data set is reported as ND, the CV is set equal to 0.6. Derivation of the multipliers is presented in section 1.4 of the SIP.

The SIP procedure assumes a 4-day averaging period for calculating the LTA. However, U.S. EPA recommends modifying the procedure for calculating permit limits for ammonia using a 30-day averaging period for the calculation of the LTA corresponding to the 30-day CCC. Therefore, while the LTAs corresponding to the acute and 4-day chronic criteria were calculated according to SIP procedures, the LTA for ammonia corresponding to the 30-day CCC was calculated assuming a 30-day averaging period.

From Table 1 in the SIP, the ECA multipliers for calculating LTAs at the 99th percentile occurrence probability for copper are 0.461 (acute multiplier) and 0.662 (chronic multiplier). The ECA multipliers for cyanide are 0.247 (acute multiplier) and 0.436 (chronic multiplier). The ECA multipliers for ammonia are 0.210 (acute multiplier), 0.382 (chronic 4-day multiplier), and 0.675 (chronic 30-day multiplier). The LTAs are determined as follows in Table F-7.

Table F-7. Determination of Long Term Averages

Pollutant	Units	ECA		ECA Multiplier		LTA	
		Acute	Chronic	Acute	Chronic	Acute	Chronic
Copper, Total Recoverable	µg/L	5.8	3.7	0.461	0.662	2.67	2.45
Cyanide, Total (as CN)	µg/L	1.0	1.0	0.247	0.436	0.247	0.436
Ammonia (as N)[1]	mg/L	1.9	0.29	0.210	0.382	0.399	0.111

Table Notes:
1. Ammonia LTAs were calculated based on applicable saltwater aquatic life criteria.

Step 3: WQBELs, including an AMEL and MDEL, are calculated using the most limiting (lowest) LTA. The LTA is multiplied by a factor that accounts for averaging periods and exceedance frequencies of the effluent limitations, and for the AMEL, the effluent monitoring frequency. The CV is set equal to 0.37 for copper, 0.81 for cyanide, and 0.97 for ammonia. The sampling frequency is set equal to 4 (n = 4) for both the acute and chronic criteria. The 99th percentile occurrence probability was used to determine the MDEL multiplier and a 95th percentile occurrence probability was used to determine the AMEL multiplier. From Table 2 of the SIP, the MDEL multiplier for copper is 2.17 and the AMEL multiplier is 1.33. From Table 2 of the SIP, the MDEL multiplier for cyanide is 4.05 and the AMEL multiplier is 1.76. From Table 2 of the SIP, the MDEL multiplier for ammonia is 4.76 and the AMEL multiplier is 1.91. Final WQBELs for copper and cyanide are determined as follows.

Final WQBELs for ammonia are determined by calculating the AIR for each of the ammonia standards (AMEL and MDEL). Attachment H of this Order includes two tables that display the AMEL and MDEL ammonia standards. The ammonia standards are calculated by taking the variable ammonia criteria and multiplying it by the ECA multiplier and the appropriate AMEL and MDEL multiplier. The 2013 ammonia criteria are dependent on the pH and temperature of the receiving water. For example:

$\textbf{AMEL Ammonia Standard} = (1989\ \textit{Chronic Ammonia Criteria}\ (ECA) * \textit{AMEL Multiplier}\ (1.91) * \textit{ECA Multiplier}\ (0.38))$

$\textbf{MDEL Ammonia Standard} = (1989\ \textit{Chronic Ammonia Criteria}\ (ECA) * \textit{MDEL Multiplier}\ (4.76) * \textit{ECA Multiplier}\ (0.38))$

The AIR, or final WQBEL, is determined by dividing the ammonia sample by the appropriate ammonia standard (AMEL and MDEL). If the AIR is greater than 1.0 then the Permittee is not in compliance with the AIR effluent limitation.

Step 4: When the most stringent water quality criterion/objective is a human health criterion/objective (as for TCDD-equivalents), the AMEL is set equal to the ECA. From Table 2 of the SIP, when CV = 0.85 and n = 4, the MDEL multiplier at the 99th percentile occurrence probability equals 4.25, and the AMEL multiplier at the 95th percentile occurrence probability equals 1.80 (for TCDD-equivalents). The MDEL for protection of human health is calculated by multiplying the ECA by the ratio of the MDEL multiplier to the AMEL multiplier. Final WQBELs for TCDD-equivalents are determined as follows.

Table F-9. Determination of Final WQBELs Based on Human Health Criteria

Pollutant	ECA (µg/L)	MDEL/AMEL	MDEL (µg/L)	AMEL (µg/L)
TCDD-Equivalents	1.4×10^{-8}	2.4	3.3×10^{-8}	1.4×10^{-8}

Input		
Ammonia Sample (mg/L)	15	This is the measured total ammonia concentration in the effluent — in this case, 15 mg/L.

