same as the flows that would be used in a constructed alternative. This is because the implementation schedule of various treatment capabilities in a constructed alternative would be optimized over the appropriate project period (e.g., the years 2005–2025), whereas the flows in the tables were determined by the priorities defined in Chapter 7, Section 7.2, along with the feasible extent of public access reuse based on methodology explained in Chapters 5 and 6. A number of the alternatives involve construction of groundwater recharge treatment units in 2005 which are later replaced by traditional reuse treatment units. The useful life of these groundwater recharge facilities would be 20 years; thus implementation of traditional reuse would be a reasonable alternative for retrofitting them.

The reclaimed water flows to traditional reuse for each of the six WWTPs under Alternative I are summarized in Table 7-1. The flows to traditional reuse for each of the six WWTPs under Alternatives II, III and IV are summarized in Table 7-2.

7.3.1 Effluent and Reclaimed Water Distribution for the Boynton-Delray WWTP

The distribution of effluent and reclaimed water from the Boynton-Delray WWTP under the four ocean outfall alternatives is summarized in Table 7-3. The rationale for the flow allocations is discussed below.

a) Flows to traditional reuse under Alternative I. The utility currently delivers 3.7 MGD flow for traditional reuse, which includes 2.2 MGD for golf course irrigation (5 golf courses), 0.8 MGD for residential irrigation (FL DEP 2004) and 0.7 MGD for on-site irrigation at the WWTP. The on-site irrigation was estimated by subtracting the on-site process use from the total on-site use of 1.3 MGD (FL DEP 2004). The on-site process use was calculated using the information given for Broward/North WWTP. This plant will need about 0.5 MGD for process use when the plant is expanded from 80 to 100 MGD (Hazen and Sawyer 2004). Therefore it was assumed that 2.5% of the plant capacity will be used for process use. The utility plans to provide reclaimed water to new users, including 0.8 MGD for irrigation of four golf courses and 0.4 MGD for residential irrigation, by the year 2010 (FL DEP 2005). Traditional reuse is expected to increase to 6.2 MGD in 2015 through additional flows of 1.4 MGD for golf course and residential irrigation in Areas 1 through 8 (Matthews Consulting 2003). The water reclamation capacity is expected to increase to 7.5 MGD by 2025, after a reclaimed water flow of 1.3 MGD is provided to Areas 9 through 16 via the ocean outfall pipeline, as suggested by Matthews Consulting (2003).

b) Flows to traditional reuse under Alternatives II, III and IV. The Consumptive Use Permits were used, as explained in Chapters 5 and 6, to project traditional reuse demand. Reuse flows of 6.5 MGD by year 2010, 12.9 MGD by year 2015, and 19.7 MGD by year 2020 are expected as the large users within 3, 6, and 9 mile metropolitan distances of the WWTP are connected. A reclaimed water flow of 22.7 MGD is expected by 2025 through inclusion of all large users within a metropolitan distance of 12.6 miles of the WWTP.

Table 7-1. Traditional Reuse and On-site Process Flows under Alternative I

Year	Boynton-Delray[1]	Boca Raton[2]	Broward/North[3]	Hollywood[4]	Miami-Dade/North[5]	Miami-Dade/ Central[6]
2005	- 0.6 MGD for on-site process use, - 3.7 MGD for golf course, on-site and residential irrigation	- 0.4 MGD for on-site process use, - 5.2 MGD for golf course, on-site, residential and other public access areas irrigation	- 2.1 MGD for on-site process use, - 2.4 MGD at another facility, on-site and other public access areas irrigation	- 2.6 MGD for golf course irrigation	- 2.2 MGD for on-site process use - 0.1 MGD for other public access areas irrigation	- 8.9 MGD for on-site process use
2010	Add 1.2 MGD for golf course and residential irrigation	Add 3.7 MGD for golf course, residential and other public access areas irrigation	- Add 2 MGD for on-site process use, - Add 1.8 MGD for another facility and other public access areas irrigation	Add 1.1 MGD for golf course and other public access areas irrigation	-	-
2015	Add 1.4 MGD for golf course and residential irrigation in Areas 1-8	Add 2.4 MGD for residential and other public access areas irrigation	Add 1 MGD for golf course irrigation	-	-	-
2020	Increase reuse capacity to 24 MGD	Add 2.4 MGD for residential and other public access areas irrigation	-	-	-	-
2025	Add 1.3 MGD for public access reuse in Areas 9-16	Add 2.4 MGD for residential and other public access areas irrigation	-	-	-	-

Sources: [1] (PBS&J 2003; FL DEP 2004); (FL DEP 2005), [2] (PBS&J 2003; FL DEP 2004), [3] (Hazen and Sawyer 2004), [4] (FL DEP 2004), [5,6] (PBS&J 2003; FL DEP 2004)

Table 7-2. Traditional Reuse and On-site Process Flows under Alternatives II, III and IV

Year	Boynton-Delray[1]	Boca Raton[2]	Broward/North[3]	Hollywood[4]	Miami-Dade/North[5]	Miami-Dade/Central[6]
2005	- 0.6 MGD for on-site process use, - 3.7 MGD for golf course, on-site and residential irrigation	- 0.4 MGD for on-site process use, - 5.2 MGD for golf course, on-site, residential and other public access areas irrigation	- 2.1 MGD for on-site process use, - 2.4 MGD at another facility, on-site and other public access areas irrigation	- 2.6 MGD for golf course irrigation	- 2.2 MGD for on-site process use - 0.1 MGD for other public access areas irrigation	- 8.9 MGD for on-site process use
2010	Add 2.8 MGD by large users within 3 mile*	Add 0.9 MGD by large users within 2 mile*	- Add 2 MGD for on-site process use, - Add 1.8 MGD for another facility and other public access areas irrigation	Add 1.1 MGD for golf course and other public access areas irrigation	Add 0.4 MGD by large users within 3 mile*	Add 0.4 MGD by large users within 5 mile*
2015	Add 6.4 MGD by large users within 6 mile*	Add 3.5 MGD by large users within 4 mile*	Add 5.2 MGD by large users within 4 mile*	Add 0.6 MGD by large users within 5 mile*	Add 1.5 MGD by large users within 5 mile*	Add 0.6 MGD by large users within 8 mile*
2020	Add 6.8 MGD by large users within 9 mile*	Add 8.5 MGD by large users within 6 mile*	Add 6.1 MGD by large users within 8 mile*	Add 1 MGD by large users within 10 mile*	Add 0.4 MGD by large users within 7 mile*	Add 1.1 MGD by large users within 10 mile*
2025	Add 3 MGD by large users within 12.6 mile*	Add 3.2 MGD by large users within 7.2 mile* (Alternatives II and IV)**	Add 7.5 MGD by large users within 12.6 mile*	Add 0.9 MGD by large users within 12.5 mile*	Add 1.3 MGD by large users within 8.4 mile*	Add 0.8 MGD by large users within 10.6 mile*

Sources: [1,2,3,4,5,6] (PBS&J 2003; FL DEP 2004), [3] (Hazen and Sawyer 2004), [4] (FL DEP 2004)
* Metropolitan distance of the WWTP
** Add 1.6 MGD by large users within 6.5 mile (Alternative III)

Table 7-3. Flow distribution for Boynton-Delray WWTP

Alt.	Year	WWTP effluent (MGD)	Ocean outfall (MGD)	Traditional reuse (MGD)	Groundwater recharge (MGD)	RO concentrate (MGD)
I	2005	19.4	15.7	3.7	0.0	0.0
	2010	21.3	16.4	4.8	0.0	0.0
	2015	23.2	17.0	6.2	0.0	0.0
	2020	25.2	19.0	6.2	0.0	0.0
	2025	27.1	19.6	7.5	0.0	0.0
II	2005	19.4	15.7	3.7	0.0	0.0
	2010	21.3	14.7	6.5	0.0	0.0
	2015	23.2	10.3	12.9	0.0	0.0
	2020	25.2	5.4	19.7	0.0	0.0
	2025	27.1	4.4	22.7	0.0	0.0
III	2005	19.4	0.4	3.7	12.2	3.1
	2010	21.3	0.7	6.5	11.2	2.8
	2015	23.2	1.4	12.9	7.1	1.8
	2020	25.2	2.1	19.7	2.7	0.7
	2025	27.1	2.4	22.7	1.5	0.4
IV	2005	19.4	0.0	3.7	12.5	3.1
	2010	21.3	0.0	6.5	11.8	2.9
	2015	23.2	0.0	12.9	8.2	2.1
	2020	25.2	0.0	19.7	4.4	1.1
	2025	27.1	0.0	22.7	3.5	0.9

c) Flows to ocean outfall and groundwater recharge. Under Alternatives I and II, the flows remaining after allocation to traditional reuse are sent to ocean outfalls. Since the flows to ocean outfalls would remain below the 2005 permitted capacity of 24 MGD, there would be no flow to groundwater recharge.

Under Alternative III, the ocean outfalls were used only as backups to traditional reuse during wet weather periods. The wet weather period was chosen as the days receiving greater than 0.4 inches of rain. For Boynton-Delray WWTP the wet weather period was 35.5 days. The ocean outfall flow was calculated multiplying the traditional reuse flow with the ratio of the wet and dry days. Flow remaining after allocation to traditional reuse and ocean outfall is directed to groundwater recharge. The groundwater recharge flow is projected to decrease from 12.2 MGD in 2005 to 1.5 MGD in 2025, as flow to traditional reuse increases.

Under Alternative IV, no flow is allowed to the ocean outfall. Flow remaining after allocation to traditional reuse is therefore directed to groundwater recharge. The groundwater recharge flow is projected to decrease from 12.5 MGD in 2005 to 3.5 MGD in 2025. The flow of reverse osmosis concentrate was assumed to be 25% of the reverse osmosis permeate flow that is injected to the potable aquifer for recharge (i.e., 20% of reverse osmosis influent flow). Thus, reverse osmosis concentrate flow varies in proportion to the groundwater recharge flow.

7.3.2 Effluent and Reclaimed Water Distribution for the Boca Raton WWTP

The distribution of effluent and reclaimed water from the Boca Raton WWTP under the four ocean outfall alternatives is summarized in Table 7-4. Rationale for the flow allocations is discussed below.

a) Flows to traditional reuse under Alternative I. The utility currently delivers 5.2 MGD of reclaimed water, including 0.8 MGD for golf course irrigation (2 golf courses with 224 acres), 1.5 MGD for residential irrigation, 2.2 MGD for other public access areas including 0.9 MGD for Florida Atlantic University (FL DEP 2004) and 0.7 MGD for on-site irrigation at the WWTP. The on-site irrigation was estimated by subtracting the on-site process use of 0.4 MGD from the total on-site use of 1.1 MGD. The CDM (1990) reclaimed water system master plan identified reuse demands of 2.1 MGD for golf courses, 9.9 MGD for residences, 2.4 MGD for other public access areas (landscape areas, green spaces, multi-family houses, highway medians, cemeteries, parks, recreational facilities, other public properties) and 0.9 MGD for Florida Atlantic University irrigation. It was assumed that golf course irrigation demand will be met by the year 2010, when 1.3 MGD is delivered to two more golf courses with 135 acres of land, as suggested by CDM (1990). It was also assumed that reclaimed water flows of 2.1 MGD for residential irrigation and 0.3 MGD for irrigation of other public access areas would be added every five years between the years 2010 and 2025 to satisfy the suggested residential and other public access irrigation reclaimed water demand.

b) Flows to traditional reuse under Alternatives II, III and IV. The reuse flow is projected to increase to 6 MGD by year 2010, 9.5 MGD by year 2015, and 18 MGD by year 2020 as large users within metropolitan distances of 2, 4 and 6 miles are connected to the reuse system. Under Alternatives III and IV reuse flows of 19.6 and 21.3 MGD would be reached by year 2025 through inclusion of all large users within 6.5 and 7.2 metropolitan miles of the WWTP.

c) Flows to ocean outfall and groundwater recharge. Under Alternatives I and II, the flows remaining after allocation to traditional reuse are sent to the ocean outfall. Since the flows to the ocean outfall would remain below the 2005 ocean outfall permitted capacity of 17.5 MGD, there would be no flow to groundwater recharge.

Under Alternative III, the wet weather period was 35.5 days for Boca Raton WWTP. The ocean outfall flow was calculated multiplying the traditional reuse flow with the ratio of the wet and dry days. Flow remaining after allocation to traditional reuse and ocean outfall is directed to groundwater recharge. The groundwater recharge flow of 8.3 MGD in 2010 is projected to diminish by 2025, as flow to traditional reuse increases.

Table 7-4. Flow distribution for Boca Raton WWTP

Alt.	Year	WWTP effluent (MGD)	Ocean outfall (MGD)	Traditional reuse (MGD)	Groundwater recharge (MGD)	RO concentrate (MGD)
I	2005	15.6	10.4	5.2	0.0	0.0
	2010	17.1	8.3	8.8	0.0	0.0
	2015	18.7	7.5	11.2	0.0	0.0
	2020	20.2	6.7	13.6	0.0	0.0
	2025	21.8	5.8	15.9	0.0	0.0
II	2005	15.6	10.4	5.2	0.0	0.0
	2010	17.1	11.1	6.0	0.0	0.0
	2015	18.7	9.1	9.5	0.0	0.0
	2020	20.2	2.2	18.0	0.0	0.0
	2025	21.8	0.5	21.3	0.0	0.0
III	2005	15.6	0.6	5.2	7.9	2.0
	2010	17.1	0.6	6.0	8.3	2.1
	2015	18.7	1.0	9.5	6.5	1.6
	2020	20.2	1.9	18.0	0.2	0.0
	2025	21.8	2.1	19.6	0.0	0.0
IV	2005	15.6	0.0	5.2	8.3	2.1
	2010	17.1	0.0	6.0	8.9	2.2
	2015	18.7	0.0	9.5	7.3	1.8
	2020	20.2	0.0	18.0	1.8	0.4
	2025	21.8	0.0	21.3	0.4	0.1

No flow may be sent to the ocean outfall under Alternative IV. The flow remaining after allocation to traditional reuse is therefore directed to groundwater recharge. The groundwater recharge flow under Alternative IV is projected to decrease from 8.9 MGD in 2010 to 0.4 MGD in 2025. Reverse osmosis concentrate flow varies in proportion to groundwater recharge flow.

7.3.3 Effluent and Reclaimed Water Distribution for the Broward/North WWTP

The distribution of effluent and reclaimed water from the Broward/North WWTP under the four ocean outfall alternatives is summarized in Table 7-5. Rationale for the flow allocations is discussed below.

a) Flows to traditional reuse under Alternative I. The utility currently delivers 2.4 MGD of flow for traditional reuse, which includes 1.3 MGD for on-site irrigation at the WWTP and 1.1 MGD for off-site use at the Broward County Office of Environmental Services septage receiving facility, Wheelabrator Environmental Services, and Pompano Commerce Park. The on-site irrigation was estimated by subtracting the on-site process use of 2.1 MGD from the total on-site use of 3.4 MGD. The utility plans to increase the total on-site and off-site reuse flow to 9.3 MGD by the year 2024 (Hazen and Sawyer 2004). The increase in traditional reuse to 4.2 MGD in 2010 includes the following reuse demands: 0.5 MGD for Pompano Commerce Park and 1.3 MGD for Wheelabrator Environmental Services if the company adds boilers at its resource recovery facility. Also, by the year 2010 a 2 MGD of reclaimed water will be added for on-site process use for WWTP expansion to 100 MGD. The next increase in traditional reuse to 5.3 MGD in 2015 includes 0.6 MGD for the Tam O'Shanter Golf Club and 0.4 MGD for the Crystal Lake Country Club.

Table 7-5. Flow distribution for Broward/North WWTP

Alt.	Year	WWTP effluent (MGD)	Ocean outfall (MGD)	Underground injection control wells (MGD)	Traditional reuse (MGD)	Groundwater recharge (MGD)	RO concentrate (MGD)
I	2005	84.2	51.7	30.0	2.4	0.0	0.0
	2010	88.6	54.3	30.0	4.2	0.0	0.0
	2015	90.8	55.5	30.0	5.3	0.0	0.0
	2020	92.2	56.9	30.0	5.3	0.0	0.0
	2025	94.1	58.8	30.0	5.3	0.0	0.0
II	2005	84.2	51.7	30.0	2.4	0.0	0.0
	2010	88.6	54.3	30.0	4.2	0.0	0.0
	2015	90.8	51.3	30.0	9.4	0.0	0.0
	2020	92.2	46.6	30.0	15.6	0.0	0.0
	2025	94.1	41.1	30.0	23.0	0.0	0.0
III	2005	84.2	0.3	30.0	2.4	41.2	10.3
	2010	88.6	0.4	30.0	4.2	43.1	10.8
	2015	90.8	1.0	30.0	9.4	40.3	10.1
	2020	92.2	1.6	30.0	15.6	36.0	9.0
	2025	94.1	2.4	30.0	23.0	30.9	7.7
IV	2005	84.2	0.0	30.0	2.4	41.4	10.3
	2010	88.6	0.0	30.0	4.2	43.5	10.9
	2015	90.8	0.0	30.0	9.4	41.1	10.3
	2020	92.2	0.0	30.0	15.6	37.3	9.3
	2025	94.1	0.0	30.0	23.0	32.8	8.2

b) Flows to traditional reuse under Alternatives II, III and IV. Traditional reuse demand under Alternatives II, III and IV is the same as under Alternative I until the year 2010. The reclaimed water demand is expected to increase to 9.4 MGD by the year 2015, which includes large users within 4 metropolitan miles of the WWTP. Connecting large users within 8 metropolitan miles of the WWTP by the year 2020 would increase the reuse demand to 15.6 MGD. A reuse demand 23 MGD by year 2025 would be realized by inclusion of all large users within 12.6 metropolitan miles of the WWTP.

c) Flows to ocean outfall and groundwater recharge. Flow to the underground injection wells is projected to remain at 30 MGD under all four alternatives. This is the current flow and is also the maximum flow that can be delivered to the wells according to their total 2005 permitted peak hourly flow of 60 MGD with a hourly peaking factor of 2.0.

