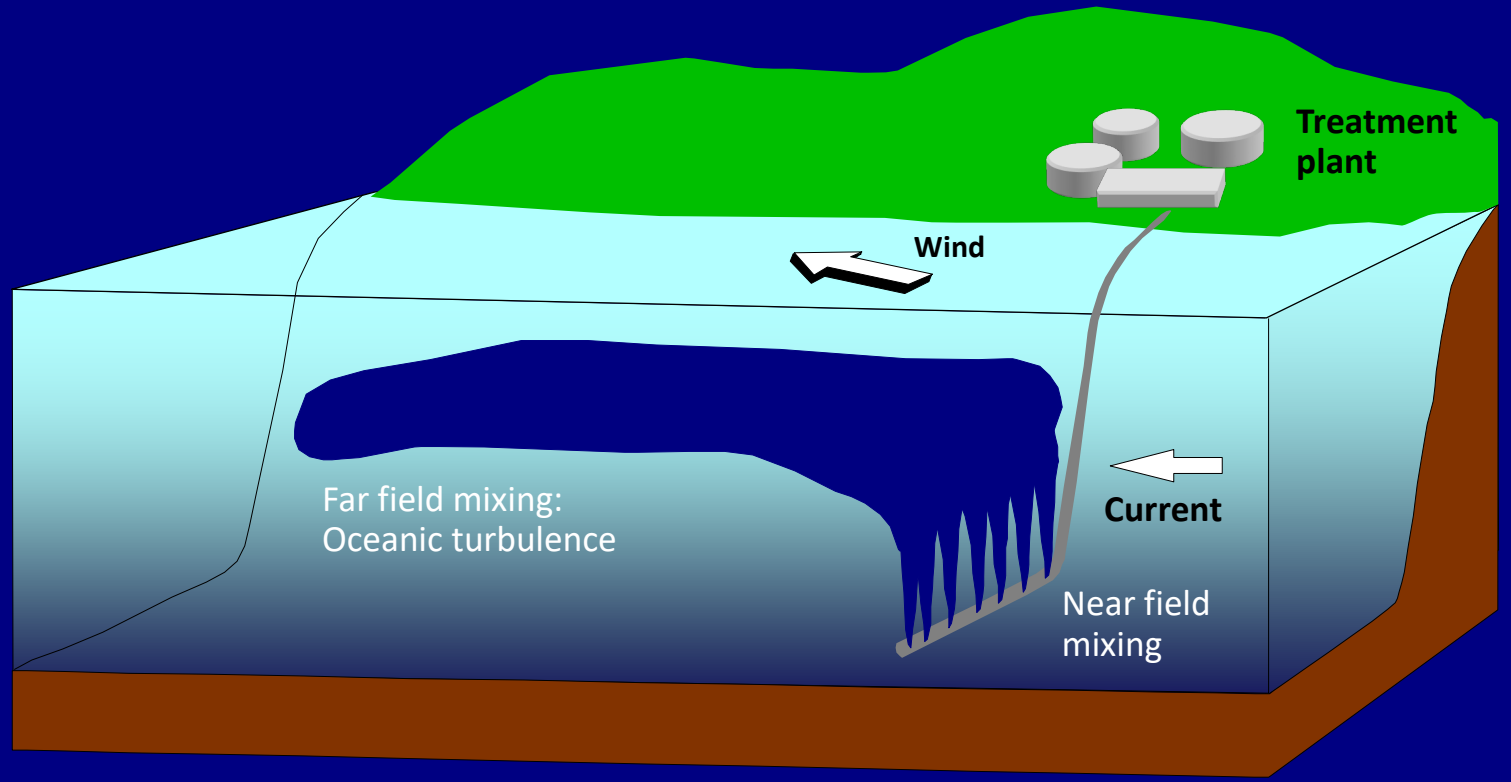
Marine Wastewater Disposal System



Parameter	Initial dilution ↑
Diffuser length	Longer
Water depth	Deeper
Ocean stratification	Weaker
Ocean currents	Faster
Effluent temp.	Higher
Effluent TDS	Lower
Effluent flow	Lower

Water reuse:

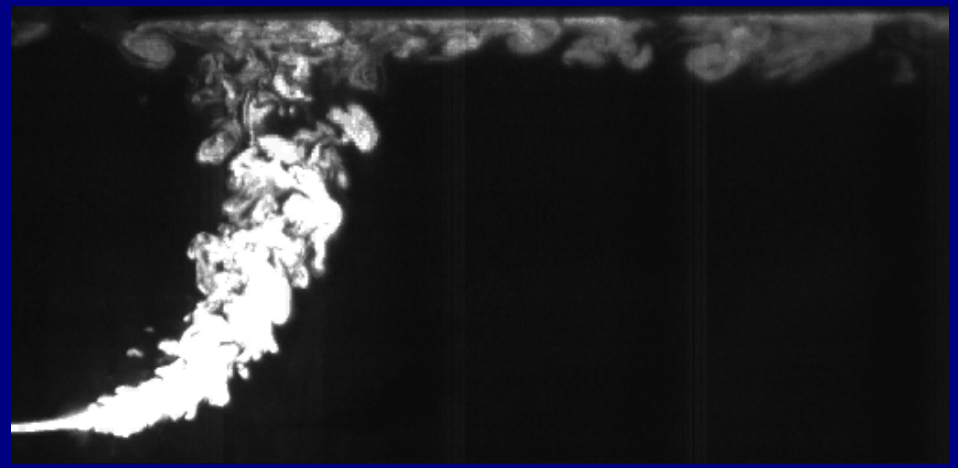
- Reduces outfall flow
- Produces ROC
- Increases effluent density