Source: Ambient Water Quality Criteria for Ammonia (Saltwater) - 1989, EPA 440/5-88-004 April 1989

Constants		
ECA Acute	0.21	ECA Acute / Chronic: These are the EPA Criteria Ammonia limits for acute and chronic toxicity.
ECA Chronic	0.38	
AMEL Multiplier	1.9	AMEL / MDEL Multipliers: Used to calculate Average Monthly Effluent Limit (AMEL) and Maximum Daily Effluent Limit (MDEL).
MDEL Multiplier	4.8	
CV	0.97	(Coefficient of Variation): Used in statistical calculations for effluent variability.

Input									Calculations									
Date	Temp (deg C)	pH (su)	Salinity (ppt)	Pressure (ATM)	Molal Ionic Strength (I) (not valid if >0.85):	pKa8 (X) @ 25 deg C	% Unionized (% UIA):	Unionized		Total NH3 (Criteria)		Long Term Average		Ammonia Standards		Ammonia Impact Ratio		Ammonia Impact Ratio
								Acute	Chronic	Acute	Chronic	Acute	Chronic	AMEL (mg/L)	MDEL (mg/L)	AMEL	MDEL	AMEL	MDEL
1/25/2023	9.50	7.50	23.47	1.00	0.48	9.30	0.005	0.23	0.04	47.04	7.07	9.87	2.70	5.17	12.86	2.4	1.0	2.9	1.2
2/22/2023	8.60	7.90	26.69	1.00	0.55	9.31	0.01	0.23	0.04	20.52	3.08	4.31	1.18	2.25	5.61	7.5	3.0	6.7	2.7
3/22/2023	12.40	8.00	22.03	1.00	0.45	9.30	0.02	0.23	0.04	12.06	1.81	2.53	0.69	1.32	3.30	9.7	3.9	11.3	4.5
4/19/2023	14.00	8.00	25.14	1.00	0.51	9.30	0.02	0.23	0.04	10.91	1.64	2.29	0.63	1.20	2.98	6.9	2.8	12.5	5.0
5/3/2023	16.60	7.90	29.96	1.00	0.62	9.32	0.02	0.23	0.04	11.61	1.74	2.44	0.67	1.28	3.17	13.6	5.4	11.8	4.7
6/15/2023	20.20	8.40	34.50	1.00	0.71	9.33	0.08	0.23	0.04	3.06	0.46	0.64	0.18	0.34	0.84	17.0	6.8	44.7	18.0
7/19/2023	22.20	8.40	36.52	1.00	0.76	9.33	0.09	0.23	0.04	2.69	0.40	0.56	0.15	0.30	0.74	5.6	2.3	50.7	20.4
8/3/2023	22.90	7.90	35.25	1.00	0.73	9.33	0.03	0.23	0.04	7.56	1.14	1.59	0.43	0.83	2.07	2.5	1.0	18.1	7.3
9/19/2023	19.40	8.00	30.08	1.00	0.62	9.32	0.03	0.23	0.04	7.57	1.14	1.59	0.43	0.83	2.07	2.8	1.1	18.0	7.2
10/18/2023	17.90	8.10	25.04	1.00	0.51	9.30	0.04	0.23	0.04	6.57	0.99	1.38	0.38	0.72	1.80	4.8	1.9	20.8	8.3
11/16/2023	15.70	8.00	21.07	1.00	0.43	9.29	0.02	0.23	0.04	9.43	1.42	1.98	0.54	1.04	2.58	8.1	3.2	14.5	5.8
12/4/2024	13.00	7.80	22.34	1.00	0.46	9.30	0.01	0.23	0.04	18.19	2.73	3.82	1.04	2.00	4.97	7.5	3.0	7.5	3.0
1/11/2024	8.44	7.60	20.18	1.00	0.41	9.29	0.01	0.23	0.04	39.74	5.97	8.34	2.28	4.37	10.87	4.1	1.7	3.4	1.4
2/8/2024	9.50	7.60	10.55	1.00	0.21	9.27	0.01	0.23	0.04	34.85	5.24	7.31	2.00	3.83	9.53	3.3	1.3	3.9	1.6
3/21/2024	14.10	7.70	24.34	1.00	0.50	9.30	0.01	0.23	0.04	21.29	3.20	4.47	1.22	2.34	5.82	4.5	1.8	6.4	2.6

AMMONIA EQUATIONS: Refer to EPA criteria document listed above for saltwater criteria calculation tables (starting on pg. 27)