Under Alternatives I and II, the flow remaining after allocation to traditional reuse and underground injection wells is sent to the ocean outfall. Since the flow to the ocean outfall remains below the 2005 ocean outfall capacity of 66 MGD, no flow is directed to groundwater recharge.

Under Alternative III, the wet weather period was 34.8 days for Broward/North WWTP. The ocean outfall flow was calculated multiplying the traditional reuse flow with the ratio of the wet and dry days. Flow remaining after allocation to traditional reuse, ocean outfall and underground injection wells is directed to groundwater recharge. The groundwater recharge flow is expected to decrease from 43.1 MGD in 2010 to 30.9 MGD by 2025, as flow to traditional reuse increases.

No flow to the ocean outfall is allowed under Alternative IV. In this case, the flow remaining after allocation to traditional reuse and underground injection wells is directed to groundwater recharge. The groundwater recharge flow is projected to decrease from 43.5 MGD in 2010 to 32.8 MGD in 2025 as flow to traditional reuse increases. Reverse osmosis concentrate flows vary in proportion to the groundwater recharge flow.

7.3.4 Effluent and Reclaimed Water Distribution for the Hollywood WWTP

The distribution of effluent and reclaimed water from the Hollywood WWTP under the four ocean outfall alternatives is summarized in Table 7-6. Rationale for the flow allocations is discussed below.

a) Flows to traditional reuse under Alternative I. The utility currently delivers 2.6 MGD of reclaimed water flow to six golf courses. There are plans to add infrastructure to supply reclaimed water for a golf course and other landscape irrigation, bringing capacity to 4 MGD (FL DEP 2004). It was assumed that this reuse demand will be met by the year 2010.

b) Flows to traditional reuse under Alternatives II, III and IV. Reuse demand under Alternatives II, III and IV will remain the same as under Alternative I through 2010. Reclaimed water flow would be increased to 4.2 MGD by year 2015, 5.2 MGD by year 2020, and 6.1 MGD by year 2025 through connection of the large users within 5, 10 and 12.5 metropolitan miles of the WWTP.

c) Flows to ocean outfall and groundwater recharge. Under Alternatives I, II and III, the flow remaining after allocation to traditional reuse is sent to the ocean outfall and groundwater recharge. The ocean outfall 2005 permitted capacity of 46.3 MGD would be reached by year 2020 under Alternative I. Groundwater recharge flow under this alternative is projected at 0.8 MGD in 2020, increasing to 3.6 MGD by 2025. Under Alternative II, the ocean outfall is expected to reach its capacity by the year 2025. The groundwater recharge flow in this year is projected at 1.7 MGD.

Table 7-6. Flow distribution for Hollywood WWTP

Alt.	Year	WWTP effluent (MGD)	Ocean outfall (MGD)	Traditional reuse (MGD)	Groundwater recharge (MGD)	RO concentrate (MGD)
I	2005	40.0	37.4	2.6	0.0	0.0
	2010	43.5	39.9	3.6	0.0	0.0
	2015	47.2	43.5	3.6	0.0	0.0
	2020	50.9	46.3	3.6	0.8	0.2
	2025	54.5	46.3	3.6	3.6	0.9
II	2005	40.0	37.4	2.6	0.0	0.0
	2010	43.5	39.9	3.6	0.0	0.0
	2015	47.2	42.9	4.2	0.0	0.0
	2020	50.9	45.6	5.2	0.0	0.0
	2025	54.5	46.3	6.1	1.7	0.4
III	2005	40.0	0.3	2.6	29.7	7.4
	2010	43.5	0.4	3.6	31.6	7.9
	2015	47.2	0.4	4.2	34.0	8.5
	2020	50.9	0.6	5.2	36.1	9.0
	2025	54.5	0.6	6.1	38.2	9.5
IV	2005	40.0	0.0	2.6	29.9	7.5
	2010	43.5	0.0	3.6	31.9	8.0
	2015	47.2	0.0	4.2	34.3	8.6
	2020	50.9	0.0	5.2	36.5	9.1
	2025	54.5	0.0	6.1	38.7	9.7

Under Alternative III, the wet weather period was 34.8 days for Hollywood WWTP. The ocean outfall flow was calculated multiplying the traditional reuse flow with the ratio of the wet and dry days. The groundwater recharge flow is projected to increase from 29.7 MGD in 2005 to 38.2 MGD in 2025.

No flow to the ocean outfall is allowed under Alternative IV. Accordingly, all flow remaining after allocation to traditional reuse flow would be directed to groundwater recharge. The projected groundwater recharge flow is very similar to the flows under Alternative III. Reverse osmosis concentrate varies in proportion to the groundwater recharge flow.

7.3.5 Effluent and Reclaimed Water Distribution for the Miami-Dade/North WWTP

The distribution of effluent and reclaimed water from the Miami-Dade/North WWTP under the four ocean outfall alternatives is summarized in Table 7-7. Rationale for the flow allocations is discussed below.

a) Flows to traditional reuse under Alternative I. The utility currently uses 2.2 MGD of reclaimed water for on-site process use and 0.1 MGD for irrigation at Florida International University. There are no plans to increase the reclaimed water flow (PBS&J 2003; FL DEP 2004).

Table 7-7. Flow distribution for Miami-Dade/North WWTP

Alt.	Year	WWTP effluent (MGD)	Ocean outfall (MGD)	Traditional reuse (MGD)	Groundwater recharge (MGD)	RO concentrate (MGD)
I	2005	107.9	107.8	0.1	0.0	0.0
	2010	111.9	111.8	0.1	0.0	0.0
	2015	116.6	112.5	0.1	3.2	0.8
	2020	121.3	112.5	0.1	6.9	1.7
	2025	126.3	112.5	0.1	10.9	2.7
II	2005	107.9	107.8	0.1	0.0	0.0
	2010	111.9	111.4	0.5	0.0	0.0
	2015	116.6	112.5	2.0	1.7	0.4
	2020	121.3	112.5	2.4	5.1	1.3
	2025	126.3	112.5	3.7	8.0	2.0
III	2005	107.9	0.0	0.1	86.2	21.6
	2010	111.9	0.1	0.5	89.1	22.3
	2015	116.6	0.2	2.0	91.5	22.9
	2020	121.3	0.3	2.4	94.9	23.7
	2025	126.3	0.4	3.7	97.7	24.4
IV	2005	107.9	0.0	0.1	86.2	21.6
	2010	111.9	0.0	0.5	89.1	22.3
	2015	116.6	0.0	2.0	91.7	22.9
	2020	121.3	0.0	2.4	95.1	23.8
	2025	126.3	0.0	3.7	98.0	24.5

b) Flows to traditional reuse under Alternatives II, III and IV. The reclaimed water flow could be increased to 0.5 MGD by year 2010, 2 MGD by year 2015, 2.4 MGD by year 2020, and 3.7 MGD by year 2025 by connecting the large users within 3, 5, 7 and 8.4 metropolitan miles of the WWTP.

c) Flows to ocean outfall and groundwater recharge. Under Alternatives I, II and III the flow remaining after allocation to traditional reuse is sent to the ocean outfall and groundwater recharge. Under Alternative I, the ocean outfall 2005 permitted capacity of 112.5 MGD would be reached by 2015, with a groundwater recharge flow of 3.2 MGD in that year, increasing to 10.9 MGD by year 2025. Similarly under Alternative II, the ocean outfall permitted capacity would be reached by the year 2015, with a groundwater recharge flow in that year of 1.7 MGD, increasing to 8.0 MGD by the year 2025.

Under Alternative III, the wet weather period was 38.5 days for Miami-Dade/North WWTP. The ocean outfall flow was calculated multiplying the traditional reuse flow with the ratio of the wet and dry days. The groundwater recharge flow is projected to increase from 86.2 MGD in 2005 to 97.7 MGD in 2025.

Under Alternative IV there is no flow to the ocean outfall. The flow remaining after allocation to traditional reuse would be directed to groundwater recharge. The groundwater recharge flows are very similar to the flows under Alternative III. Reverse osmosis concentrate flow varies in proportion to groundwater recharge flow.

7.3.6 Effluent and Reclaimed Water Distribution for the Miami-Dade/Central WWTP

The distribution of effluent and reclaimed water from the Miami-Dade/Central WWTP under the four ocean outfall alternatives is summarized in Table 7-8. Rationale for the flow allocations is discussed below.

a) Flows to traditional reuse under Alternative I. The utility currently uses 8.9 MGD for on-site process use. There are no plans to increase reclaimed water flow (PBS&J 2003; FL DEP 2004).

b) Flows to traditional reuse under Alternatives II, III and IV. The demand for traditional reuse could be increased to 0.4 MGD by year 2010, 1 MGD by year 2015, 2.1 MGD by year 2020, and 2.9 MGD by year 2025 through inclusion of the large users within 5, 8, 10 and 10.6 metropolitan miles of the WWTP. Since the chloride levels are high at the Miami-Dade/Central WWTP, users with landscapes resistant to high-chloride levels would be required.

c) Flows to ocean outfall and groundwater recharge. Under Alternatives I, II and III the flow remaining after allocation to traditional reuse is sent to the ocean outfall and groundwater recharge. Under Alternatives I and II, the ocean outfall 2005 permitted capacity of 143 MGD would be reached by 2020. Under Alternative I, groundwater recharge flow will be 1.9 MGD in that year, increasing to 6.7 MGD by year 2025. Under Alternative II, groundwater recharge flow will increase to 4.4 MGD by the year 2025.

Under Alternative III, the wet weather period was 38.5 days for Miami-Dade/Central WWTP. The ocean outfall flow was calculated multiplying the traditional reuse flow with the ratio of the wet and dry days. The groundwater recharge flow is projected to increase from 103.5 MGD in 2005 to 118.5 MGD in 2025.

Table 7-8. Flow distribution for Miami-Dade/Central WWTP

Alt.	Year	WWTP effluent (MGD)	Ocean outfall (MGD)	Traditional reuse (MGD)	Groundwater recharge (MGD)	RO concentrate (MGD)
I	2005	129.4	129.4	0.0	0.0	0.0
	2010	134.1	134.1	0.0	0.0	0.0
	2015	139.8	139.8	0.0	0.0	0.0
	2020	145.4	143.0	0.0	1.9	0.5
	2025	151.3	143.0	0.0	6.7	1.7
II	2005	129.4	129.4	0.0	0.0	0.0
	2010	134.1	133.7	0.4	0.0	0.0
	2015	139.8	138.9	1.0	0.0	0.0
	2020	145.4	143.0	2.1	0.2	0.1
	2025	151.3	143.0	2.9	4.4	1.1
III	2005	129.4	0.0	0.0	103.5	25.9
	2010	134.1	0.1	0.4	106.9	26.7
	2015	139.8	0.1	1.0	111.0	27.8
	2020	145.4	0.2	2.1	114.5	28.6
	2025	151.3	0.3	2.9	118.5	29.6
IV	2005	129.4	0.0	0.0	103.5	25.9
	2010	134.1	0.0	0.4	106.9	26.7
	2015	139.8	0.0	1.0	111.1	27.8
	2020	145.4	0.0	2.1	114.6	28.7
	2025	151.3	0.0	2.9	118.8	29.7

Under Alternative IV, no flow may be sent to the ocean outfall. The flow remaining after allocation to traditional reuse would be directed to groundwater recharge. The projected groundwater recharge flow is very similar to the flows under Alternative III. Reverse osmosis concentration varies in proportion to groundwater recharge flow.

7.4 Wastewater Management Options and their Water Quality Requirements

Current and potential treatment requirements for the considered wastewater management options are summarized in Table 7-9.

Dischargers to Class I injection wells were required to provide secondary treatment with no disinfection. The U.S. EPA published new rules governing Class I underground injection wells in 24 Florida Counties including Palm Beach, Broward and Miami-Dade Counties on 11/22/05. These federal rules became effective on 12/22/05. The new requirements for underground injection wells include secondary treatment with filtration and high-level disinfection. Secondary treatment with filtration and high-level disinfection is required for reclaimed water supplied for traditional (public access) reuse activities. Groundwater recharge would require full treatment and disinfection. The regulatory requirements for these wastewater management options are shown in Table 7-10. Ocean outfall dischargers are currently required to provide secondary treatment with basic-level disinfection as explained in Chapter 2, Table 2-5. The future requirements for ocean outfalls could include intermediate or full nutrient control (Table 7-11) with basic-level disinfection. Reclaimed water suitable for groundwater recharge would also be sufficiently low in phosphorus concentration (< 10 μg/L) for use as makeup water for the Everglades.

Table 7-9. Current and Potential Treatment Requirements of Wastewater Management Options*

Option	Treatment requirements	
	Current	**Potential**
Ocean outfalls	Secondary with basic-level disinfection (T2)	Intermediate or full nutrient control w/ basic-level disinfection (T4/T5)
Class I injection wells	Secondary with no disinfection (T1)	Secondary w/ filtration & high-level disinfection (T3)
Traditional reuse	Secondary w/ filtration & high-level disinfection (T3)	
Groundwater recharge	Full treatment and disinfection (T6)	

*Process trains (T1, T2, etc.) capable of meeting the requirements are described in Figure 7-1

In order to conceptualize the linkage between process trains and the different wastewater management options, a code is appended to each treatment requirement in Table 7-9. This code (T1, T2, etc.) identifies a specific process train that has been conceptualized for meeting the effluent quality requirements of the associated wastewater management option. The process trains are presented in Figure 7-1. Schematic diagrams of the process sequences along with information about the application of each process train and the effluent quality standards that the process train is capable of meeting are given in Appendix 2. There are many options for process sequences that could meet the requirements shown in Table 7-9. The appropriate choice would be influenced by site-specific conditions.

Table 7-10. Regulatory Requirements for Different Wastewater Management Options

Parameter	Units	Limit	Class I Injection Wells *	Public Access Reuse	Groundwater Recharge
$CBOD_5$	mg/L	Maximum annual average	20	20	-
TSS	mg/L	Maximum annual average	20	5.0	-
Total Nitrogen as N	mg/L	Maximum annual average	-	-	10
Total Phosphorus as P	mg/L	Maximum annual average	-	-	-
Total Dissolved Solids (TDS)	mg/L	Maximum annual average	-	-	500
Total Organic Carbon (TOC)	mg/L	Maximum monthly average	-	-	3.0
Total Organic Halogen (TOX)	mg/L	Maximum monthly average	-	-	0.2
Fecal Coliforms			-	**	***

* These requirements are for secondary treatment with no disinfection and do not include the new rules by U.S. EPA published on 11/22/05 and became effective on 12/22/05.

** *[62-600.440(5)f]*

- Over a 30-day period, 75 percent of the fecal coliform values shall be below the detection limits.
- Any one sample shall not exceed 25 fecal coliform values per 100 mL of sample.
- Any one sample shall not exceed 5.0 milligrams per liter of TSS at a point before application of the disinfectant.