OCSan Workshop

CASA PFI Meeting

Effect of Density Stratification

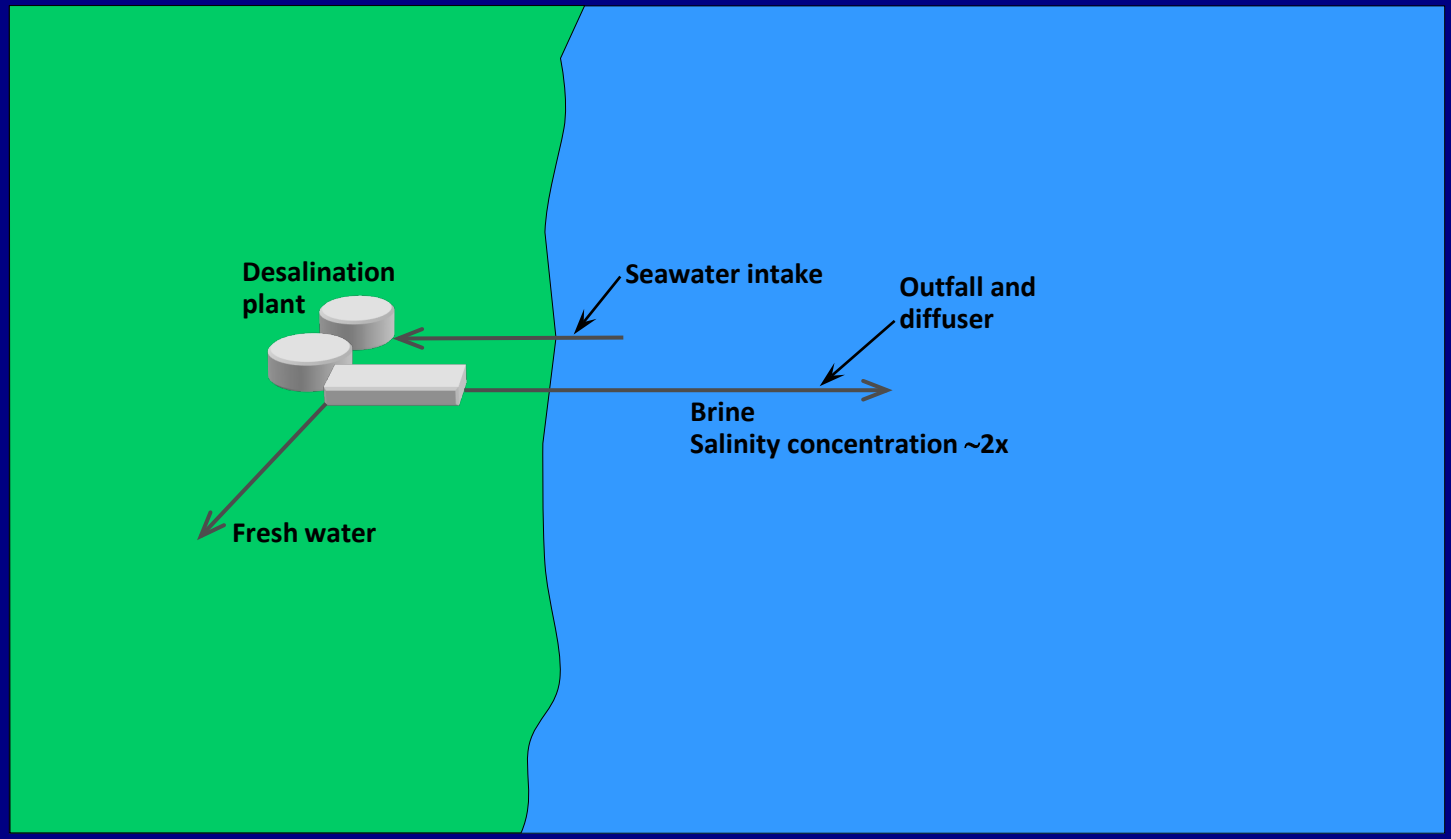
Horizontal Buoyant Jet



No Stratification

Stratified

Seawater Desalination



Seawater	~34 ppt	~1025 kg/m^3
Brine	~68 ppt	~1047 kg/m^3
ROC	~5 ppt	~1001 kg/m^3

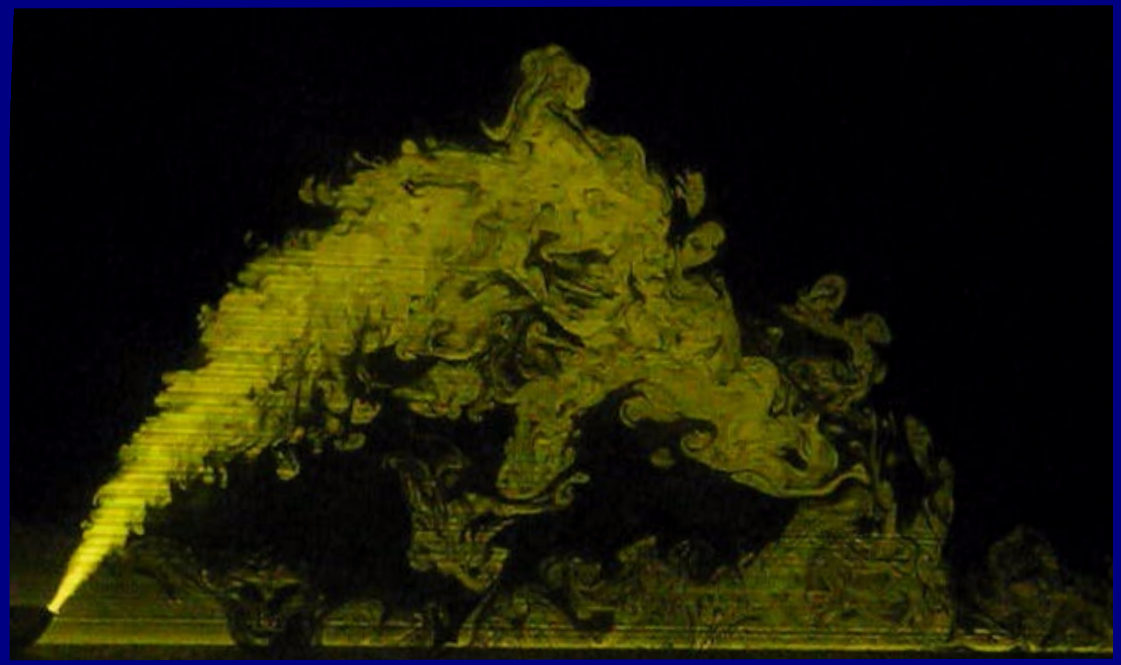
Ocean Plan requirement for desalination:

Salinity <2 ppt within BMZ of 100 m

Dilution = (68-34)/2 = 17:1

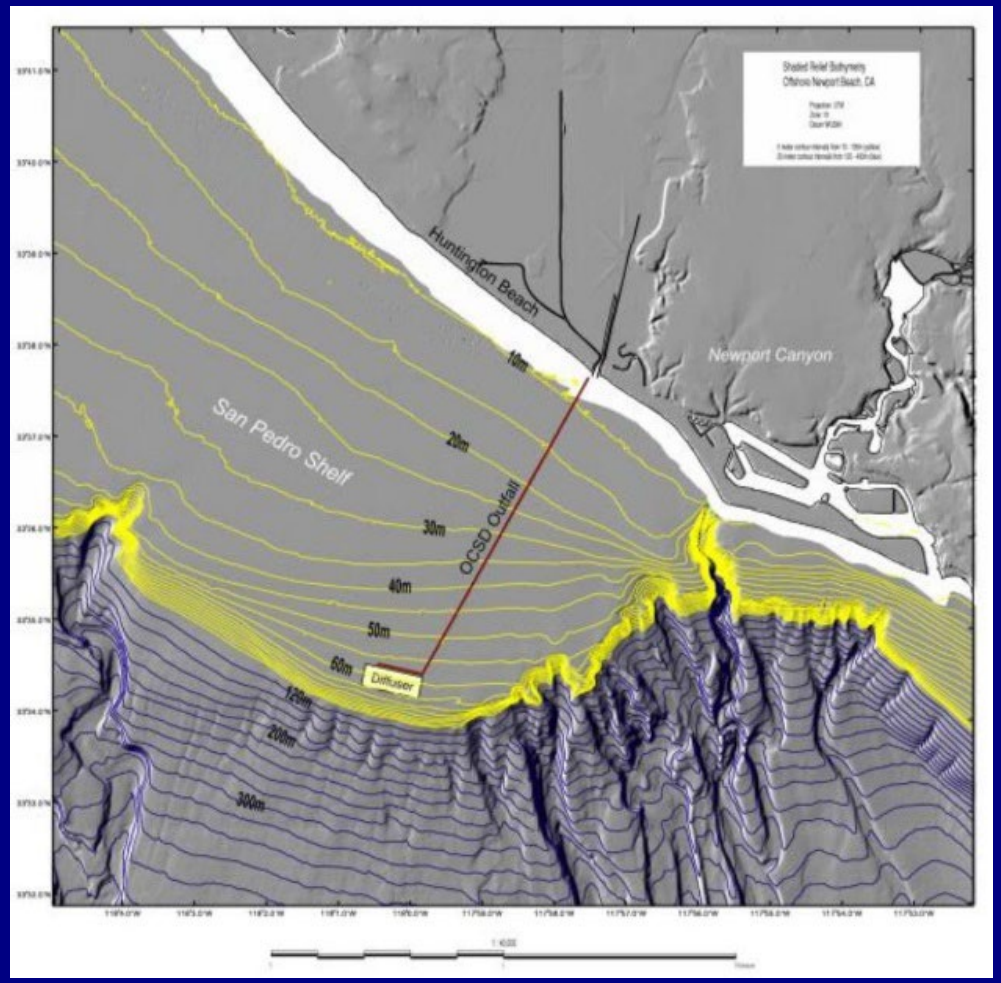
Diffuser with Inclined Dense Jets

Discharge as 60° high velocity jet to achieve high dilution and reduce salinity to safe levels

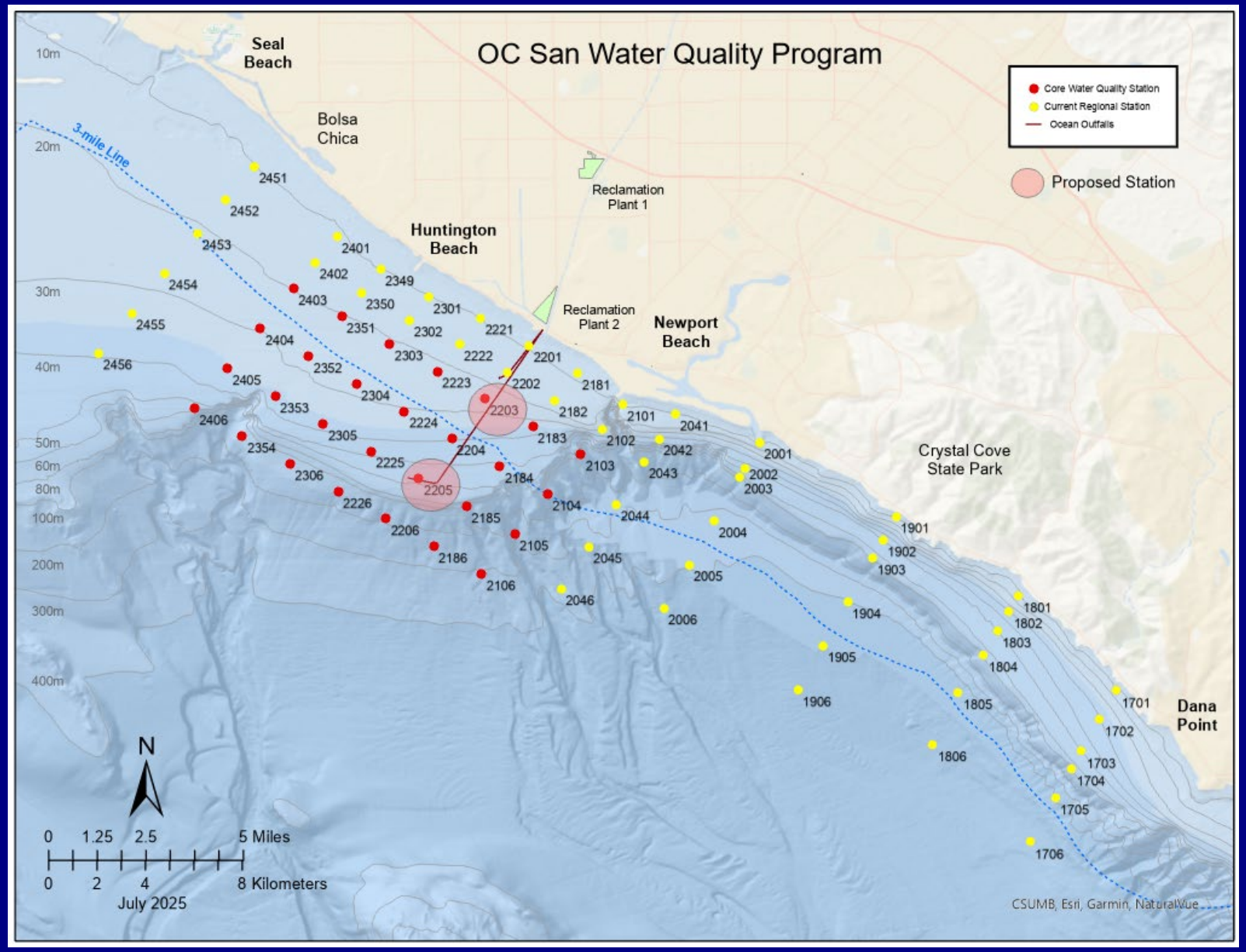


Orange County

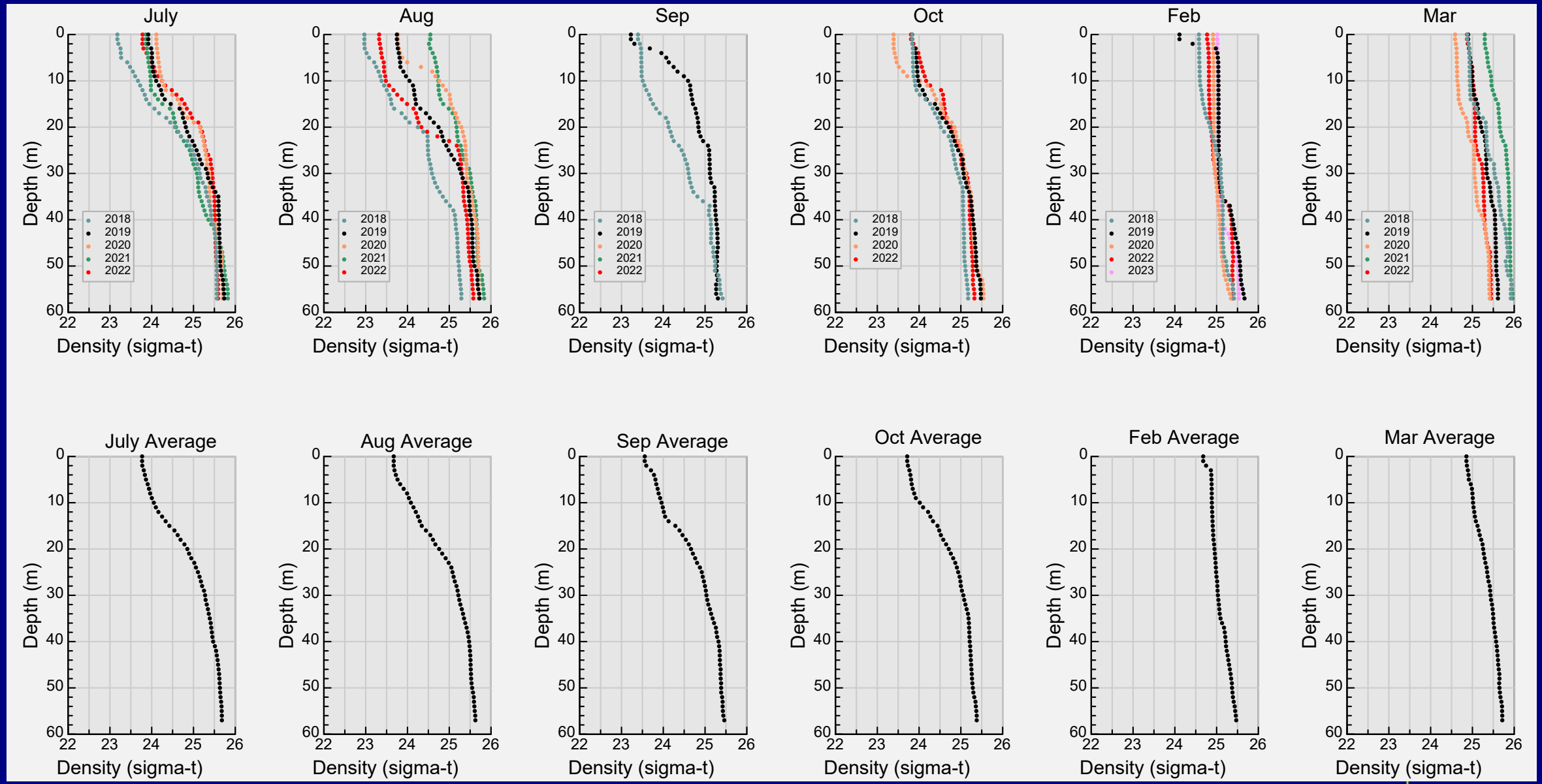
120-inch Outfall



Monitoring Stations for Density Profiles



Density Profiles: Station 2205 (120-inch outfall)



120-inch Modeling Scenarios

Case	Present Flows					Sensitivity Analysis at Present Flows								Future Flows	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Scenarios	Separated Mode	Separated Mode	Combined Mode	Combined Mode	Combined Mode	Temperature Sensitivity	Temperature Sensitivity	Density Sensitivity	Density Sensitivity	Temperature Sensitivity	Temperature Sensitivity	Density Sensitivity	Density Sensitivity	Lower Bound Flow	Upper Bound Flow
	Avg Separated Mode Flow	Min Separated Mode Flow	Avg Combined Mode Flow	Max Dry Weather Flow	Max Wet Weather Flow	Max Dry Weather Flow	Max Dry Weather Flow	Max Dry Weather Flow	Max Dry Weather Flow	Max Wet Weather Flow	Max Wet Weather Flow	Max Wet Weather Flow	Max Wet Weather Flow	Lower Bound Flow	Upper Bound Flow
	Avg Separated Mode Temp	Avg Separated Mode Temp	Avg Combined Mode Temp	Avg Combined Mode Temp	Avg Combined Mode Temp	Max Combined Mode Temp	Min Combined Mode Temp	Avg Combined Mode Temp	Avg Combined Mode Temp	Max Combined Mode Temp	Min Combined Mode Temp	Avg Combined Mode Temp	Avg Combined Mode Temp	Avg Future Effluent Temp	Avg Future Effluent Temp
	Avg Separated Mode Density/TDS	Avg Separated Mode Density/TDS	Avg Combined Mode Density/TDS	Avg Combined Mode Density/TDS	Avg Combined Mode Density/TDS	Avg Combined Mode Density/TDS	Avg Combined Mode Density/TDS	Max Combined Mode Density/TDS	Min Combined Mode Density/TDS	Avg Combined Mode Density/TDS	Avg Combined Mode Density/TDS	Max Combined Mode Density/TDS	Min Combined Mode Density/TDS	Avg Future Density/TDS	Avg Future Density/TDS
Flow (mgd)	76	55	105	185	256	185	185	185	185	256	256	256	256	58	71
Effluent Temperature (degC)	23.8	23.8	24.2	22.6	22.2	27.0	18.5	22.6	22.6	26.7	19.0	22.2	22.2	25.2	25.1
Effluent Density (g/cm^3)	1.0005	1.0005	0.999	0.9994	0.9992	0.9994	0.9994	1.0014	0.9974	0.9992	0.9992	1.0006	0.9974	1.0021	1.0016
TDS (mg/L)	3624	3624	2142	2016	1736	2016	2016	3456	655	1736	1736	3028	814	2945	2833
Density Profiles	July, August, September, October	July, August, September, October	July, August, September, October	July, August, September, October	February, March	July, August, September, October	July, August, September, October	July, August, September, October	July, August, September, October	February, March	February, March	February, March	February, March	July, August, September, October	July, August, September, October