*** Total coliforms undetectable, any one sample shall not exceed 4 total coliform values per 100 mL of sample.

Table 7-11. Assumed Annual Effluent Limits for Ocean Outfall Disposal

Parameter	Units	Level of nutrient control	
		Intermediate	Full
$CBOD_5$	mg/L	10.0	5.0
TSS	mg/L	10.0	5.0
Total Nitrogen	mg/L as N	10.0	3.0
Total Phosphorus	mg/L as P	3.0	1.0

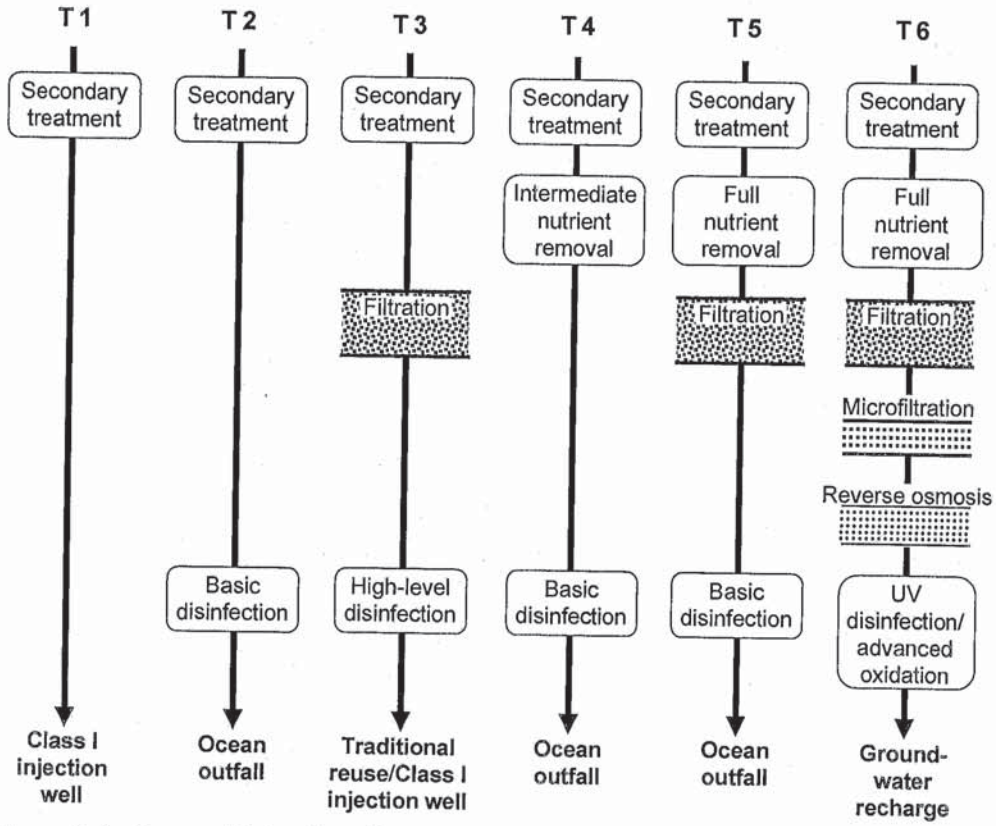

Figure 7-1. Process Trains Capable of Meeting Current and Potential Treatment Requirements of Wastewater Management Options

7.5 Summary

- The Boynton-Delray and Boca Raton WWTPs are reclaiming 19% and 33%, respectively, of their 2005 total wastewater flows for traditional reuse
- The Broward/North and Hollywood WWTPs are reclaiming 3% and 7%, respectively, of their 2005 total wastewater flows for traditional reuse
- The Miami-Dade/North and Miami-Dade/Central WWTPs are using small amounts of reclaimed water—mainly for on-site process use; therefore traditional reuse constitutes 0% of their 2005 total wastewater flows
- Under current plans (Alternative I), the Boynton-Delray and Boca Raton WWTPs would increase their reuse percentages to 28% and 73%, respectively, by 2025
- Under current plans (Alternative I), the Broward/North would increase its reuse percentage slightly (to 6%) by 2025
- Under current plans (Alternative I), the Hollywood, Miami-Dade/North and Miami-Dade/Central WWTPs would see no increase in their reuse percentages by 2025

- Under Alternatives II, III and IV, the Boynton-Delray and Boca Raton WWTPs would increase their reuse percentages to 84% and greater than 90%, respectively
- Under Alternatives II, III and IV, the Broward/North and Hollywood WWTPs would increase their reuse percentages to 24% and 11%, respectively
- Under Alternatives II, III and IV, the Miami-Dade/North and Miami-Dade/Central WWTPs would increase their reuse percentages to 3% and 2%, respectively

As seen from Alternatives II, III and IV, the WWTPs in Palm Beach County (Boynton-Delray and Boca Raton) have large potential for traditional reuse. The WWTPs in Miami-Dade County (Miami-Dade/North and Miami-Dade/Central) have small potential for traditional reuse but high potential for groundwater recharge. However, groundwater recharge costs for the Miami-Dade/Central WWTP are high relative to the estimated groundwater recharge costs for other five facilities due to the large transmission costs from the WWTP to groundwater recharge sites on the mainland.

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8. Indicators

The 2003 Reuse Strategies Report (Reuse Coordinating Committee and the Water Conservation Initiative Water Reuse Work Group 2003) presented the following vision for water reuse in Florida in 2020:

- Water reuse will be employed by all domestic wastewater treatment facilities having capacities of 0.1 million gallons per day (MGD) and larger. Statewide, on the order of 65 percent of all domestic wastewater will be reclaimed and reused for beneficial purposes.
- Effluent disposal using ocean outfalls, other surface discharges, and deep injection wells will be largely limited to facilities that serve as backups to water reuse facilities.
- Regulatory agencies, health agencies, utilities, and the public will embrace a "water is water" philosophy and will fully and readily accept the full range of water reuse options and the full range of alternative water supplies.
- Reclaimed water will be used in an efficient and effective manner, as a means to conserve and recharge potable quality water resources. Newer reuse systems will have potable quality water offsets and/or recharge fractions of 75 percent or larger.
- Groundwater recharge and indirect potable reuse projects will become common practice.
- Membrane treatment technologies will be widely used for the production of high-quality reclaimed water, particularly for the control of pathogens and organic compounds.
- Ultraviolet (UV) disinfection will be the norm for water reuse and domestic wastewater facilities.
- Use of satellite facilities will be common practice, particularly in the larger urban areas, as a means for enabling effective use of reclaimed water.
- Reclaimed water will be widely used to flush toilets in commercial facilities, industrial facilities, hotels and motels, and multiple-family residential units in Florida.

The second of the above goals relates to the stated desire to reduce disposal of treated wastewater via ocean outfalls and deep injection wells. This study focuses on evaluating current prospects for reuse based on specific evaluations of the six ocean outfalls in Southeast Florida.

The 2003 Reuse Strategies Report (Reuse Coordinating Committee and the Water Conservation Initiative Water Reuse Work Group 2003) used the following three criteria to rank a variety of water conservation initiatives including water reuse:

- Amount of water saved (maximum of 5 points)
- Cost effectiveness (maximum of 3 points)
- Ease of implementing (maximum of 3 points)

These three criteria are used in this report with a fourth criterion and a point system was not used during the evaluation of these indicators.

- Public health and Environmental impact

Definitions of these criteria and how they are measured are presented below.

8.1 Amount of Water Saved

Whitcomb (2005) provides data on water use throughout Florida for single family homes. His summary statistics can be used to estimate indoor and outdoor water use for the six water utilities in southeast Florida. Based on a detailed evaluation of the tax assessor's database for every parcel in Florida, Whitcomb (2005) developed the following median attributes of residential users:

- Property value = $84,330
- Year built = 1979
- House size = 1,747 square feet
- Lot size = 9,931 square feet (0.23 acres).

Heaney (1998) and Mayer (1999) summarized the results of a nationwide evaluation of water use in 1,200 houses in 12 cities across North America, including Tampa, Florida. The average annual water use for the 100 residences in Tampa was 98,900 gallons per year of which 54.5% was indoor and 45.5% was outdoor. Using the Tampa numbers to calibrate the estimates for Southeast Florida yields the following irrigation estimates for SE Florida:

- People/house = 2.5
- Indoor gal./capita/day = 60
- Irrigation rate, feet/year = 3.0
- % of non-house area that is irrigated = 25%

These calibrated estimates indicate the following median water use per residence in Southeast Florida:

- Indoor water use = 54,750 gallons per year
- Irrigation water use = 45,800 gallons per year
- Irrigable area per house about 2,000 square feet.

Water use per square foot of house and irrigated area are similar (31 vs. 23 gal/sq ft/yr). At this rate, each added person has an average annual outdoor demand equivalent to applying 3 feet of water on 800 square feet of area.

A study by GEC (2003) indicates that water users in Southeast Florida are often classified by the water utilities as being high outdoor water users if their outdoor water use is about 65% of total use. Similarly, medium outdoor water use is defined as 50% outdoor water use and low outdoor water use is considered to be 35% of total use.

Water utilities in Southeast Florida employ conservation rate structures wherein the first block is assumed to represent indoor water use. Whitcomb (2005) lists the initial block as monthly water use up to 4,000 gallons for Palm Beach County and 3,750 gallons for Miami-Dade County. These numbers are slightly less than our estimate of outdoor use for Tampa of 4,500 gallons per month.

Whitcomb (2005) estimates the following percentages of residential customers who use individual wells for irrigation.

- Miami-Dade—27%
- Palm Beach—20%
- Broward—No estimate provided
- Average for Florida—28%

Local data are needed to get accurate information on individual irrigation wells. Using the average of the three estimates shown above results in an estimate that 25% of the residential customers have individual irrigation wells. We could not find any data that showed the spatial distribution of individual wells.

Irrigation is the largest water user in Florida and in many parts of the United States. Most of this irrigation is for agricultural purposes. As mentioned above, irrigation accounts for roughly 40 to 60% of residential water use in urban areas. Outdoor water use is much more sensitive to increasing prices. Whitcomb (2005) recently completed the largest study ever conducted on how water rates affect single-family residential water use in Florida. An illustrative increasing block rate structure for water supply is shown in Figure 8-1 (SWFWMD 2005). The lowest rate of $1.50/1,000 gallons is for the initial 5,000 gallons per month which approximates indoor water usage for a typical family. The rate then jumps to $2.50/1,000 gallons for the next 7,500 gallons per month. This range would represent the outdoor water use by a typical family. Usage beyond 12,500 gallons per month is charged an even higher rate of $3.50/1,000 gallons. The purpose of the conservation rate structure is to assure that people can have access to relatively inexpensive water for their more critical indoor needs. However, it also tries to reduce outdoor water use that is less critical by charging higher rates for this less vital use of water.

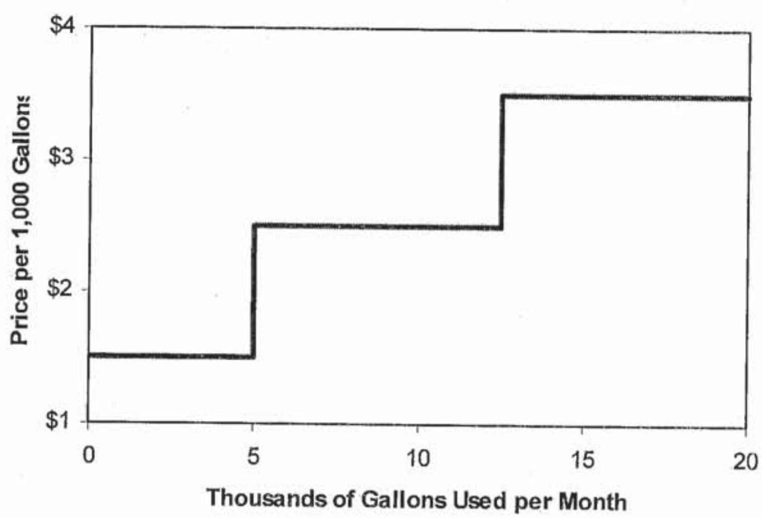

Figure 8-1. Inclining Block Rate Structure Example

Whitcomb (2005) divided single-family residential water customers into four profiles based on assessed property values of homes, with Profile 1 being the homes with the lowest assessed value and Profile 4 the highest. Demand curves for water in Florida are shown in Figure 8-2. The report takes several factors into account when calculating water demand per household. Factors such as net irrigation rate, people per household, pool data, and irrigation restriction data were normalized in this calculation and shown as such in Figure 8-2. At relatively low water prices of $2.00/1,000 gallons, per capita demand for a Profile 2-3 user would be about 180 gal/capita/day. Profile 2-3 represents the average single-family residential water customer based on property value and is represented in Figure 8-2 by interpolating between the Profile 2 and Profile 3 demand curves. Indoor water use is about 60-70 gal/capita/day so about 2/3 of the water use is outdoor. If the water price is $4.00/1,000 gallons, then the demand for the profile 2-3 user decreases sharply to about 120 gal/capita/day, a 33% reduction. Now the mix of indoor and outdoor water use is about equal. This is about where we are in Southeast Florida at present. If water prices are $6.00/1,000 gallons, then total water use drops to about 90 gal/capita/day and outdoor water use is only about 33% of total use. Finally, at $8.00/1,000 gallons, water demand is about 70 gal/capita/day with outdoor water use constituting an even smaller percentage of total water use. As prices increase, indoor water use can be expected to decline. Best estimates at present are that indoor water use will decrease from 60 to about 40 gal/capita/day due to the installation of low-flush toilets and other water saving devices. Thus, given expected increasing scarcity of water, prices will increase and people will use water more efficiently.

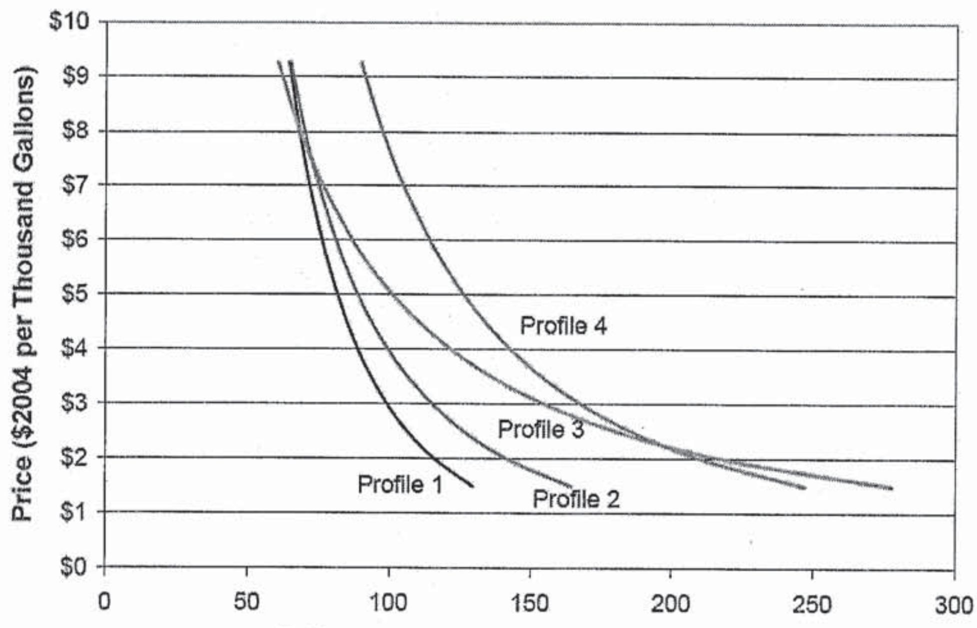

Figure 8-2. Demand for water as a function of price in Florida for four wealth profiles (Whitcomb 2005)

Irrigation water use per family can also be expected to decline due to smaller irrigable area per family. About one half of the future housing starts in southeast Florida will be multi-family dwellings. As land use intensifies, irrigable area per family can be expected to decline. Thus, overall, future outdoor water use per family should decrease. However, additional population growth can be expected to offset these savings. Also, the need for much more high quality water going to the Everglades will further intensify competition for the available fresh water supply. It is reasonable to assume that a larger percentage of future water use will be for indoor purposes. The water demand forecasts presented in Chapter 3 assumed a constant per capita usage over the planning horizion from 2005 to 2025. These estimates were based on the best available information from published reports by consultants and planning agencies in Southeast Florida. They probably did not take into account the very recent results of Whitcomb (2005) that were described in this section. In terms of reuse planning, it is probably more accurate to assume that per capita outdoor water use will decline due to a combination of decreased irrigable area and more efficient irrigation practices in response to the growing scarcity and cost of water. On the other hand, water use forecasts for Southeast Florida need to more fully incorporate the demand for fresh water associated with the Everglades Restoration.

8.2 Public Health and Environmental impact

A wide range of pollutants are removed by wastewater treatment processes. Water quality regulations are typically based on key indicators of water quality that are most important for a receiving water. Total maximum daily loads are being calculated for receiving waters throughout the State of Florida. Drew (2005) summarizes the first five years of this program. She notes that Florida has 52,000 miles of rivers and streams, nearly 800 lakes, 4,500 square miles of estuaries, and more than 700 springs. Drew (2005) points out three open issues with regard to assessing receiving water quality in Florida as described below:

- *Most Florida waterways are identified as Class III, "fishable and swimmable." It has become clear in recent years that this classification, which includes rivers, streams, lakes and estuaries as well as wetlands, urban drainage ditches, urban lakes, and canal systems, is too broad. Some of these water bodies or water body types never did and indeed should not be expected to provide the same quality of "swimmable or fishable" recreation as others.*
- *Florida's freshwater dissolved oxygen (DO) criterion requires oxygen levels in surface waters to be at or above five milligrams per liter (5 mg/l) at all times at all places, ostensibly in an effort to protect water quality. In fact, wetlands, springs, drainage ditches, and canals do not typically exist, whether naturally or as artificially created, with DO levels as high as 5 mg/l, often because of the significant inflow of low-oxygen groundwater into surface waters. In effect, some water bodies are being required to meet unnatural conditions or conditions that are not otherwise caused by pollutants.*
- *The state's criteria for nutrients (nitrogen and phosphorous, for example) are narrative rather than numeric, which on occasion has led to differing interpretations by third parties on DEP's determination as to whether a water body is impaired by excessive nutrients.*

Drew (2005) listed the primary pollutants that are causing the impairment of Florida's surface waters and the number of water body segments impaired. These were:

- *Nutrients, such as nitrogen and phosphorus, which promote the growth of algae and other aquatic plants that cause wide swings in oxygen levels and lead to fish kills and damaged habitat-373 segments*
- *Bacteria, which may threaten public health and can close waters to swimming or shellfish harvesting-236 segments*
- *Metals, such as iron, silver, copper, cadmium, and zinc that adversely affect the health and reproduction of aquatic organisms-61 segments*
- *Mercury, based largely on the existence of Department of Health fish consumption advisories. (It generally is agreed that mercury is predominately the result of atmospheric deposition, but the relative contributions of local, regional and even global sources remains the subject of debate.)-40 segments*

Water reuse is an important benefit of a total maximum daily load program. For a given receiving water, a determination is made of the allowable load of the constituent(s) of interest. Then, a combination of point and nonpoint controls must be installed to avoid exceeding this allowable load. Reclaimed water can be given full credit for eliminating a discharge to a receiving water. Thus, it is very attractive from this point of view for most receiving waters.