120-inch Outfall: NRFIELD Dilution Results

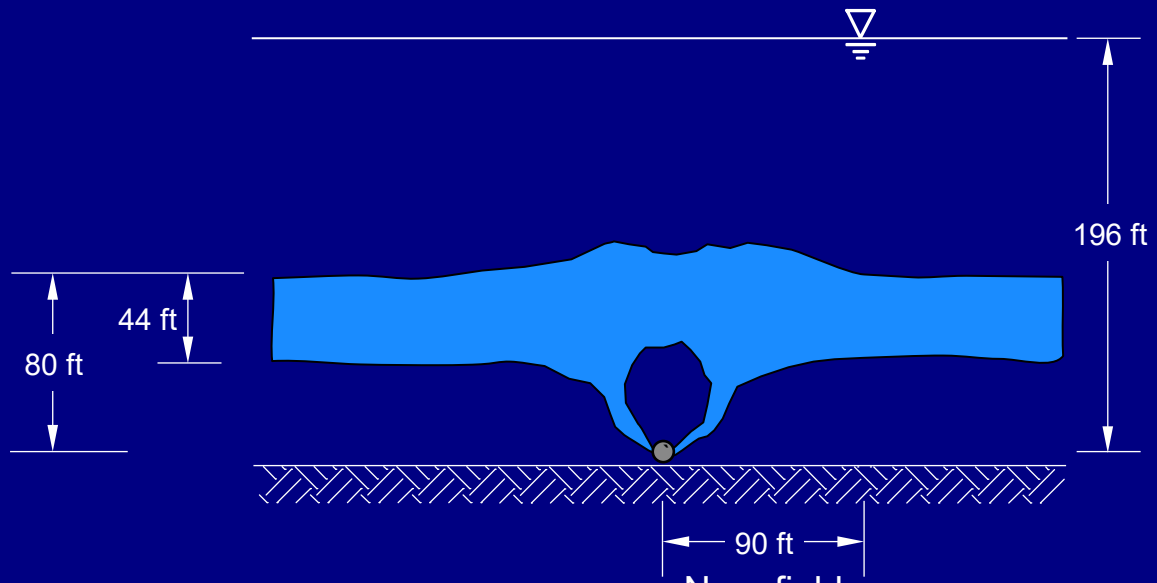
Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow (mgd)	76	55	105	185	256	185	185	185	185	256	256	256	256	58	71
Temperature (°C)	23.8	23.8	24.2	22.6	22.2	27.0	18.5	22.6	22.6	26.7	19.0	22.2	22.2	25.2	25.1
TDS (mg/L)	3624	3624	2142	2016	1736	2016	2016	3456	655	1736	1736	3028	814	2945	2833
Effluent Density (g/cm3)	1.0005	1.0005	0.9990	0.9994	0.9992	0.9994	0.9994	1.0014	0.9974	0.9992	0.9992	1.0006	0.9974	1.0021	1.0016
July18	329	380	296	219		225	214	207	230					357	330
July19	336	404	298	222		228	216	210	233					380	342
July20	291	312	282	243		246	238	231	252					294	286
July21	202	230	185	152		157	149	144	160					219	200
July22	454	537	397	281		289	281	273	296					505	457
Aug18	274	323	235	179		184	175	169	184					303	271
Aug19	326	358	294	216		222	211	210	227					337	326
Aug20	352	416	317	276		284	268	260	290					391	360
Aug21	321	365	298	241		247	235	228	246					343	318
Aug22	343	373	325	266		274	260	255	280					350	340
Sept18	271	316	232	166		171	162	161	174					289	268
Sept19	420	474	404	291		299	297	288	306					445	412
Sept20	365	431	320	256		263	250	245	269					405	372
Sept21	284	318	265	222		227	217	210	233					299	281
Sept22	324	353	278	215		221	209	207	226					332	321
Oct18	385	447	340	258		265	251	244	267					420	391
Oct19	317	361	275	216		222	211	207	227					339	320
Oct20	301	326	272	213		217	208	201	222					306	299
Oct22	412	480	346	263		271	257	248	277					451	408
Feb18					218					224	214	210	224		
Feb19					156					162	154	151	165		
Feb20					215					221	211	207	230		
Feb22					193					199	189	186	202		
Feb23					182					187	179	172	190		
Mar18					201					207	197	194	210		
Mar19					258					257	253	249	261		
Mar20					228					234	224	213	238		
Mar21					274					282	270	265	287		
Mar22					235					241	231	227	244		
Mar23					207					213	204	202	217		

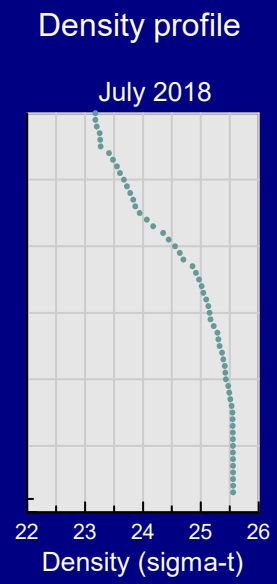
Plume surfacing:

0% Summer

0% Winter

Typical Result





z_m = 24.5 m (80 ft)

h_n = 13.5 m (44 ft)

x_n = 27.5 m (90 ft)

Dilution = 386

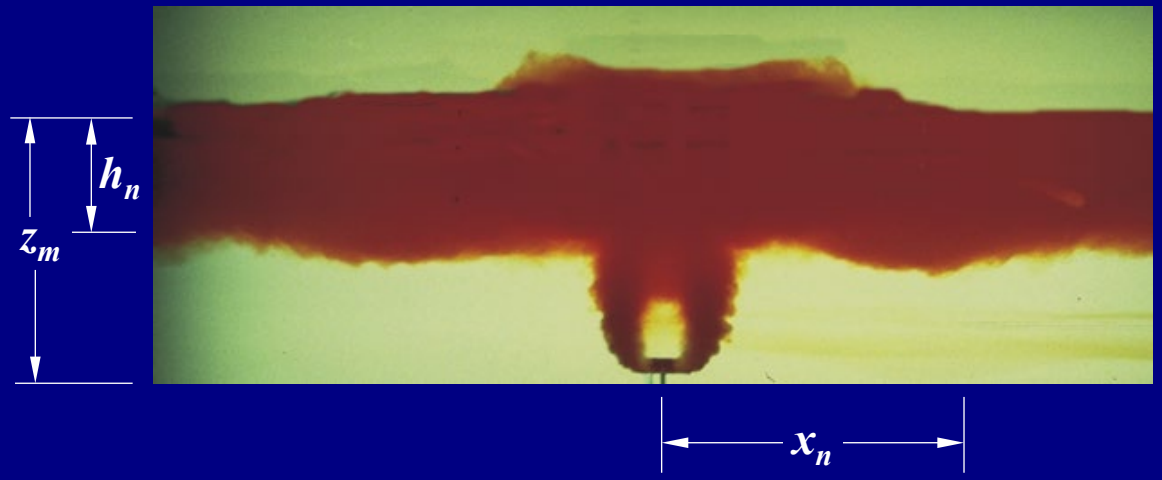
120-Inch Outfall - Modeling Summary

	Summer		Winter	
	Average	Range	Average	Range
Dilution	285	144 - 537	216	151 - 287
Height to wastefield top, z_m (m)	24.7	15.7 – 32.9	29.9	22.7 – 37.1
Wastefield thickness, h_n (m)	19.0	12.1 - 25.3	23.0	17.0 - 28.6
Length of near field (ZID), x_n (m)	27.6	17.2 – 36.2	33.3	26.0 – 40.3