In the case of ocean disposal via outfalls, the assimilative capacity of the ocean is extremely large. Thus, total maximum daily loads have not been developed for these cases. From a total maximum daily load perspective, discharge to an ocean outfall or landside water reuse eliminates a direct source of pollution to a receiving water.

For ocean disposal via outfalls, one may distinguish two different environments:

1. Discharge to open marine waters
2. Discharge to open marine waters that are near reefs.

Existing evidence suggests that the human and ecological risks from ocean outfalls are low because the wastewater is treated to reduce the contaminants and the rapid mixing and dilution reduces residual impacts to low levels (US EPA 2003). Studies by Tichenor (Tichenor 2003; Tichenor 2004b; Tichenor 2004a) suggest that the outfall discharge at Boynton Beach may be having an adverse effect on Lynn's Reef. A biomarker study by Fauth et al. (Fauth et al. 2006) also indicates that reefs are being impacted. However, neither of these studies attempted to directly link the outfall discharges to reef impacts by measuring the concentrations of contaminants from the outfalls. LaPointe et al. (2004) have shown how wastewater discharges can detrimentally impact reefs in the Florida Keys. In this case, the wastewater discharges are not by ocean outfalls and the effluents are discharged in close proximity to the reefs with much less dilution. If scientific evidence demonstrates that current wastewater treatment levels are insufficient to protect water quality, then more stringent treatment requirements such as intermediate or full nutrient control may be imposed in the future. However, the current water quality impacts near these six ocean outfalls are less obvious than in other receiving waters in the State of Florida that have experienced more apparent impacts such as widespread algal blooms.

8.3 Cost Effectiveness

8.3.1 Cost of the Reuse System

Water and wastewater infrastructure are very capital intensive with long service lives that extend to 100 years for some transmission systems. For this project, excellent information is available on how costs should be calculated. The Florida DEP (1991) developed guidelines for estimating costs for reuse projects. The Reuse Coordinating Committee (1996) for the State of Florida expanded on the 1991 FL DEP guidelines. The 1996 Reuse Feasibility Study Guidelines deal with preparation of reuse feasibility studies by water users (applicants for consumptive use permits). The LEES (1997) report contains excellent cost information for water and wastewater systems. This database was updated and refined by SFWMD (2004) as part of the South Florida Water Management District's water supply planning program. In addition to these general references, numerous consulting reports on water and wastewater infrastructure in Southeast Florida provided additional cost information. Finally, state of the art wastewater treatment cost estimating software called CapdetWorks was used to do more detailed process-level cost estimating (Hydromantis Inc., Hamilton, Ontario, Canada). All costs are expressed in July 2005 dollars. A discount rate of 7% and a service life of 20 years are assumed, consistent with the LEES (1997) report.

8.3.2 Benefits of the Reuse System

As described above, customers on the central water supply system are paying in the range of \$4.00 per 1,000 gallons for water. Typically, they would be paying this rate as the second step in the water use rate structure. Thus, if reclaimed water is available, they would save this amount assuming that the reclaimed water was provided free of a separate charge.

8.3.3 Determining the Optimal Amount of Reuse

As detailed in Chapter 6, two definitions of optimality can be used for this problem. If the utility follows a profit maximizing objective, then the optimal amount of reclaimed water is found by maximizing total benefits minus total costs. This model is typically used by private enterprise. However, public utilities have traditionally used a breakeven objective of finding that flow where total benefits = total costs. Public utilities are regulated as monopolies. Thus, they are typically restricted to recovering their costs including a "fair" rate of return on their investment (AWWA 1990; AWWA 1999). This is an important point as illustrated by the simple example shown below.

Assume that total benefits from reuse, $TB = 3x$ and total costs for reuse, $TC = x^2/2$ where x = amount of reuse. Thus, the net benefits (NB) are given by

$$NB = TB - TC = 3x - x^2/2 \qquad (8\text{-}1)$$

This net benefit function is plotted in Figure 8-3.

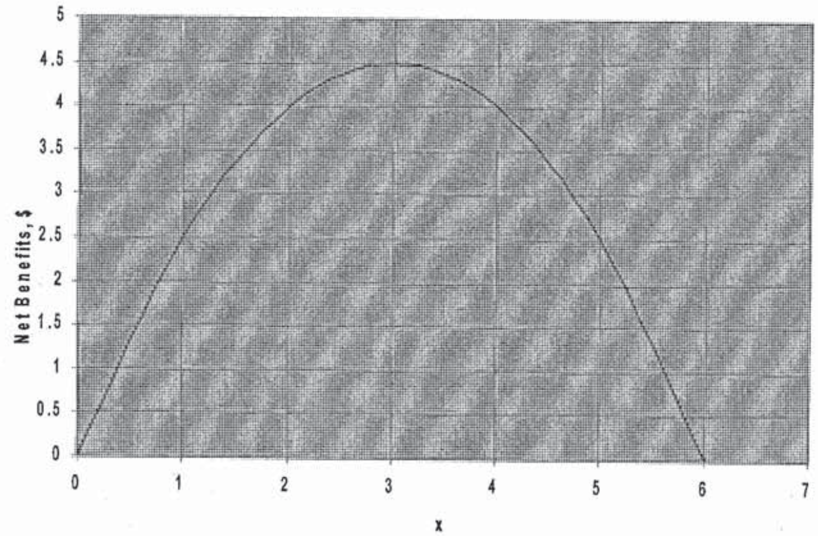

Figure 8-3. Hypothetical Net Benefit Function for Water Reuse

If the utility seeks to maximize net benefits, then the optimal solution is a net benefit of $4.50 and 3 units of reclaimed water would be provided. However, if the utility seeks to maximize the amount of reclaimed water provided subject to breaking even, i.e., net benefits = 0, then 6 units of reclaimed water will be provided. The breakeven objective has been used traditionally for public utilities. Both solutions were presented for the cost effectiveness analysis.

8.4 Ease of Implementation

The results of three recent surveys of public acceptance of reuse are shown in Table 8-1. Public acceptance is very high for irrigation types of reuse. It is also high for other non-human contact uses such as street sweeping, fire protection, concrete production, vehicular wash water and dust control. Toilet flushing is also considered to be an acceptable use. However, toilet flushing is not widely used at this time with the exception of newer high rise construction. Discharge of reclaimed water to augment streams and wetlands is less favored and also has significant regulatory hurdles. Water reuse associated with human contact and/or ingestion is less popular (Marks 2003; Po et al. 2003; CDM 2004; Hartley 2006) Similarly, early social-psychological studies of Bruvold (1988) showed that greater than 94% of the respondents were positive towards using reclaimed water for irrigation purposes whereas 77% were positive towards using reclaimed water to recharge groundwater and 44% were positive towards drinking reclaimed water. Proactive utilities (Orange County, CA and Singapore, for example) have successfully implemented projects involving groundwater recharge and indirect potable reuse, respectively. This was achieved through engagement of the public throughout the planning, implementation and operational phases of the projects, documentation of the ability of the water reclamation system to reliably meet water quality goals, and scientific validation of the absence of health impacts from ingestion of reclaimed water (FSAWWA Water Conservation Committee 1999; Macpherson et al. 2003; Crook 2004). A good example of the public engagement is the approach developed by the City of

San Diego to study all aspects of a viable water reuse program (City of San Diego 2005). Steps of the study approach are

- Assemble stakeholders and identify issues
- Develop a public involvement program
- Identify reuse opportunities and investigate issues
- Assess reuse opportunities based on community values

It should also be noted that generating public acceptance of traditional reuse activities such as irrigation of public access landscapes may translate to greater potential for generating public support for indirect potable reuse and groundwater recharge.

Table 8-1. Positive and Negative Responses* to Potential Alternatives for Reclaimed Water. Adapted from CDM (2004)

Use	% Yes WW operators	% Yes Tampa	% Yes San Fran.
Concrete production	90%		
Golf course irrigation	89%		96%
Street cleaning	87%		96%
Irrigation of highway right of way	85%		
Fire protection	84%		98%
Irrigation of parks			96%
Irrigation of athletic fields	84%		
Wetland creation	84%		
Dust control	82%		
Irrigation of agricultural crops	82%		
Irrigation of office parks and business campuses	82%	94%	
Toilet flushing	80%		92%
Industrial process water	78%		
Vehicle wash water	76%		
Residential landscape irrigation & maintenance	74%	84%	
Stream augmentation	67%		
Ornamental ponds/fountains	56%		
Potable reuse-indirect	40%		
Irrigation of crops for direct human consumption	30%		
Potable reuse-direct	18%		
Pools/spas	15%		

*Based on a survey of 50 wastewater treatment plant operators and managers and 15,000 Tampa customers

8.5 Summary

Four indicators of amount of water saved (freshwater savings), cost effectiveness, public health and environmental impact (nutrient load reduction) and ease of implementation (public acceptance) are used in the evaluation of the alternatives without a point system applied.

- Several studies have shown that residential irrigation accounts for 35 to 65% of residential water use in urban areas. In terms of reuse planning, it is expected that per capita outdoor water use will decline due to a combination of decreased irrigable area and more efficient irrigation practices in response to the growing scarcity and cost of water. The indoor water use is also estimated to decrease from 60 to about 40 gal/capita/day due to the installation of low-flush toilets and other water saving devices.
- Nutrients (nitrogen and phosphorus) are found to be among the primary pollutants that are causing the impairment of Florida's surface waters. Some studies have shown evidence for reef damage from ocean outfalls. However, there is need for definitive studies that explore the link between wastewater disposal through ocean outfalls and reefs.
- The water users in the second step of the rate structure are paying in the range of $4.00 per 1,000 gallons for water. If reclaimed water is available, they would save this amount assuming that the reclaimed water was provided free of a separate charge.
- Public acceptance of reclaimed water used for irrigation is higher than groundwater recharge. Public education programs and community involvement throughout the planning, implementation, and continued use of water reuse projects can help mitigate public concerns.

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9. Evaluation of Ocean Outfall Strategies

An evaluation of the four ocean outfall strategies (use at current levels, limited use, use as backup for traditional reuse, and no use) with respect to four indicators (pollutant load reduction, cost effectiveness, amount of freshwater saved and public acceptance) is presented in this chapter. Methods for quantifying the indicators are described in Section 9.1, followed by presentation of indicator outcomes in Sections 9.2–9.7, comparison of the outcomes among the six WWTPs in Section 9.8, and a summary in Section 9.9.

9.1 Methods for Quantifying Indicators

Methods for estimating freshwater savings, nutrient load reductions, and costs for liquid treatment, reuse and disposal are described below.

9.1.1 Definition of the Base Case

A base case against which the outcomes of the various ocean outfall alternatives can be compared is defined as follows:

- Treatment level: secondary with basic level disinfection for disposal using ocean outfalls and no disinfection for disposal using Class I injection wells
- Disposal method: discharge of 100% of flow to ocean outfalls or, in the case of the Broward/North WWTP, discharge of 100% of flow to ocean outfalls and Class I injection wells.

Flows and nutrient loads to the ocean associated with the base case are summarized in Table 9-1.

9.1.2 Estimation of Freshwater Savings

Freshwater may be saved by substituting reclaimed water for water from a potable supply. Thus, a savings of 1.0 gallon of freshwater per gallon of reclaimed water provided for traditional reuse was assumed. No credit for offsetting municipal water treatment demands was taken, since consumptive use permittees withdraw water from local wells rather than public supplies. Water savings from groundwater recharge was taken as 0.8 gallons of freshwater per gallon of reclaimed water recharged. Selection of the recharge value was based on the assumption that the groundwater recharge fraction for injection through shallow wells near the coast is intermediate to recharge fractions for canals and rapid infiltration basins, which are given as 0.7 and 0.95, respectively, in the *2003 Reuse Strategies Report* (Reuse Coordinating Committee and the Water Conservation Initiative Water Reuse Work Group 2003). Freshwater savings in percent are expressed relative to the ocean outfall flows under the base case as defined in Section 9.1.1 (Table 9-1).

9.1.3 Estimation of Nutrient Load Reductions

Nitrogen and phosphorus are of documented concern with respect to the health of reefs in the coastal waters of southeast Florida. These nutrients are therefore used as model pollutants. Nutrient loads to the ocean can be decreased by reducing flows to ocean outfalls and by tertiary treatment to remove nutrients from wastewater. Nutrient load reductions in percent are expressed relative to ocean nutrient loads under the base case as defined in Section 9.1.1 (Table 9-1).

Table 9-1. Flows and Nutrient Loads to the Ocean associated with the Base Case

	Effluent conc.* (mg/L)	Year	Flows (MGD) Influent	UIC wells**	Ocean outfall	Loads to ocean (tons/yr) TN	TP
Boynton-Delray	Total N	2005	19.4	0	19.4	551	50.1
	18.7	2010	21.3	0	21.3	605	55.0
	Total P	2015	23.2	0	23.2	660	60.0
	1.7	2020	25.2	0	25.2	716	65.1
		2025	27.1	0	27.1	771	70.1
		Avg	23.2	0	23.2	661	60.1
Boca Raton	Total N	2005	15.6	0	15.6	401	16.6
	16.9	2010	17.1	0	17.1	440	18.2
	Total P	2015	18.7	0	18.7	480	19.9
	0.7	2020	20.2	0	20.2	520	21.6
		2025	21.8	0	21.8	560	23.2
		Avg	18.7	0	18.7	480	19.9
Broward/ North	Total N	2005	84.2	30	54.2	1,220	107.2
	14.8	2010	88.6	30	58.6	1,320	115.9
	Total P	2015	90.8	30	60.8	1,369	120.3
	1.3	2020	92.2	30	62.2	1,400	123.0
		2025	94.1	30	64.1	1,444	126.8
		Avg	90.0	30	60.0	1,351	118.6
Hollywood	Total N	2005	40.0	0	40.0	1,010	66.9
	16.6	2010	43.5	0	43.5	1,100	72.9
	Total P	2015	47.2	0	47.2	1,192	79.0
	1.1	2020	50.9	0	50.9	1,286	85.2
		2025	54.5	0	54.5	1,376	91.2
		Avg	47.2	0	47.2	1,193	79.0
Miami-Dade/ North	Total N	2005	107.9	0	107.9	2,874	279.2
	17.5	2010	111.9	0	111.9	2,980	289.5
	Total P	2015	116.6	0	116.6	3,107	301.8
	1.7	2020	121.3	0	121.3	3,230	313.8
		2025	126.3	0	126.3	3,363	326.7
		Avg	116.8	0	116.8	3,111	302
Miami-Dade/ Central	Total N	2005	129.4	0	129.4	3,308	315.0
	16.8	2010	134.1	0	134.1	3,430	326.6
	Total P	2015	139.8	0	139.8	3,575	340.5
	1.6	2020	145.4	0	145.4	3,717	354.0
		2025	151.3	0	151.3	3,870	368.6
		Avg	140.0	0	140.0	3,580	341

*From 31 Aug. 2003 through 31 Oct. 2004 Monthly Discharge Reports
**Class I

9.1.4 Estimation of the Costs for Liquid Treatment, Reuse and Disposal

The costs reported in this chapter are the sum of liquid treatment, reuse and disposal costs. Methods employed to estimate these costs are described below.

a) Costs of liquid treatment. Costs of primary treatment, secondary treatment, nutrient removal, filtration, basic level disinfection with chlorine, high level disinfection with chlorine, and high level disinfection with UV were estimated using CapdetWorks 2.1. Costs of microfiltration, reverse osmosis and advanced oxidation were estimated on the basis of case studies. Details of these methods are given in Chapter 6.

b) Costs of reclaimed water distribution for traditional reuse. Equation (6-7) gives the sum of costs for treatment beyond secondary (filtration and the difference between high level and basic level disinfection) and distribution costs as a function of flow for traditional reuse. Data used in the fitting of this equation are given in Table 6-29. Since the costs of treatment for reuse are included in the CapdetWorks simulations, the costs of treatment beyond secondary must be removed from Equation (6-7) in order to avoid double-counting.