Plume surfacing:

0% Summer

0% Winter



Near field

Effect of Water Reuse

Effluent variables affecting dilution:

- Flow rate
- Effluent density
  - Temperature
  - TDS or salinity

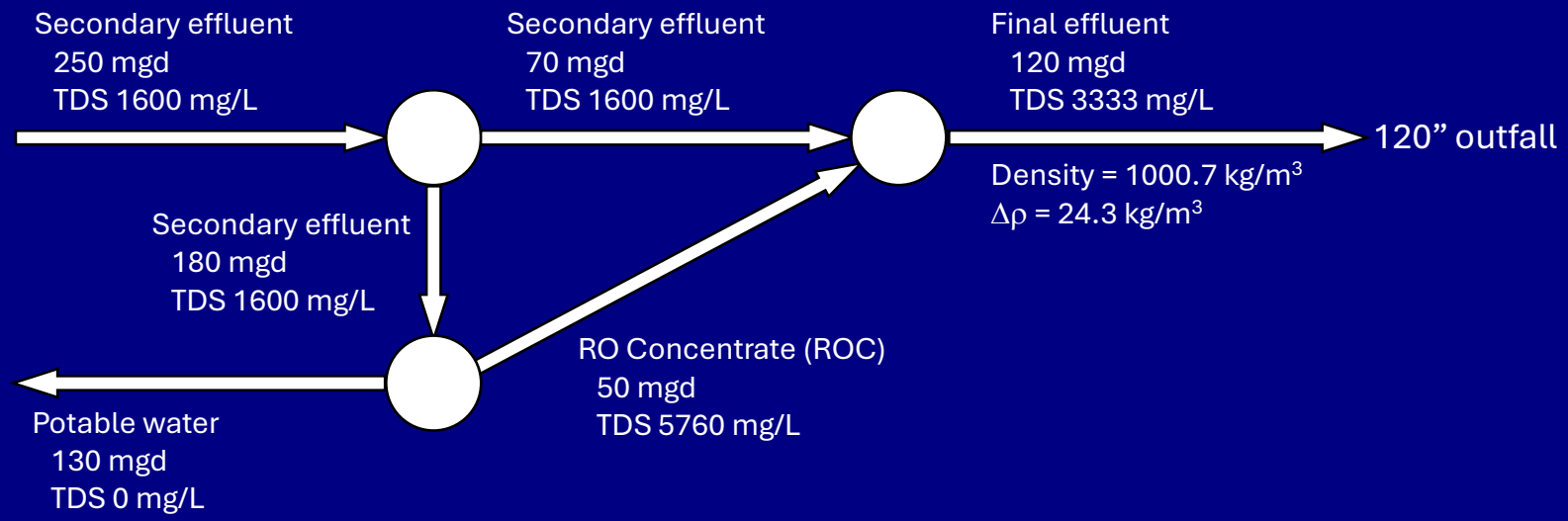
Water reuse:

- Flow decreases and density increases

Effect of Water Reuse on Dilution

Without recycling

With recycling



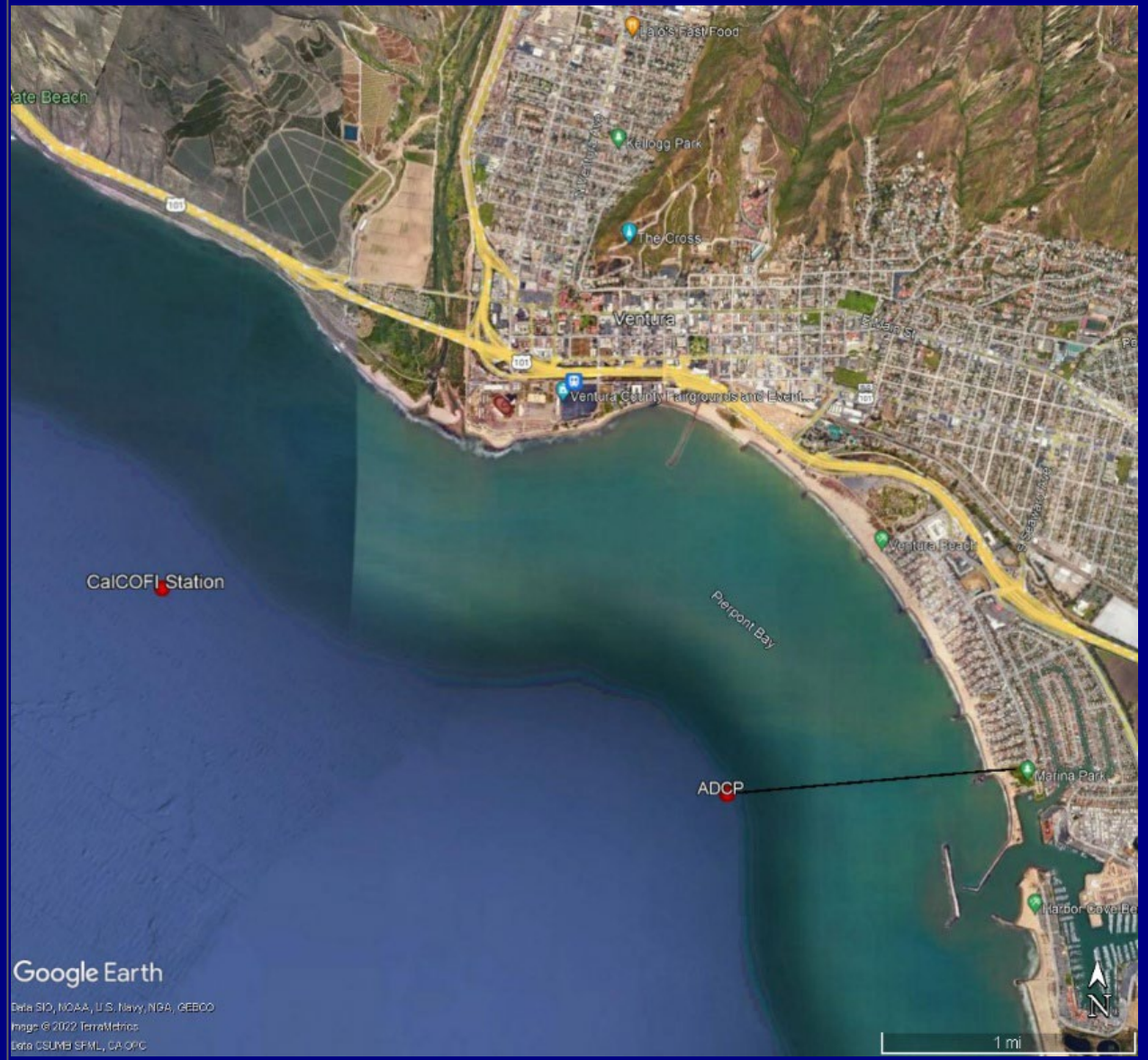
Dilutions for July 2018 profile:

Without reuse = 197

With reuse = 261

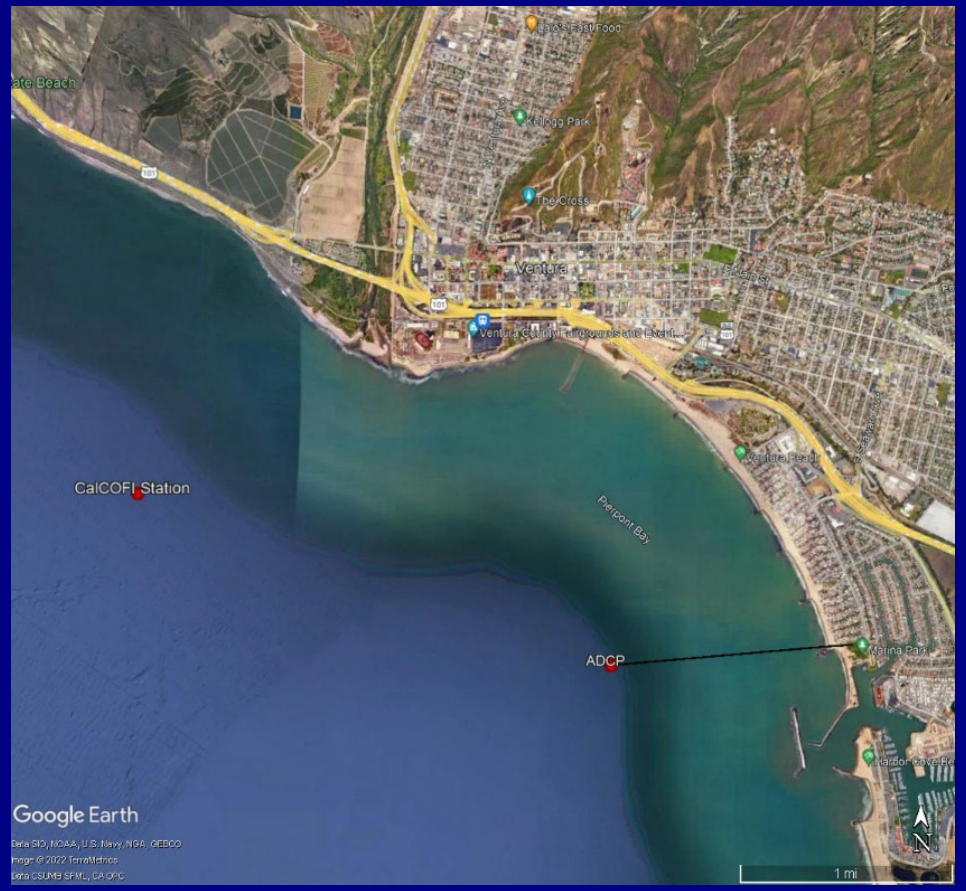
Overall, about 30% increase in dilution with reuse

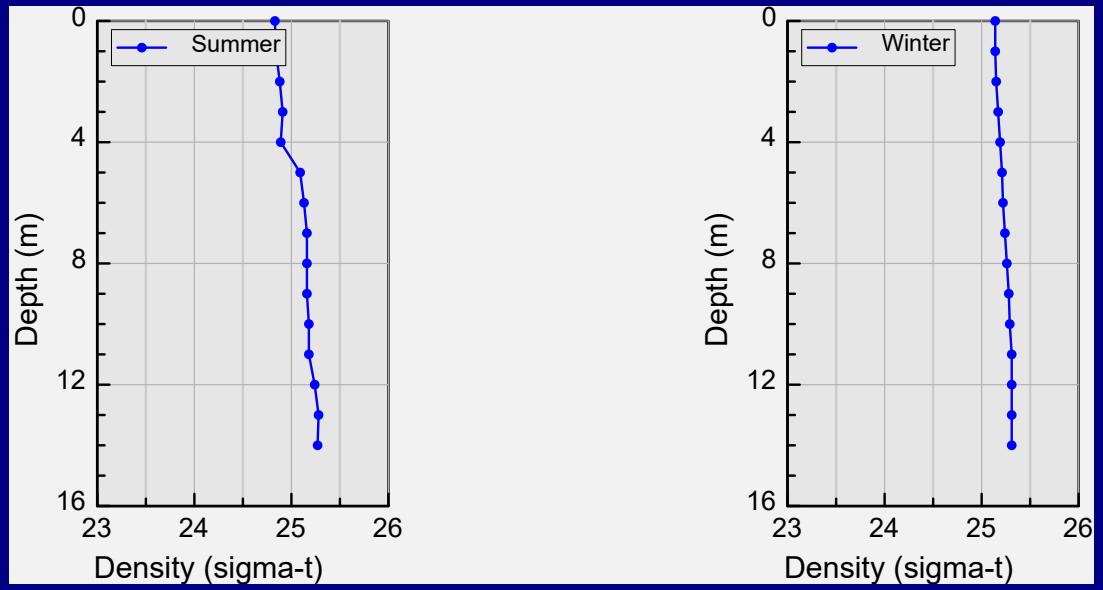
Ventura



Scenario	Constituents		Final effluent		
	ROC (mgd)	Tertiary (mgd)	Flow (mgd)	Salinity (ppt)	Density (kg/m^3)
I. Phase 1b typical operation	4.3	0	4.3	8.23	1004.2
II. Pipeline maintenance	0	4.3	4.3	0.51	998.6
III. VWRF PWWF	0	10.0	10.0	0.51	998.6
IV. Phase 1a typical operation	1.6	2.7	4.3	3.29	1000.6
V. Phase 1a PWWF	0.8	9.2	10.0	1.13	999.0

Density Profiles





Generally weak

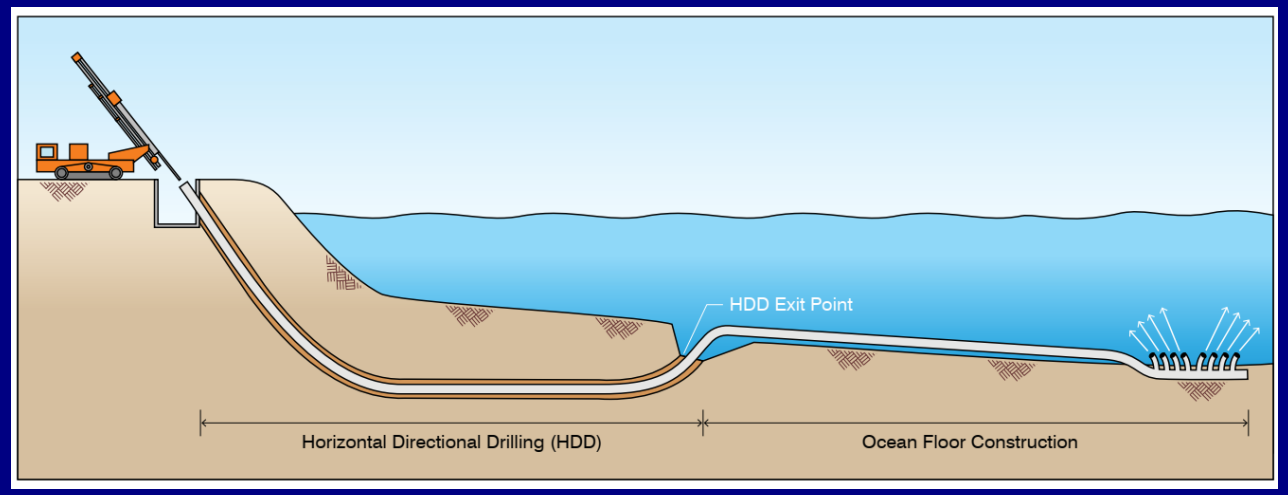
NPDES
CalCofi
Rincon
38 in all

Ventura - Recommended Outfall

Outfall
- 5300 ft long
- 56 ft MSL

Diffuser
- 272 ft long
- 36 ports
- 16 ft spacing
- Check valves diameter ~2.5 inches

Diffuser Configuration



Optimal port spacing s/H ~ 0.3
∴ Paired spacing on each side 16 ft
Or four ports per riser at 32 ft