The capital costs for treatment beyond secondary are given in Table 6-25. These costs were annualized on the basis of a 20 year service life and 7% discount rate and then subtracted from the annual costs in Table 6-29. Operation and maintenance costs for treatment beyond secondary are not separated from reclaimed water distribution costs in the Hazen and Sawyer (2004) database. They were therefore estimated using CapdetWorks. The results, expressed in power equation form, are given by

$$C = 24{,}330\,Q^{0.8506} \qquad (9\text{-}1)$$

where C is the operations and maintenance cost for treatment beyond secondary in \$/yr and Q is the reclaimed water flow in MGD. The operations and maintenance costs thus estimated were also subtracted from the annual costs in Table 6-29. The remaining costs of reclaimed water distribution within the applicable range of flows (4.46–30 MGD) were fitted to a power relationship, giving

$$C = 8{,}167\,Q^{2.3496} \qquad (9\text{-}2)$$

where C and Q have the same units described previously. Equation 9-2 is used to estimate the cost of distributing reclaimed water to large users in the present chapter.

Equation (9-2) is specific to the service area of the Broward/North WWTP in Broward County. Costs reflected in this equation are influenced by the density of large users. The densities of large consumptive use permittees in the service areas of the Boynton-Delray and Boca Raton WWTPs are similar to the density near the Broward/North plant. Equation (9-2) should therefore provide a reasonably good approximation for these plants. Densities of large consumptive use permittees in the Hollywood, Miami-Dade/North and Miami-Dade/Central WWTP service areas are lower. As a result, Equation (9-2) will underestimate reclaimed water distribution costs at these facilities. Because the projected traditional reuse demands for the Hollywood, Miami-Dade/North and Miami- Dade/Central WWTPs are low (10% or less of the total wastewater treated), underestimation of traditional reuse distribution costs will have a negligible effect on overall cost trends that are projected for these facilities. For example, the Hollywood WWTP has the highest traditional reuse among the three facilities with low densities of consumptive use permittees. The maximum contribution of traditional reuse distribution cost to the cost of liquid treatment, reuse and disposal at this facility is estimated to be less than 3%.

c) Costs of reclaimed water injection through shallow wells. The methodology for estimating costs to inject highly treated reclaimed water through shallow wells was described in Chapter 6.

d) Disposal costs. It is assumed that the permitted capacities of the ocean outfalls and Class I UIC wells will be held constant. Therefore, no costs are allocated for these disposal methods. Deep well injection is assumed as a disposal method for concentrate from the reverse osmosis process. Costs for this disposal method are based on case studies, as described in Chapter 6.

9.2 Boynton-Delray WWTP

A summary of the projected flow allocations and costs for liquid treatment, reuse and disposal for the Boynton-Delray WWTP is given in Table 9-2. A matrix of indicator outcomes for the 2005–2025 projection period is shown in Table 9-3.

Freshwater savings. Total wastewater flows are expected to increase from 19.4 MGD in 2005 to 27.1 MGD in 2025 for all four alternatives. The current level of ocean outfall discharge of 15.7 MGD is expected to increase to 19.6 MGD under alternative I (currently planned use of ocean outfalls). Under alternative II (limited use of ocean outfalls), traditional reuse would grow from 3.7 to 22.7 MGD. If groundwater recharge and concentrate are included, then ocean outfall discharges in 2025 can be reduced to 2.4 MGD or eliminated.

Freshwater savings of 24–56% are achieved in the first two alternatives through traditional reuse. The freshwater savings for alternative III (use of ocean outfalls as backups) is 80% while that for alternative IV (no use of ocean outfalls) is 84%. Much of the freshwater savings under the latter two alternatives comes from groundwater recharge (24% and 28% of the flow treated, respectively).

Nutrient load reduction. In scenario A (secondary treatment of ocean-bound wastewater), ocean discharge of nitrogen and phosphorus is decreased by 24% under alternative I and 56% under alternative II. These percentages are identical to the respective freshwater savings under the two alternatives and represent diversions of the nutrients from the ocean to land. Greater load reductions (up to 93% for nitrogen and 74% for phosphorus) are achieved by applying nutrient removal processes to ocean-bound wastewater.

Table 9-2. Summary of Projected Flow Allocations and Costs for Liquid Treatment, Disposal and Reuse for the Boynton-Delray WWTP

		Flows (MGD)					Cost ($/1000 gal)		
Alterna-tive	Year	WWTP	Ocean outfall	Trad. Reuse	GW recharge	Concen-trate	Scenario* A	Scenario* C	Scenario* E
I	2005	19.4	15.7	3.7	0	0	0.90	1.22	1.50
	2010	21.3	16.4	4.8	0	0	0.91	1.21	1.48
	2015	23.2	17.0	6.2	0	0	0.93	1.21	1.46
	2020	25.2	19.0	6.2	0	0	0.91	1.18	1.44
	2025	27.1	19.6	7.5	0	0	0.95	1.19	1.44
II	2005	19.4	15.7	3.7	0	0	0.90	1.22	1.50
	2010	21.3	14.7	6.5	0	0	0.97	1.24	1.49
	2015	23.2	10.3	12.9	0	0	1.29	1.50	1.66
	2020	25.2	5.4	19.7	0	0	1.91	2.03	2.12
	2025	27.1	4.4	22.7	0	0	2.21	2.27	2.33
III	2005	19.4	0.4	3.7	12.2	3.1	4.10	4.10	4.10
	2010	21.3	0.7	6.5	11.2	2.8	3.64	3.64	3.64
	2015	23.2	1.4	12.9	7.1	1.8	3.14	3.14	3.14
	2020	25.2	2.1	19.7	2.7	0.7	2.78	2.78	2.78
	2025	27.1	2.4	22.7	1.5	0.4	2.80	2.80	2.80
IV	2005	19.4	0	3.7	12.5	3.1		4.13	
	2010	21.3	0	6.5	11.8	2.9		3.70	
	2015	23.2	0	12.9	8.2	2.1		3.25	
	2020	25.2	0	19.7	4.4	1.1		2.96	
	2025	27.1	0	22.7	3.5	0.9		3.02	

*The scenarios for ocean outfall treatment requirements preceding basic level disinfection are: A--secondary, C--intermediate nutrient removal, and E--full nutrient removal. These scenarios are applicable to alternatives I, II, and III, which involve use of ocean outfalls.

Table 9-3. Outcomes of Indicators for Ocean Outfall Alternatives at the Boynton-Delray WWTP

		Treatment applied for ocean outfall discharge		
		A--Secondary treatment	**C**--Intermediate nutrient removal	**E**--Full nutrient removal
Alternative I-- Ocean outfalls used at current levels	N load reduction	24%	60%	88%
	P load reduction	24%	24%	56%
	Freshwater savings	24% (including 0% from groundwater recharge)		
	Public acceptance	High		
Alternative II-- Limited use of ocean outfalls	N load reduction	56%	77%	93%
	P load reduction	56%	56%	74%
	Freshwater savings	56% (including 0% from groundwater recharge)		
	Public acceptance	High		
Alternative III-- Ocean Outfalls as backups	N load reduction	94%	97%	99%
	P load reduction	94%	94%	96%
	Freshwater savings	80% (including 24% from groundwater recharge)		
	Public acceptance	Low-Moderate to Moderate-High		
Alternative IV-- No use of ocean outfalls	N load reduction	100%		
	P load reduction	100%		
	Freshwater savings	84% (including 28% from groundwater recharge)		
	Public acceptance	Low-Moderate to Moderate-High		

Discharge of nutrients to the ocean is decreased by 94–99% under alternative III. The nutrient load reduction in alternative III is high compared to alternatives I and II, due to the low volumes of treated effluent that are discharged through the ocean outfall. The nutrient load reduction in alternative III increases slightly as the degree of treatment is increased from secondary to full nutrient removal. Discharge of nutrients to the ocean is decreased by 100% under alternative IV, where use of the ocean outfall is eliminated.

Public acceptance. The public acceptance of alternatives I and II is anticipated to be high because water reuse is primarily for irrigation by large users. Groundwater recharge in alternative III at 24% could be expected to lead to low-to-moderate public acceptance, but a concerted effort to engage and educate the public could boost this level to moderate-to-high. Public acceptance of alternative IV—with groundwater recharge accounting for 28% of the flow treated—would be similar to that for alternative III.

Cost-effectiveness. The costs for the three liquid treatment scenarios range from $0.90 to $1.50/1,000 gallons in 2005 under both alternatives I and II. They increase to the range of $0.95 to $1.40/1,000 gallons in 2025 under alternative I and $2.20–2.30/1,000 gal under alternative II. Increases of costs due to higher degrees of treatment of ocean-bound wastewater are limited under alternative II because most of the flow is reused. The costs under alternative IV are in the range of $3.00 to $4.10/1,000 gal. These costs are high because full treatment (including membrane filtration and reverse osmosis) is applied to flow not destined for traditional reuse. Additionally, the highly treated reclaimed water must be transported to the injection site and the reverse osmosis concentrate must be disposed of. The costs of alternative IV decrease between 2005 and 2025 because more flow is applied for traditional reuse in 2025 and therefore less is groundwater injected. Alternative III allows use of ocean outfalls as backups and therefore involves slightly lower recharge flows. This leads to slightly lower costs than alternative IV.

Summary. The benefits, costs and public acceptance of the ocean outfall alternatives for the Boynton-Delray WWTP are compared in Figure 9-1. The benefit is the average of percent freshwater savings and overall nutrient (N, P) load reduction. Public acceptance is rated on a scale of high = 97%, moderate = 71%, and low = 45%, as suggested by the survey from CDM (2004).

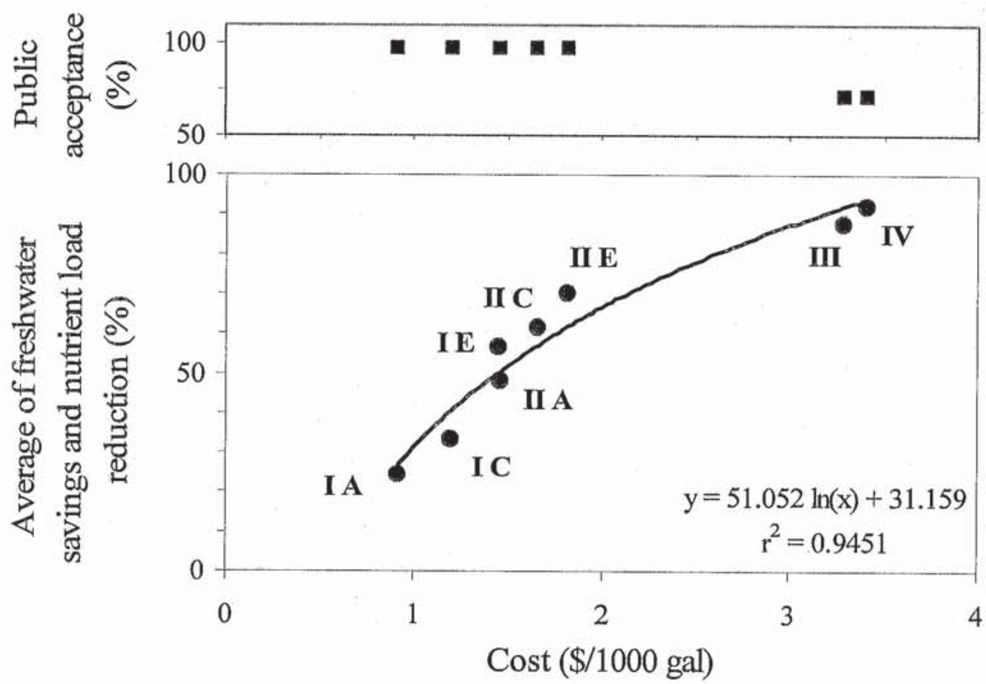

Figure 9-1. Public Acceptance and the Average of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for the Boynton-Delray WWTP. Alternatives are Currently Planned Use (I), Limited Use (II), Ocean Outfalls as Backups (III) and No Use (IV). The scenarios for ocean outfall treatment are: A–secondary, C–intermediate nutrient removal, and E–full nutrient removal.

A benefit of up to 70% is achieved through various combinations of traditional reuse and nutrient control technology (alternatives I and II). These are also the alternatives with the highest public acceptance. The alternatives involving groundwater recharge (III and IV) achieve the highest benefits (87–92%), but are also most expensive and receive a lower level of public acceptance. The cost to achieve a benefit of 50% is $1.40/1,000 gal. The cost to achieve a benefit of 75% increases to $2.40/1,000 gal.

9.3 Boca Raton WWTP

A summary of the projected flow allocations and costs for liquid treatment, reuse and disposal for the Boca Raton WWTP is given in Table 9-4. A matrix of indicator outcomes over the years 2005–2025 is shown in Table 9-5.

Freshwater savings. Freshwater savings of 59–64% are achieved in the first two alternatives (currently planned and limited use of ocean outfalls) through implementation of traditional reuse. The freshwater recovery under alternative III (use of ocean outfalls as backups) is 82%, while that under alternative IV (no use of ocean outfalls) is 87%. Much of the freshwater savings under alternatives III and IV is from groundwater recharge, which accounts for savings of 20 to 23% relative to total flow treated.

Nutrient load reduction. Management options that include currently planned or limited use of ocean outfalls (alternatives I and II, respectively) reduce ocean discharge of nitrogen by up to 94% and phosphorus by up to 64% through a combination of effluent diversion to traditional reuse and application of nutrient control treatment technology. Limitation of phosphorus discharge under alternatives I and II is achieved exclusively through effluent diversion to reuse, since the secondary effluent phosphorus concentration of 0.8 mg/L is below the target effluent qualities of either the intermediate or full nutrient removal technologies. Discharge of nutrients to the ocean is decreased by 93–99% under alternative III and by 100% under alternative IV.

Public acceptance. The public acceptance of alternatives I and II is anticipated to be high since all freshwater savings are achieved through traditional reuse. A groundwater recharge level of 20% could result in a low-to-moderate level of public acceptance in alternative III. However, misgivings about groundwater recharge could be substantially mitigated by public education efforts and community participation in the planning process, boosting the acceptance level to the moderate-to-high range. Alternative IV has a similar level of groundwater recharge and is thus expected to receive the same level of public acceptance.

Cost-effectiveness. The costs under the first two alternatives range from $1.05 to $1.40/1,000 gal in 2005 under alternatives I and II and increase to the range of $1.65–2.40/1,000 gal in 2025. Under alternative II, in 2025, there is little variation in costs between treatment scenarios because most of the flow is reused. The costs under alternative IV range from $2.50 to $3.90/1,000 gal, decreasing from 2005 to 2025 because of increasing traditional reuse, which leads to less recharge. The costs under alternative III are slightly lower, since a small portion of the flow is discharged to the ocean.

Table 9-4. Summary of Projected Flow Allocations and Costs for Liquid Treatment, Disposal and Reuse for the Boca Raton WWTP

		Flows (MGD)					Cost ($/1000 gal)		
Alterna-tive	Year	WWTP	Ocean outfall	Trad. Reuse	GW recharge	Concen-trate	Scenario* A	C	E
I	2005	15.6	10.4	5.2	0	0	1.05	1.21	1.40
	2010	17.1	8.3	8.8	0	0	1.20	1.33	1.49
	2015	18.7	7.5	11.2	0	0	1.33	1.45	1.58
	2020	20.2	6.7	13.6	0	0	1.48	1.58	1.69
	2025	21.8	5.8	15.9	0	0	1.65	1.74	1.83
II	2005	15.6	10.4	5.2	0	0	1.05	1.21	1.40
	2010	17.1	11.1	6.0	0	0	1.05	1.22	1.42
	2015	18.7	9.1	9.5	0	0	1.20	1.33	1.48
	2020	20.2	2.2	18.0	0	0	1.99	2.04	2.08
	2025	21.8	0.5	21.3	0	0	2.35	2.37	2.38
III	2005	15.6	0.6	5.2	7.9	2.0	3.84	3.84	3.84
	2010	17.1	0.6	6.0	8.3	2.1	3.76	3.76	3.76
	2015	18.7	1.0	9.5	6.5	1.6	3.22	3.22	3.22
	2020	20.2	1.9	18.0	0.2	0.0	2.31	2.31	2.31
	2025	21.8	2.1	19.6	0.0	0.0	2.15	2.15	2.15
IV	2005	15.6	0	5.2	8.3	2.1		3.90	
	2010	17.1	0	6.0	8.9	2.2		3.83	
	2015	18.7	0	9.5	7.3	1.8		3.32	
	2020	20.2	0	18.0	1.8	0.4		2.57	
	2025	21.8	0	21.3	0.4	0.1		2.47	

*The scenarios for ocean outfall treatment requirements preceding basic level disinfection are: A--secondary, C--intermediate nutrient removal, and E--full nutrient removal. These scenarios are applicable to alternatives I, II, and III, which involve use of ocean outfalls.