Monterey

Outfall 11,298 ft long

60-inch ID reinforced concrete pipe

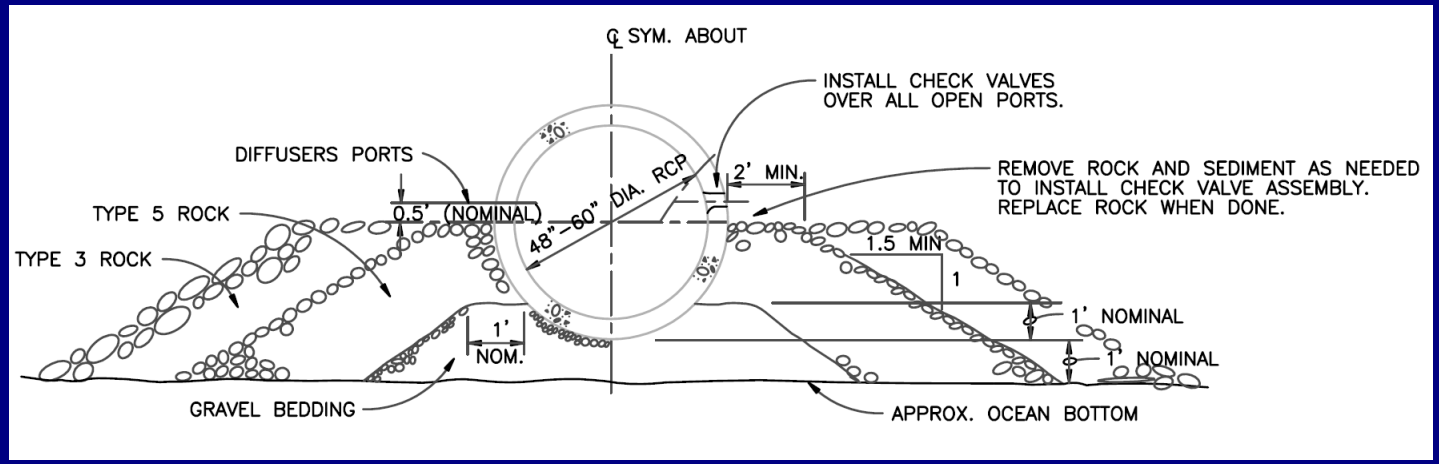
Projected flows

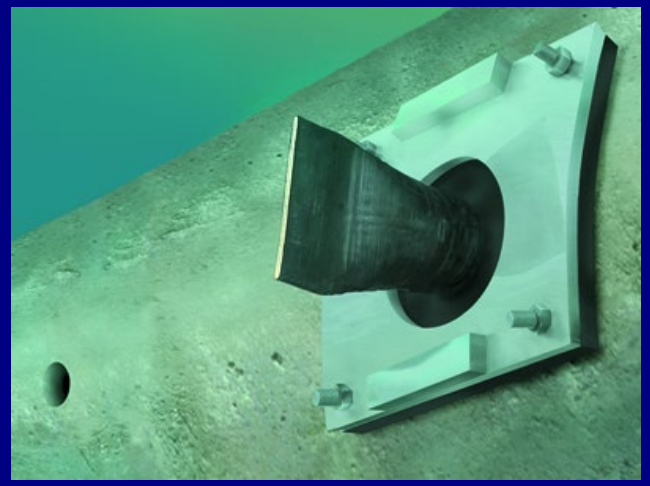
- Secondary effluent
- RO concentrate
- Desalination brine

Effluent densities can be more or less dense than seawater

Diffuser Details

- Diffuser 1,406 ft long , 100 ft deep
- 171 ports of two-inch diameter
- 42 ports presently closed - 129 ports open
- Discharge horizontally from both sides of the diffuser at a spacing of 16 ft
- Open ports are fitted with Tideflex “duckbill” check valves





Design Criteria

Water Quality: Ocean Plan Table 3 (formerly Table B)

Compound	Limiting Concentrations			
	Units of Measurement	6-Month Median	Daily Maximum	Instantaneous Maximum
Arsenic	µg/l	8.	32.	80.
Cadmium	µg/l	1.	4.	10.
Chromium (Hexavalent)	µg/l	2.	8.	20.
Copper	µg/l	3.	12.	30.
Lead	µg/l	2.	8.	20.
Mercury	µg/l	0.04	0.16	0.4
Nickel	µg/l	5.	20.	50.
Selenium	µg/l	15.	60.	150.
Silver	µg/l	0.7	2.8	7.
Zinc	µg/l	20.	80.	200.
Cyanide	µg/l	1.	4.	10.
Total Chlorine Residual	µg/l	2.	8.	60.
Ammonia (as nitrogen)	µg/l	600.	2400.	6000.
Acute* Toxicity	TUa	N/A	0.3	N/A
Chronic* Toxicity	TUc	N/A	1.	N/A
Phenolic Compounds (non-chlorinated)	µg/l	30.	120.	300.
Chlorinated Phenolics	µg/l	1.	4.	10.
Endosulfan	µg/l	0.009	0.018	0.027
Endrin	µg/l	0.002	0.004	0.006
HCH*	µg/l	0.004	0.008	0.012
Radioactivity	Not to exceed limits specified in Title 17, Division 1, Chapter 5, Subchapter 4, Group 3, Article 3, Section 30253 of the California Code of Regulations. Reference to Section 30253 is prospective, including future changes to any incorporated provisions of federal law, as the changes take effect.			

Water quality:

- Ammonia <80% = 480 µg/l
- Salinity increment <2 ppt within BMZ of 100 m

Hydraulics constraints

Turbulence shear mortality

Flow Constituents

Constituent	Flow (mgd)	Ammonia (mg/l)	TDS (mg/l)	Density (kg/m^3)
Secondary effluent	0 to 30	45.6	1,000	998.1
ROC	0 to 1.78	208.4	5,400	1001.3
Brine	0 to 8.66	0.1	60,000	1046.7

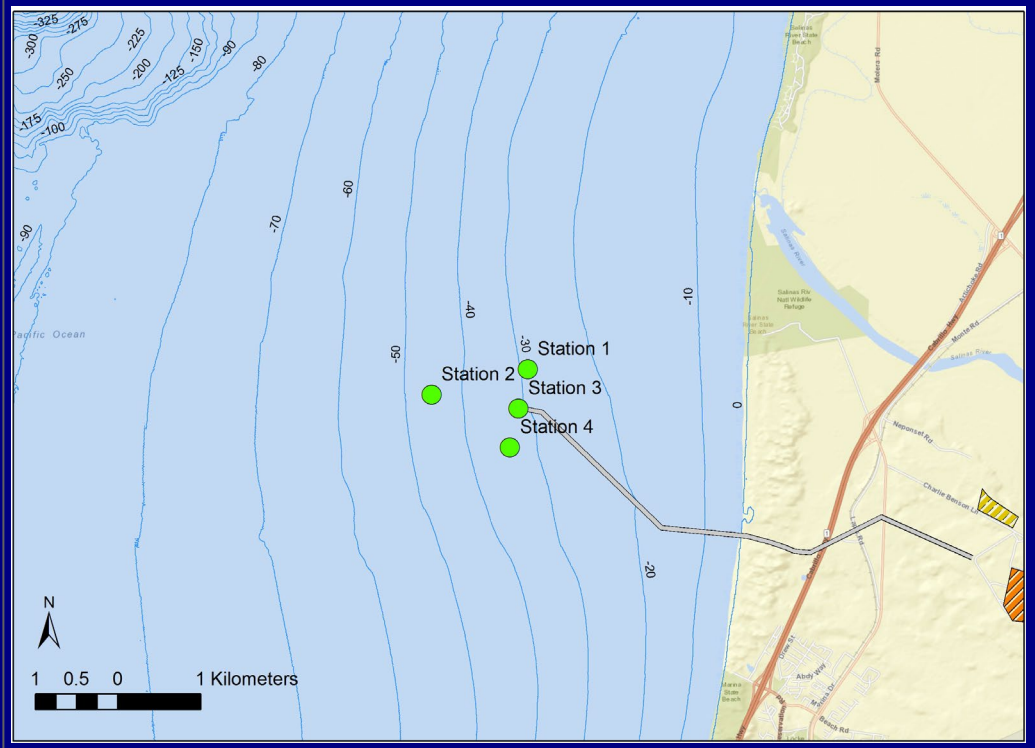
Modeled scenarios (120):