Table 9-5. Outcomes of Indicators for Ocean Outfall Alternatives at the Boca Raton WWTP

		Treatment applied for ocean outfall discharge		
		A--Secondary treatment	C--Intermediate nutrient removal	E--Full nutrient removal
Alternative I-- Ocean outfalls used at current levels	N load reduction	59%	76%	93%
	P load reduction	59%	59%	59%
	Freshwater savings	59% (including 0% from groundwater recharge)		
	Public acceptance	High		
Alternative II-- Limited use of ocean outfalls	N load reduction	64%	79%	94%
	P load reduction	64%	64%	64%
	Freshwater savings	64% (including 0% from groundwater recharge)		
	Public acceptance	High		
Alternative III Ocean outfalls as back up	N load reduction	93%	96%	99%
	P load reduction	93%	93%	93%
	Freshwater savings	82% (including 20% from groundwater recharge)		
	Public acceptance	Low-Moderate to Moderate-High		
Alternative IV-- No use of ocean outfalls	N load reduction	100%		
	P load reduction	100%		
	Freshwater savings	87% (including 23% from groundwater recharge)		
	Public acceptance	Low-Moderate to Moderate-High		

Summary. The benefits, costs and public acceptance of the ocean outfall alternatives for the Boca Raton WWTP are compared in Figure 9-2. The benefit is the average of percent freshwater savings and overall nutrient (N, P) load reduction. Public acceptance is rated on a scale of high = 97%, moderate = 71%, and low = 45%, as suggested by the survey from CDM (2004).

A benefit of up to 71% is achieved through various combinations of traditional reuse and nutrient control technology (alternatives I and II). These are also the alternatives with the highest public acceptance. The alternatives involving groundwater recharge (III and IV) achieve the highest benefits (88–93%), but are also most expensive and receive a lower level of public acceptance. The cost to achieve a benefit of 50% is $1.00/1,000 gal. The cost to achieve a benefit of 75% increases to $2.00/1,000 gal.

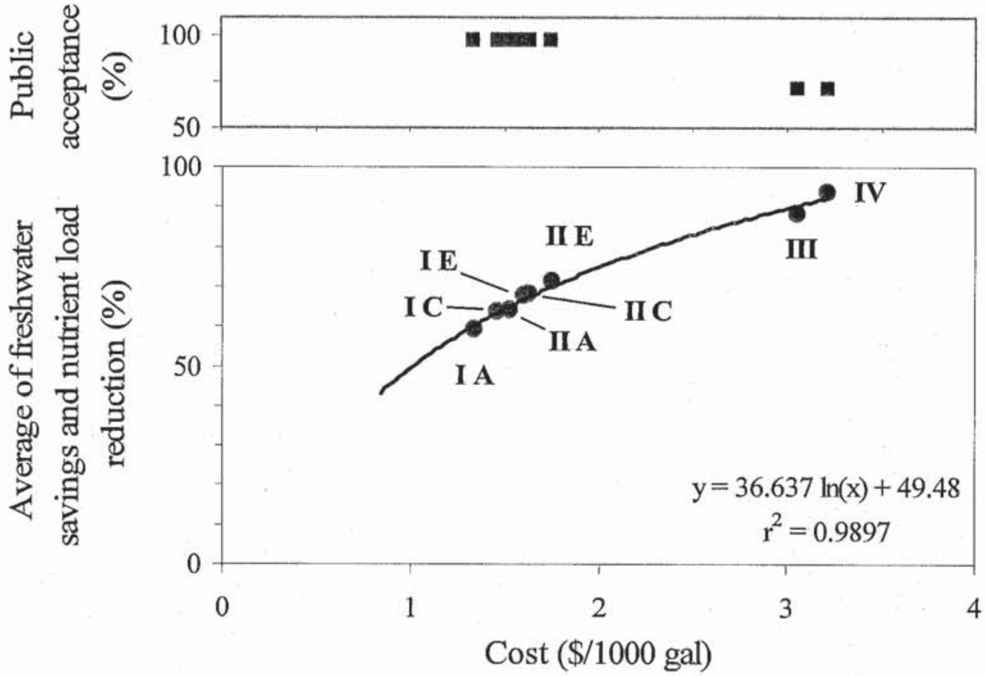

Figure 9-2. Public Acceptance and the Average of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for the Boca Raton WWTP.

9.4 Broward/North WWTP

A summary of the projected flow allocations and costs for liquid treatment, reuse and disposal for the Broward/North WWTP is given in Table 9-6. A matrix of indicator outcomes over the years 2005–2025 is shown in Table 9-7.

Freshwater savings. Freshwater savings of 8–18% are achieved under alternatives I and II. The values of freshwater savings are expressed relative to the wastewater flow not discharged to Class I injection wells. The freshwater recovery under alternative III is 69%, which includes savings of 51% from groundwater recharge. The freshwater recovery under alternative IV is 71%, which includes savings of 52% from groundwater recharge.

Nutrient load reduction. Management options that include currently planned or limited use of ocean outfalls (alternatives I and II, respectively) limit ocean discharge of nitrogen by up to 83% and discharge of phosphorus by up to 37% through a combination of effluent diversion to traditional reuse and application of advanced treatment technology. The secondary effluent phosphorus concentration of the Broward/North WWTP averages 1.3 mg/L, which is less than the target effluent quality of intermediate nutrient removal technology and only slightly higher than the target effluent quality of full nutrient removal technology. Most of the phosphorus discharge limitation is therefore achieved through effluent diversion to reuse. Discharge of nutrients to the ocean is decreased by 98–100% under alternative III and by 100% under alternative IV.

Table 9-6. Summary of Projected Flow Allocations and Costs for Liquid Treatment, Disposal and Reuse for the Broward/North WWTP

		Flows (MGD)						Cost ($/1000 gal)					
								Scenario[2]					
Alt	Year	WWTP	Ocean outfall	UIC wells[1]	Trad. reuse	GW re-charge	Concen-trate	A	B	C	D	E	F
	2005	84.2	51.7	30.0	2.4	0	0	0.60	0.68	0.75	0.82	0.92	0.99
	2010	88.6	54.3	30.0	4.2	0	0	0.61	0.68	0.76	0.83	0.91	0.98
I	2015	90.8	55.5	30.0	5.3	0	0	0.61	0.68	0.76	0.83	0.91	0.98
	2020	92.2	56.9	30.0	5.3	0	0	0.61	0.68	0.76	0.82	0.92	0.98
	2025	94.1	58.8	30.0	5.3	0	0	0.61	0.68	0.76	0.82	0.92	0.98
	2005	84.2	51.7	30.0	2.4	0	0	0.60	0.68	0.75	0.82	0.92	0.99
	2010	88.6	54.3	30.0	4.2	0	0	0.61	0.68	0.76	0.83	0.91	0.98
II	2015	90.8	51.3	30.0	9.4	0	0	0.66	0.72	0.79	0.85	0.94	1.00
	2020	92.2	46.6	30.0	15.6	0	0	0.77	0.83	0.89	0.95	1.02	1.08
	2025	94.1	41.1	30.0	23.0	0	0	1.01	1.07	1.11	1.17	1.22	1.28
	2005	84.2	0.3	30.0	2.4	41.2	10.3	2.58	2.66	2.58	2.66	2.58	2.66
	2010	88.6	0.4	30.0	4.2	43.1	10.8	2.54	2.61	2.54	2.61	2.54	2.61
III	2015	90.8	1.0	30.0	9.4	40.3	10.1	2.49	2.55	2.49	2.55	2.49	2.55
	2020	92.2	1.6	30.0	15.6	36.0	9.0	2.36	2.42	2.36	2.42	2.36	2.42
	2025	94.1	2.4	30.0	23.0	30.9	7.7	2.37	2.43	2.37	2.43	2.37	2.43
	2005	84.2	0	30.0	2.4	41.4	10.3		2.58[3]			2.66[4]	
	2010	88.6	0	30.0	4.2	43.5	10.9		2.54			2.61	
IV	2015	90.8	0	30.0	9.4	41.1	10.3		2.50			2.56	
	2020	92.2	0	30.0	15.6	37.3	9.3		2.38			2.44	
	2025	94.1	0	30.0	23.0	32.8	8.2		2.40			2.46	

[1] Class I

[2] The scenarios are defined in terms of ocean outfall treatment requirements preceding basic level disinfection (A, B--secondary; C, D--intermediate nutrient removal; E, F--full nutrient removal) and level of disinfection for discharge to Class I injection wells (A, C, E--none; B, D, F--high level). These scenarios are applicable to alternatives I, II and III, which involve use of ocean outfalls.

[3] No disinfection of effluent discharged to Class I UIC wells

[4] High-level disinfection of effluent discharged to Class I UIC wells

Public acceptance. The public acceptance of alternatives I and II is anticipated to be high because reclaimed water is used primarily for irrigation by larger users. The more substantial degree of freshwater savings due to groundwater recharge under alternatives III and IV will present a challenge in gaining public acceptance. However, misgivings about groundwater recharge may be substantially mitigated by public education efforts and community participation in the planning process. Thus, public acceptance is considered low-to-moderate for alternatives III and IV.

Cost-effectiveness. The costs range from $0.60 to $1.30/1,000 gal under alternatives I and II and $2.40 to $2.70/1,000 gal under alternatives III and IV. The Broward/North WWTP is the only facility of the six with Class I injection wells for effluent disposal in operation at the time the dataset for the present study was collected. Differences in costs between scenarios

A and B, C and D, and E and F represent an upgrade from no disinfection to high level disinfection for discharge to these wells. Accordingly, the costs increase somewhat between each pair of scenarios. Slight increments in the costs are also apparent as the degree of treatment for ocean-bound wastewater is increased from secondary (scenarios A and B) to intermediate nutrient removal (scenarios C and D) and finally to full nutrient removal (scenarios E and F). Under alternatives III and IV, costs are seen to decrease somewhat from 2005 to 2025. This is because the extent of traditional reuse increases with time, diminishing the flow that is recharged.

Table 9-7. Outcomes of Indicators for Ocean Outfall Alternatives at the Broward/North WWTP

		Secondary treatment for ocean outfall discharge		Intermediate nutrient removal for ocean outfall discharge		Full nutrient removal for ocean outfall discharge	
	Scenario*	A	B	C	D	E	F
Alt. I-- Ocean outfalls used at current levels	N load reduction	8%	8%	38%	38%	81%	81%
	P load reduction	8%	8%	8%	8%	29%	29%
	Freshwater savings	8% of wastewater not injected to Class I inection wells (including 0% from groundwater recharge)					
	Public acceptance	High					
Alt. II-- Limited use of ocean outfalls	N load reduction	18%	18%	45%	45%	83%	83%
	P load reduction	18%	18%	18%	18%	37%	37%
	Freshwater savings	18% of wastewater not injected to Class I injection wells (including 0% from groundwater recharge)					
	Public acceptance	High					
Alt III-- Ocean outfalls as backups	N load reduction	98%	99%	99%	98%	100%	100%
	P load reduction	98%	98%	98%	98%	99%	99%
	Freshwater savings	69% of wastewater not injected to Class I injection wells (including 51% from groundwater recharge)					
	Public acceptance	Low-Moderate					
Alt. IV-- No use of ocean outfalls	N load reduction		100%		100%		
	P load reduction		100%		100%		
	Freshwater savings	71% of wastewater not injected to Class I injection wells (including 52% from groundwater recharge)					
	Public acceptance	Low-Moderate					

*Scenarios: A, C, E--no disinfection for discharge to Class I injection wells; B, D, F--high level disinfection for discharge to Class I injection wells

Summary. The benefits, costs and public acceptance of the ocean outfall alternatives for the Broward/North WWTP are compared in Figure 9-3. The benefit is the average of percent freshwater savings and overall nutrient (N, P) load reduction. Public acceptance is rated on a scale of high = 97%, moderate = 71%, and low = 45%, as suggested by the survey from CDM (2004).

A benefit of up to 39% is achieved through various combinations of traditional reuse and nutrient control technology (alternatives I and II). These are also the alternatives with the highest public acceptance. The alternatives involving groundwater recharge (III and IV) achieve the highest benefits (84–85%), but are also most expensive and receive a lower level of public acceptance. The cost to achieve a benefit of 50% is $1.30/1,000 gal. The cost to achieve a benefit of 75% increases to $2.10/1,000 gal.

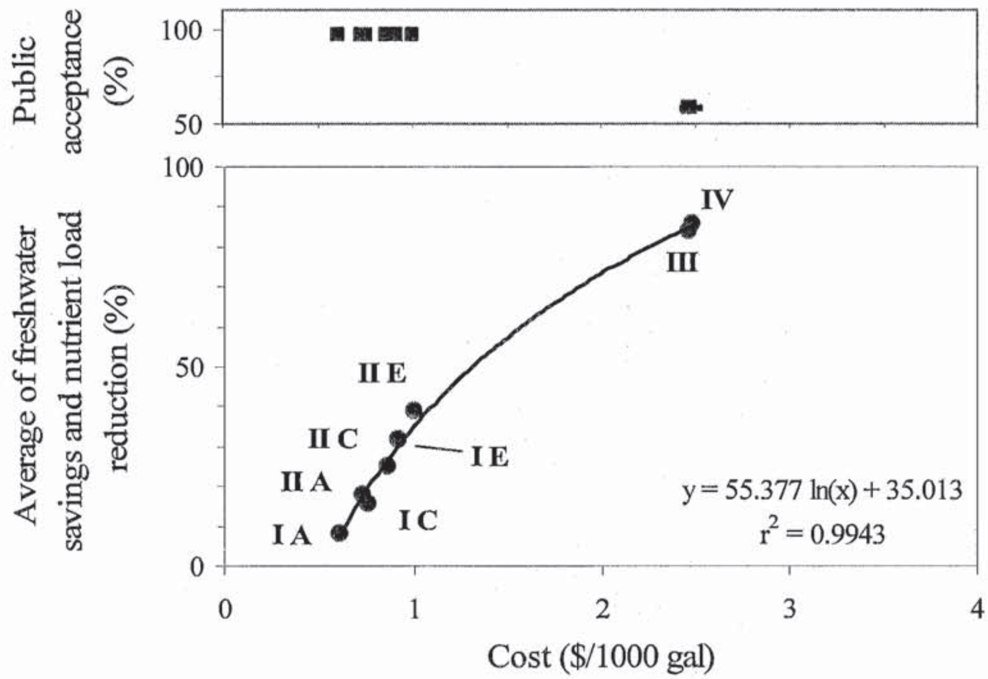

Figure 9-3. Public Acceptance and the Average of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for the Broward/North WWTP.

9.5 Hollywood WWTP

A summary of the projected flow allocations and costs for liquid treatment, reuse and disposal for the Hollywood WWTP is given in Table 9-8. A matrix of indicator outcomes over the years 2005–2025 is shown in Table 9-9.

Freshwater savings. Freshwater savings of 9 to 10% are achieved under alternatives I and II, due mostly to the limited extent of traditional reuse. There is a modest level of groundwater recharge under these two alternatives, which also contributes to the freshwater savings. The freshwater savings under alternatives III and IV are 67%, which includes savings of 57–58% from groundwater recharge.

Nutrient load reduction. Management options that include currently planned or limited use of ocean outfalls (alternatives I and II, respectively) limit ocean discharge of nitrogen by up to 84%. The maximum limitation of phosphorus discharge for these alternatives is 18%, due to the limited extent of traditional reuse and the effluent total phosphorus concentration of 1.1 mg/L, which is only slightly higher than the target effluent quality for full nutrient removal technology. Discharge of nutrients to the ocean is decreased by 99–100% under alternative III and by 100% under alternative IV.

Table 9-8. Summary of Flow Allocations and Costs for Liquid Treatment, Disposal and Reuse for the Hollywood WWTP

		Flows (MGD)					Cost ($/1000 gal)		
Alterna-tive	Year	WWTP	Ocean outfall	Trad. Reuse	GW recharge	Concen-trate	Scenario* A	C	E
I	2005	40.0	37.4	2.6	0	0	0.62	0.95	1.17
	2010	43.5	39.9	3.6	0	0	0.62	0.93	1.15
	2015	47.2	43.5	3.6	0	0	0.61	0.92	1.14
	2020	50.9	46.3	3.6	0.75	0.19	0.72	1.01	1.23
	2025	54.5	46.3	3.6	3.6	0.9	1.08	1.36	1.53
II	2005	40.0	37.4	2.6	0	0	0.62	0.95	1.17
	2010	43.5	39.9	3.6	0	0	0.62	0.93	1.15
	2015	47.2	42.9	4.2	0	0	0.62	0.92	1.15
	2020	50.9	45.6	5.2	0	0	0.63	0.91	1.13
	2025	54.5	46.3	6.1	1.7	0.4	0.86	1.13	1.31
III	2005	40.0	0.3	2.6	29.7	7.4	3.96	3.96	3.96
	2010	43.5	0.4	3.6	31.6	7.9	3.86	3.86	3.86
	2015	47.2	0.4	4.2	34.0	8.5	3.81	3.81	3.81
	2020	50.9	0.6	5.2	36.1	9.0	3.72	3.72	3.72
	2025	54.5	0.6	6.1	38.2	9.5	3.66	3.66	3.66
IV	2005	40.0	0.0	2.6	29.9	7.5		3.96	
	2010	43.5	0.0	3.6	31.9	8.0		3.88	
	2015	47.2	0.0	4.2	34.3	8.6		3.84	
	2020	50.9	0.0	5.2	36.5	9.1		3.76	
	2025	54.5	0.0	6.1	38.7	9.7		3.71	

*The scenarios for ocean outfall treatment requirements preceding basic level disinfection are: A--secondary, C--intermediate nutrient removal, and E--full nutrient removal. These scenarios are applicable to alternatives I, II, and III, which involve use of ocean outfalls.