5.6 to 30 mgd

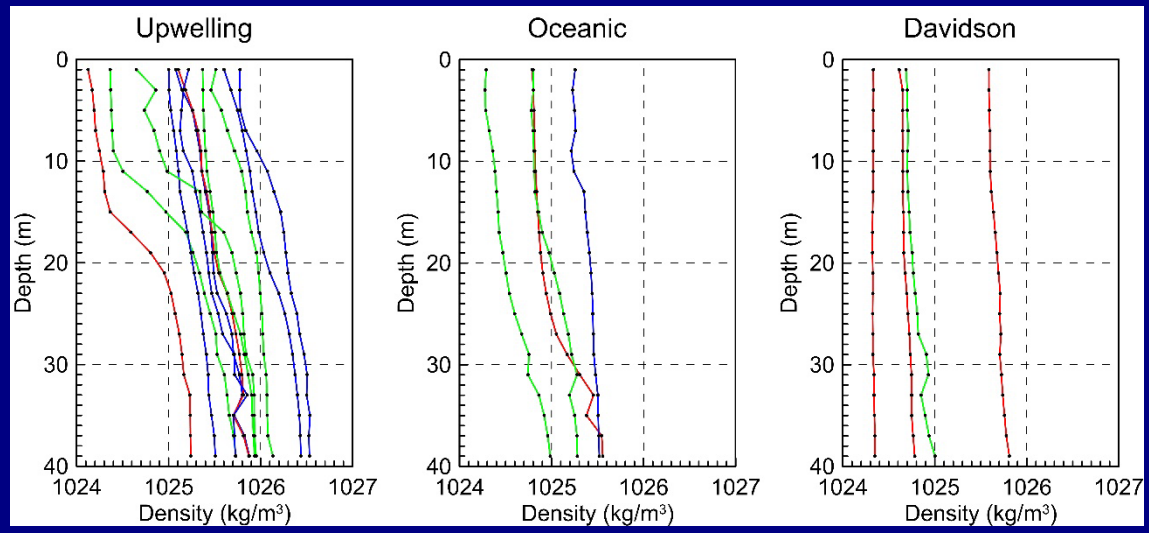
998.1 to 1046.7 kg/m^3

Can be positively or negatively buoyant

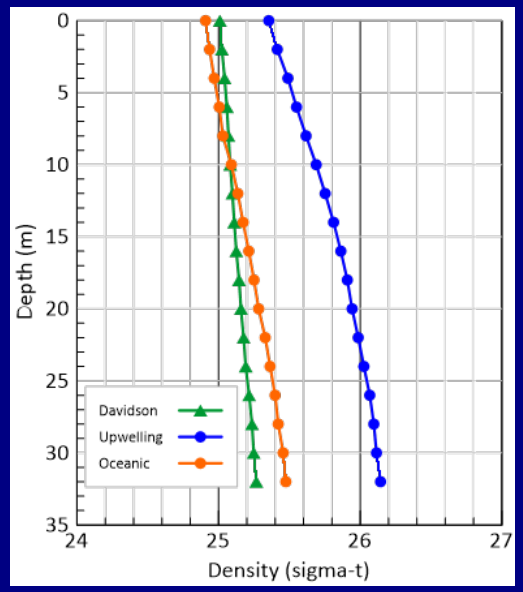
Oceanic Scenarios - Density Stratification



Locations of water column profiles
Bathymetry in meters



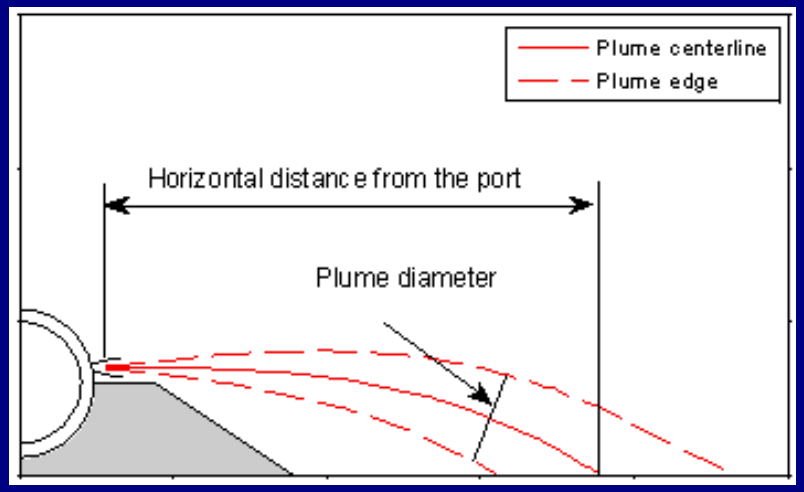
Seasonal density profiles

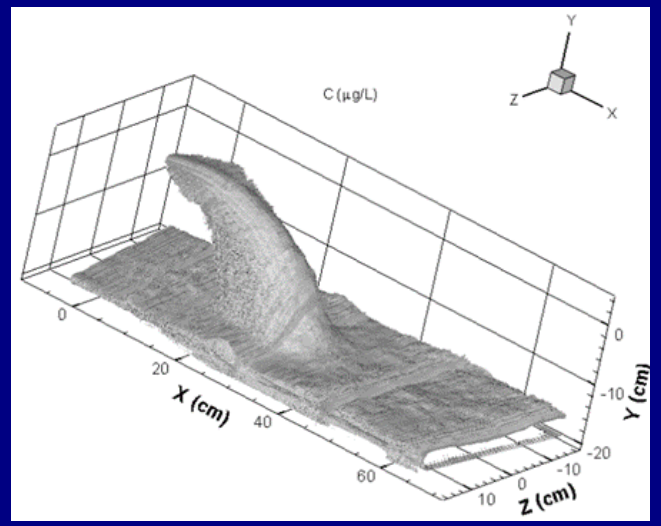


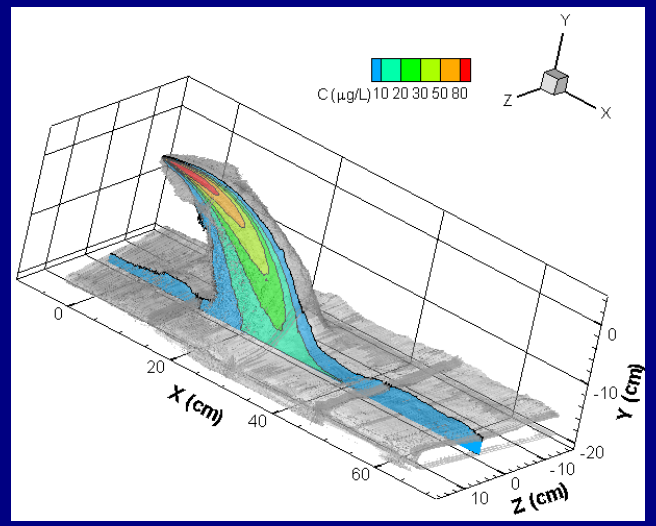
Seasonally averaged
density profiles

Existing Diffuser

Horizontal dense jet dynamics





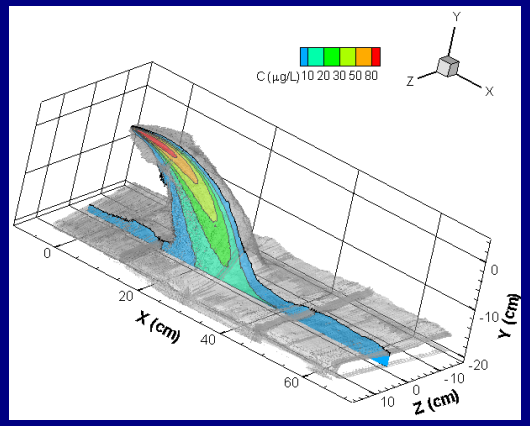


3DLIF images of horizontal dense jet
(Nemlioglu and Roberts, 2006)

Summary of Existing and Modified Diffusers

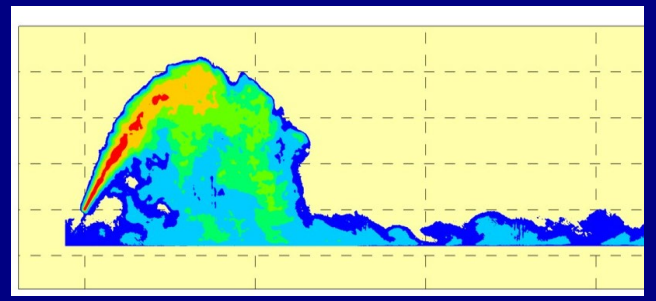
Existing diffuser: 129 ports horizontal, HC61

- Buoyant effluents
  - Dilutions generally very high, always >100:1
  - Ammonia <209 μg/l
- Dense effluents
  - Lower dilutions ~17
  - Salinity increment <2 ppt within BMZ 100 m
  - Ammonia criteria not met



Modified diffuser: 158 ports, 60°, HC24

- Increase dense jet dilutions considerably
- Reduces buoyant jet dilutions slightly (because buoyancy dominates)



Summary of Permitting Issues with Reuse and Brine Disposal

1. Orange County: Existing outfall and diffuser, increasing reuse
   Minimal: Higher dilutions

2. Ventura: New outfall and diffuser with wastewater and ROC
   Part of regular outfall design process

Density less than seawater

3. Monterey: Existing outfall and diffuser with wastewater, ROC, and brine
   Most challenging

More or less dense than seawater