Public acceptance. The public acceptance of alternatives I and II is anticipated to be high because reclaimed water is used primarily for irrigation by larger users. The substantial degree of freshwater savings due to groundwater recharge under alternatives III and IV presents a challenge in gaining public acceptance. Accordingly, public acceptance is considered to be low-to-moderate for these two alternatives.

Cost-effectiveness. The costs under alternatives I and II range from $0.60 to $1.50/1,000 gal, while the projected costs for alternatives III and IV range between $3.70 and $4.00/1,000 gal. Increments in the costs are apparent as the degree of treatment for ocean-bound wastewater is increased from secondary to full nutrient removal. The inflow to the plant is projected to exceed the ocean outfall permitted capacity of 46.3 MGD sometime before the year 2015. The amount of inflow in excess of this value must be handled by a combination of traditional reuse and groundwater recharge. Projected traditional reuse flows will be insufficient to handle the excess towards the end of the projection period, necessitating a modest flow to groundwater recharge. The higher extent of traditional reuse projected under alternative II results in lowered costs for this alternative.

Table 9-9. Outcomes of Indicators for Ocean Outfall Alternatives at the Hollywood WWTP

		Treatment applied for ocean outfall discharge		
		A--Secondary treatment	**C**--Intermediate nutrient removal	**E**--Full nutrient removal
Alternative I-- Ocean outfalls used at current levels	N load reduction	10%	46%	84%
	P load reduction	10%	10%	18%
	Freshwater savings	9% (including 2% from groundwater recharge)		
	Public acceptance	High		
Alternative II-- Limited use of ocean outfalls	N load reduction	10%	46%	84%
	P load reduction	10%	10%	18%
	Freshwater savings	10% (including 1% from groundwater recharge)		
	Public acceptance	High		
Alternative III-- Ocean outfalls as back up	N load reduction	99%	99%	100%
	P load reduction	99%	99%	99%
	Freshwater savings	67% (including 57% from groundwater recharge)		
	Public acceptance	Low-Moderate		
Alternative IV-- No use of ocean outfalls	N load reduction	100%		
	P load reduction	100%		
	Freshwater savings	67% (including 58% from groundwater recharge)		
	Public acceptance	Low-Moderate		

Summary. The benefits, costs and public acceptance of the ocean outfall alternatives for the Hollywood WWTP are compared in Figure 9-4. The benefit is the average of percent freshwater savings and overall nutrient (N, P) load reduction. Public acceptance is rated on a scale of high = 97%, moderate = 71%, and low = 45%, as suggested by the survey from CDM (2004).

A benefit of up to 30% is achieved through various combinations of traditional reuse, groundwater recharge and nutrient control technology (alternatives I and II). These are also the alternatives with the highest public acceptance. The alternatives involving extensive groundwater recharge (III and IV) achieve the highest benefits (83%), but are also most expensive and receive a lower level of public acceptance. The cost to achieve a benefit of 50% is $1.90/1,000 gal. The cost to achieve a benefit of 75% increases to $3.25/1,000 gal.

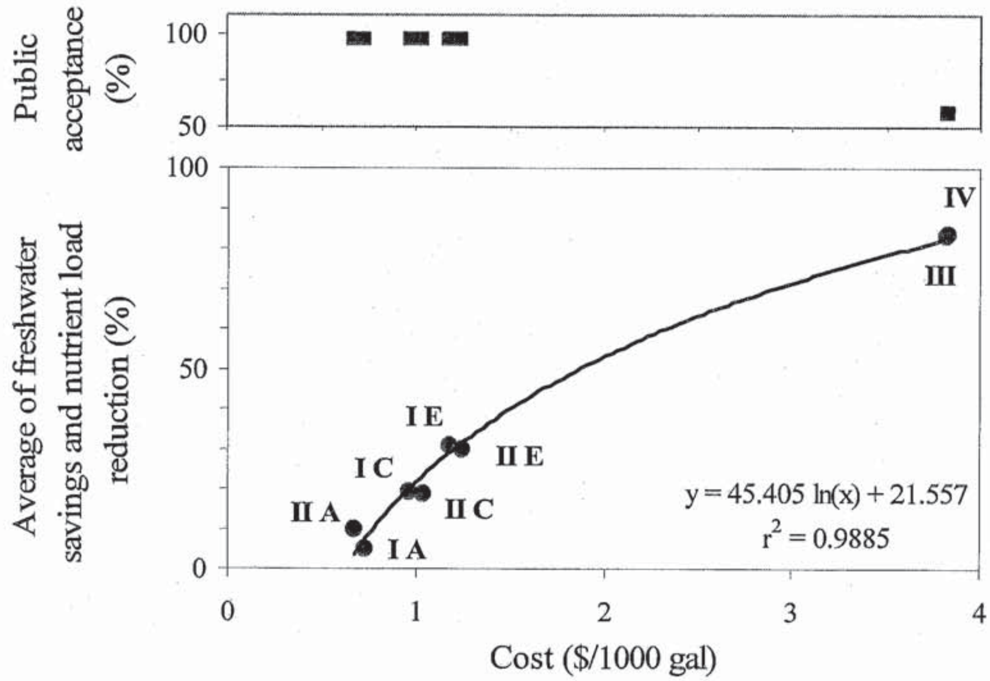

Figure 9-4. Public Acceptance and the Average of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for the Hollywood WWTP.

9.6 Miami-Dade/North WWTP

A summary of the projected flow allocations and costs for liquid treatment, reuse and disposal for the Miami-Dade/North WWTP is given in Table 9-10. A matrix of indicator outcomes over the years 2005–2025 is shown in Table 9-11.

Freshwater savings. Modest freshwater savings of 3% under alternative I and 4% under alternative II are achieved, with half or more of the savings deriving from groundwater recharge. The freshwater savings under alternatives III and IV is 64–65%, which includes savings of 63% from groundwater recharge.

Pollutant load reduction. Management options that include currently planned or limited use of ocean outfalls (alternatives I and II, respectively) limit ocean discharge of nitrogen by up to 84% and discharge of phosphorus by up to 44%. Nutrient load reduction under alternatives III and IV is 100%.

Public acceptance. The public acceptance of alternatives I and II is anticipated to be high because of the very limited extent of water reuse. The substantial degree of freshwater savings due to groundwater recharge under alternatives III and IV poses a challenge to gaining public acceptance. However, a concerted public education efforts and community participation in the planning process could overcome this challenge. Thus, the degree of public acceptance is considered to be low-moderate for this alternative.

Table 9-10. Summary of Flow Allocations and Costs for Liquid Treatment, Disposal and Reuse for the Miami-Dade/North WWTP

Alternative	Year	Flows (MGD) WWTP	Ocean outfall	Trad. Reuse	GW recharge	Concentrate	Cost ($/1000 gal) Scenario* A	C	E
I	2005	107.9	107.8	0.1	0.0	0.0	0.55	0.84	1.08
	2010	111.9	111.8	0.1	0.0	0.0	0.54	0.83	1.07
	2015	116.6	112.5	0.1	3.2	0.8	0.68	0.97	1.19
	2020	121.3	112.5	0.1	6.9	1.7	0.84	1.11	1.32
	2025	126.3	112.5	0.1	10.9	2.7	0.96	1.22	1.43
II	2005	107.9	107.8	0.1	0.0	0.0	0.55	0.84	1.08
	2010	111.9	111.4	0.5	0.0	0.0	0.54	0.83	1.07
	2015	116.6	112.5	2.0	1.8	0.4	0.60	0.89	1.13
	2020	121.3	112.5	2.4	5.1	1.3	0.78	1.06	1.25
	2025	126.3	112.5	3.7	8.1	2.0	0.85	1.12	1.32
III	2005	107.9	0.0	0.1	86.2	21.6	3.15	3.15	3.15
	2010	111.9	0.1	0.5	89.1	22.3	3.10	3.10	3.10
	2015	116.6	0.2	2.0	91.5	22.9	3.05	3.05	3.05
	2020	121.3	0.3	2.4	94.9	23.7	3.00	3.00	3.00
	2025	126.3	0.4	3.7	97.7	24.4	2.95	2.95	2.95
IV	2005	107.9	0.0	0.1	86.2	21.6		3.15	
	2010	111.9	0.0	0.5	89.1	22.3		3.10	
	2015	116.6	0.0	2.0	91.7	22.9		3.05	
	2020	121.3	0.0	2.4	95.1	23.8		3.00	
	2025	126.3	0.0	3.7	98.0	24.5		2.95	

*The scenarios for ocean outfall treatment requirements preceding basic level disinfection are: A--secondary, C--intermediate nutrient removal, and E--full nutrient removal. These scenarios are applicable to alternatives I, II, and III, which involve use of ocean outfalls.

Cost-effectiveness. The projected costs under alternatives I and II range from $0.55 to $1.40/1,000 gal, whereas the projected costs for alternatives III and IV are in the range of $2.95 to $3.15/1,000 gal. Increments in the costs are apparent as the degree of treatment for ocean-bound wastewater is increased from secondary to full nutrient removal. The inflow to the plant is projected to reach the permitted capacity of the ocean outfall (112.5 MGD) by the year 2010. Flows in excess of 112.5 MGD must be handled by a combination of traditional reuse and groundwater recharge. The higher extent of traditional reuse projected under alternative II thus leads to somewhat lower costs.

Table 9-11. Outcomes of Indicators for Ocean Outfall Alternatives at the Miami-Dade/North WWTP

	Treatment applied for ocean outfall discharge		
	A--Secondary treatment	C--Intermediate nutrient removal	E--Full nutrient removal
N load reduction	5%	45%	84%
P load reduction	5%	5%	44%
Freshwater savings	3% (almost all from groundwater recharge)		
Public acceptance	High		
N load reduction	5%	46%	84%
P load reduction	5%	5%	44%
Freshwater savings	4% (including 2% from groundwater recharge)		
Public acceptance	High		
N load reduction	100%	100%	100%
P load reduction	100%	100%	100%
Freshwater savings	64% (including 63% from groundwater recharge)		
Public acceptance	Low-Moderate		
N load reduction	100%		
P load reduction	100%		
Freshwater savings	65% (including 63% from groundwater recharge)		
Public acceptance	Low-Moderate		

Summary. The benefits, costs and public acceptance of the ocean outfall alternatives for the Miami-Dade/North WWTP are compared in Figure 9-5. The benefit is the average of percent freshwater savings and overall nutrient (N, P) load reduction. Public acceptance is rated on a scale of high = 97%, moderate = 71%, and low = 45%, as suggested by the survey from CDM (2004).

A benefit of up to 34% is achieved through various combinations of traditional reuse, groundwater recharge and nutrient control technology (alternatives I and II). These are also the alternatives with the highest public acceptance. The alternatives involving extensive groundwater recharge (III and IV) achieve the highest benefits (82%), but are also most expensive and receive a lower level of public acceptance. The cost to achieve a benefit of 50% is $1.70/1,000 gal. The cost to achieve a benefit of 75% increases to $2.70/1,000 gal.

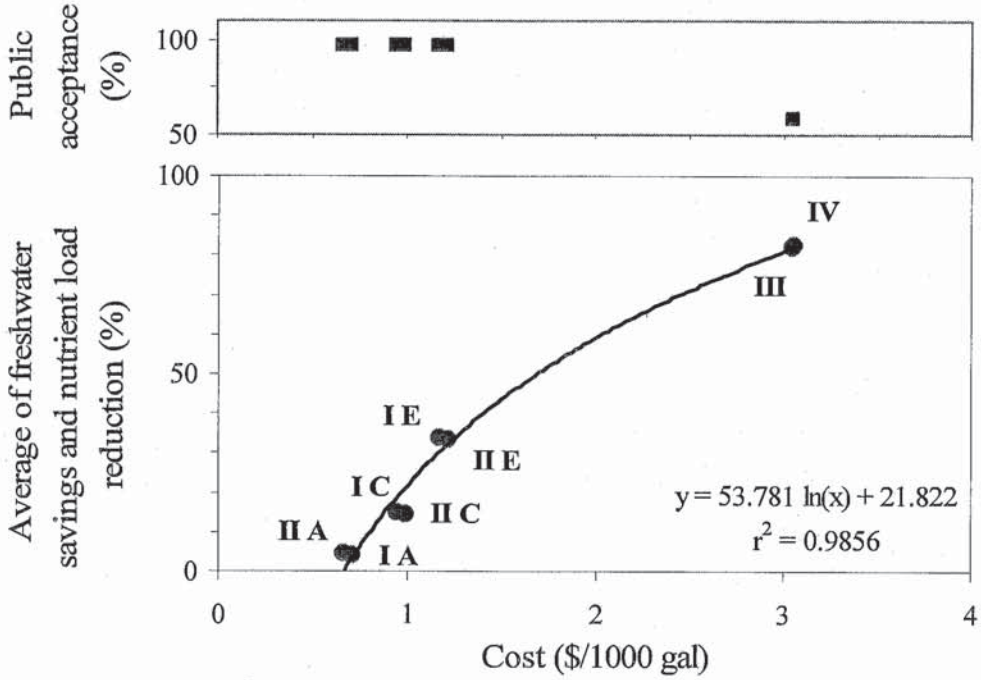

Figure 9-5. Public Acceptance and the Average of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for the Miami-Dade/North WWTP.

9.7 Miami-Dade/Central WWTP

A summary of the projected flow allocations and costs for liquid treatment, reuse and disposal for the Miami-Dade/Central WWTP is given in Table 9-12. A matrix of indicator outcomes over the years 2005–2025 is shown in Table 9-13.

Freshwater savings. Very modest freshwater savings of 1% under alternatives I and II are achieved, due to the limited extent of traditional reuse. The freshwater savings under alternatives III and IV are 64%, which includes savings of 63% from groundwater recharge.

Pollutant load reduction. Management options that include currently planned or limited use of ocean outfalls (alternatives I and II, respectively) limit ocean discharge of nitrogen by up to 83% and discharge of phosphorus by up to 39%. Nutrient load reduction under alternatives III and IV is 100%.

Public acceptance. The public acceptance of alternatives I and II is anticipated to be high because of the very limited extent of water reuse. The substantial extent of groundwater recharge under alternatives III and IV presents a challenge in gaining public acceptance. Depending on the extent and success of the community involvement and public education efforts, a public acceptance of low-to-moderate could be expected.

Table 9-12. Summary of Flow Allocations and Costs for Liquid Treatment, Disposal and Reuse for the Miami-Dade/Central WWTP

Alterna-tive	Year	Flows (MGD) WWTP	Ocean outfall	Trad. Reuse	GW recharge	Concen-trate	Cost ($/1000 gal) Scenario* A	C	E
I	2005	129.4	129.4	0.0	0.0	0.0	0.50	0.87	1.12
	2010	134.1	134.1	0.0	0.0	0.0	0.50	0.87	1.12
	2015	139.8	139.8	0.0	0.0	0.0	0.49	0.86	1.12
	2020	145.4	143.0	0.0	1.9	0.5	0.54	0.90	1.15
	2025	151.3	143.0	0.0	6.7	1.7	0.60	1.00	1.25
II	2005	129.4	129.4	0.0	0.0	0.0	0.50	0.87	1.12
	2010	134.1	133.7	0.4	0.0	0.0	0.50	0.86	1.11
	2015	139.8	138.9	1.0	0.0	0.0	0.49	0.86	1.11
	2020	145.4	143.0	2.1	0.2	0.1	0.50	0.86	1.11
	2025	151.3	143.0	2.9	4.4	1.1	0.58	0.94	1.19
III	2005	129.4	0.0	0.0	103.5	25.9	3.96	3.96	3.96
	2010	134.1	0.1	0.4	106.9	26.7	3.90	3.90	3.90
	2015	139.8	0.1	1.0	111.0	27.8	3.82	3.82	3.82
	2020	145.4	0.2	2.1	114.5	28.6	3.77	3.77	3.77
	2025	151.3	0.3	2.9	118.5	29.6	3.72	3.72	3.72
IV	2005	129.4	0	0.0	103.5	25.9		3.96	
	2010	134.1	0	0.4	106.9	26.7		3.91	
	2015	139.8	0	1.0	111.1	27.8		3.83	
	2020	145.4	0	2.1	114.6	28.7		3.78	
	2025	151.3	0	2.9	118.8	29.7		3.72	

*The scenarios for ocean outfall treatment requirements preceding basic level disinfection are: A--secondary, C--intermediate nutrient removal, and E--full nutrient removal. These scenarios are applicable to alternatives I, II, and III, which involve use of ocean outfalls.

Cost-effectiveness. The costs under alternatives I and II range from $0.50 to $1.25/1,000 gal, whereas costs under alternatives III and IV range from $3.70 to $4.00/1,000 gal. Increments in the costs are apparent as the degree of treatment for ocean-bound wastewater is increased from secondary to full nutrient removal. The permitted ocean outfall capacity is 143 MGD. Projected traditional reuse will not be sufficient to handle flows in excess of this amount after the plant inflow reaches 143 MGD sometime between the years 2015 and 2020. Thus, a modest degree of groundwater recharge is required under alternative I and a lesser extent of groundwater recharge is required under alternative II.

Table 9-13. Outcomes of Indicators for Ocean Outfall Alternatives at the Miami-Dade/Central WWTP

		Treatment applied for ocean outfall discharge		
		A--Secondary treatment	C--Intermediate nutrient removal	E--Full nutrient removal
Alternative I-- Ocean outfalls used at current levels	N load reduction	2%	42%	82%
	P load reduction	2%	2%	39%
	Freshwater savings	1% (all from groundwater recharge)		
	Public acceptance	High		
Alternative II-- Limited use of ocean outfalls	N load reduction	2%	42%	83%
	P load reduction	2%	2%	39%
	Freshwater savings	1% (including 0.5% from groundwater recharge)		
	Public acceptance	High		
Alternative III-- Ocean outfalls as back up	N load reduction	100%	100%	100%
	P load reduction	100%	100%	100%
	Freshwater savings	64% (including 63% from groundwater recharge)		
	Public acceptance	Low-Moderate		
Alternative IV-- No use of ocean outfalls	N load reduction	100%		
	P load reduction	100%		
	Freshwater savings	64% (including 63% from groundwater recharge)		
	Public acceptance	Low-Moderate		

Summary. The benefits, costs and public acceptance of the ocean outfall alternatives for the Miami-Dade/North WWTP are compared in Figure 9-6. The benefit is the average of percent freshwater savings and overall nutrient (N, P) load reduction. Public acceptance is rated on a scale of high = 97%, moderate = 71%, and low = 45%, as suggested by the survey from CDM (2004).

A benefit of up to 31% is achieved through various combinations of traditional reuse, groundwater recharge and nutrient control technology (alternatives I and II). These are also the alternatives with the highest public acceptance. The alternatives involving extensive groundwater recharge (III and IV) achieve the highest benefits (82%), but are also most expensive and receive a lower level of public acceptance. The cost to achieve a benefit of 50% is \$1.90/1,000 gal. The cost to achieve a benefit of 75% increases to \$3.40/1,000 gal.

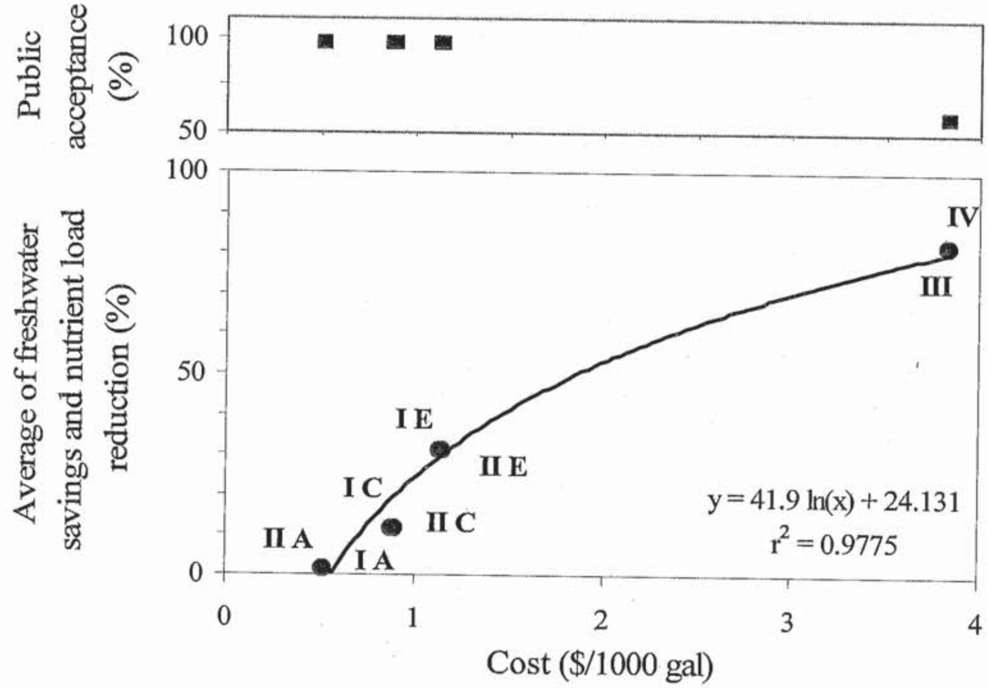

Figure 9-6. Public Acceptance and the Average of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for the Miami-Dade/Central WWTP.

9.8 Comparison of Indicators among the Six WWTPs with Ocean Outfalls

Nutrient load reductions, freshwater savings and costs averaged over the 2005–2025 projection period are compared among the six WWTPs in this section. The Ocean Outfalls as Backups (Alt III) and No Use (Alt IV) alternatives have very similar values of these indicators. Therefore, values of the indicators under alternative IV are not discussed.

9.8.1 Nutrient Load Reductions

Reductions in nutrient load to the ocean are summarized in Figure 9-7 for three levels of treatment—secondary, intermediate nutrient removal and full nutrient removal—under the Currently Planned Use (Alt I), Limited Use (Alt II), and Use as Backups (Alt III) alternatives. Since the base case is defined on the basis of secondary treatment, nutrient reductions under the secondary treatment scenario are achieved by diverting flow from the ocean outfalls to reuse and are identical to the reuse percentages. The Boca Raton and Boynton-Delray WWTPs have the highest projected traditional reuse percentages and thus achieve the highest nutrient load reductions—57% and 64%, respectively, under alternative II (Fig. 9-7a, d). The Broward/North, Hollywood, Miami-Dade/North and Miami-Dade/Central WWTPs have lower projected traditional reuse percentages and therefore lower nutrient reductions—18% or less under alternative II. The results for alternative I are similar, but generally involve less reuse and therefore lower nutrient reductions.

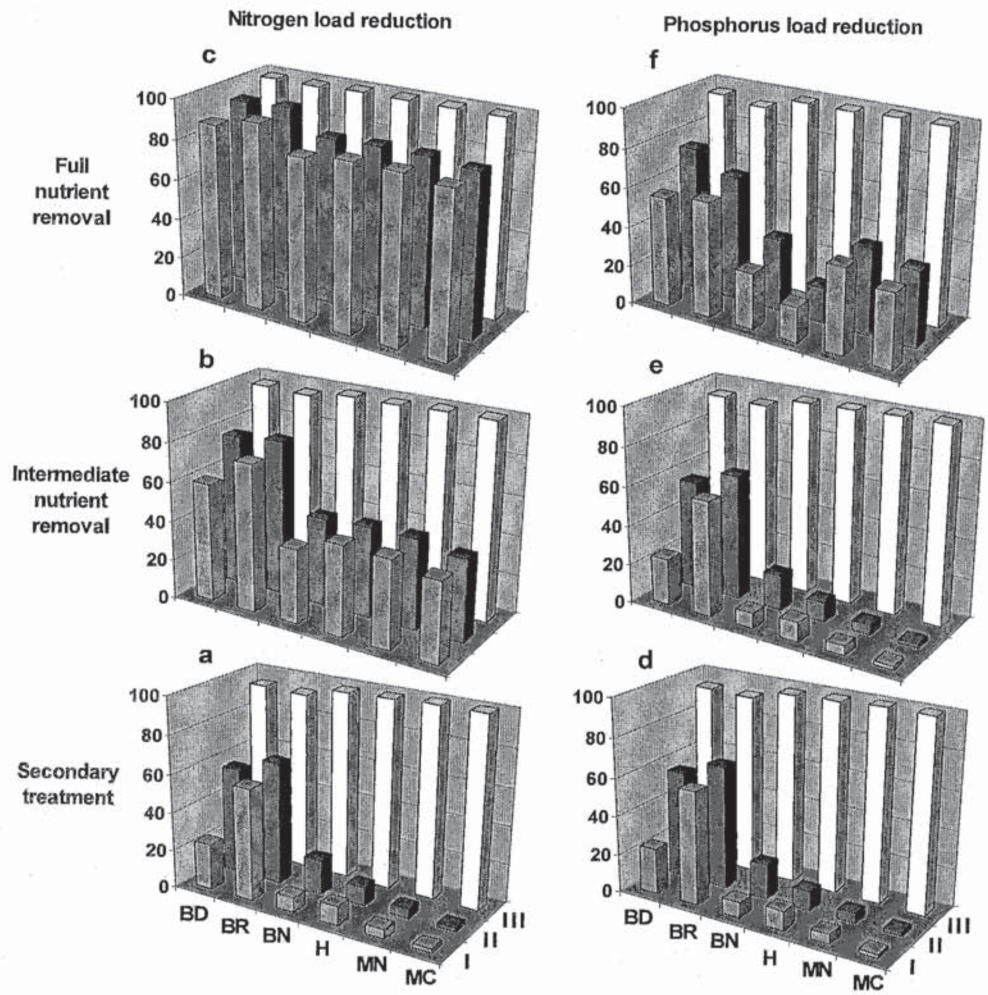

Figure 9-7. Percentage Reductions in Ocean Nutrient Load Achieved by Ocean Outfall Alternatives. I = currently planned use of ocean outfalls, II = limited use of ocean outfalls and III = ocean outfalls as backups; BD = Boynton-Delray, BR = Boca Raton, BN = Broward/North, H = Hollywood, MN = Miami-Dade/North, and MC = Miami-Dade/Central.

Intermediate nutrient control technology improves nitrogen load reductions at all the facilities relative to secondary treatment (Fig. 9-7b). Under alternatives I and II, the Palm Beach County facilities (Boynton-Delray, Boca Raton) reduce nitrogen loads by 77–79% whereas the Broward County (Broward/North, Hollywood) and Miami-Dade County (Miami-Dade/North, Miami-Dade/Central) facilities reduce nitrogen loads by 42–46%. Intermediate nutrient control technology does not improve phosphorus load reductions (Fig. 9-7e), since the effluent phosphorus levels in secondary effluents from all six facilities are below the concentration of 3 mg/L normally achievable by this technology.

Full nutrient removal technology brings the nitrogen load reductions at the Palm Beach County WWTPs to the range of 93–94% under alternatives I and II (Fig. 9-7c), which is comparable to that achieved under alternative III. Nitrogen load reductions at the Broward and Miami-Dade County facilities are somewhat lower—in the range of 83–84%—because of less traditional reuse. Phosphorus load reductions under alternatives I and II reach 64–74% at the Palm Beach County plants and 18–44% at the Broward County and Miami-Dade County plants (Fig. 9-7f).

9.8.2 Freshwater Savings

Freshwater savings relative to the base case, which has zero reuse, are summarized in Figure 9-8. Savings due to traditional reuse are highest at the Palm Beach County WWTPs, reaching 56–64% under alternatives II and III, compared to 18% or less under these alternatives at the Broward and Miami-Dade County WWTPs (Fig. 9-8a). Results for alternative I are similar, but involve less traditional reuse and therefore less freshwater savings. Groundwater recharge is negligible under alternatives I and II and accordingly there is little or no freshwater savings attributable to groundwater recharge under these alternatives (Fig. 9-8b). Groundwater recharge is extensive under alternative III, particularly at the facilities with limited traditional reuse. The Broward/North, Hollywood, Miami-Dade/North and Miami-Dade/Central WWTPs have freshwater savings of 51–63% due to groundwater recharge under alternative III, compared to 20–28% at the Boynton-Delray and Boca Raton WWTPs. The total freshwater savings are highest at the facilities with most extensive traditional reuse (Fig. 9-8c), ranging from 1% to 59% under alternative I, 1% to 64% under alternative II, and 64% to 82% under alternative III.

9.8.3 Costs

The costs of the various scenarios are compared among the six WWTPs in Figure 9-9. Under the Limited Use alternative (Alt II) and the secondary treatment scenario, costs vary in proportion to the extent of traditional reuse, ranging from \$0.50 to \$0.70/1,000 gal at the Broward County and Miami-Dade County facilities, where traditional reuse is least, to \$1.50/1,000 gal at the Palm Beach County WWTPs, where traditional reuse is greatest (Fig. 9-9a). Costs under the intermediate nutrient removal scenario increase to \$0.90–1.00/1,000 gal at the Broward County and Miami-Dade County facilities and \$1.60–1.70/1,000 gal at the Boynton-Delray and Boca Raton facilities (Fig. 9-9b). Under the full nutrient removal scenario, costs increase to \$1.00–1.20/1,000 gal at the Broward County and Miami-Dade County facilities and \$1.80/1,000 gal at the Palm Beach County facilities (Fig. 9-9c). The results under alternative I are generally similar.

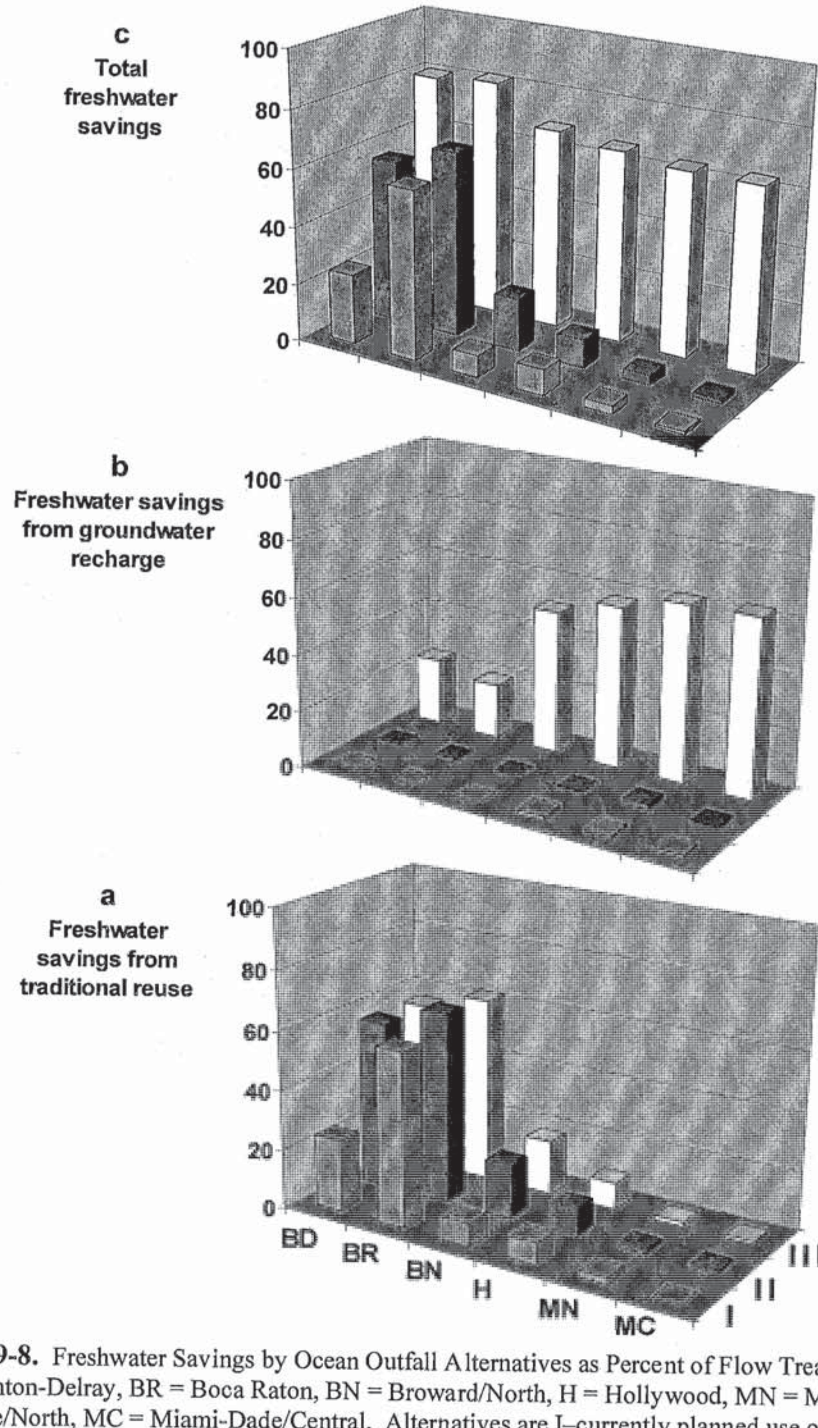

Figure 9-8. Freshwater Savings by Ocean Outfall Alternatives as Percent of Flow Treated. BD = Boynton-Delray, BR = Boca Raton, BN = Broward/North, H = Hollywood, MN = Miami-Dade/North, MC = Miami-Dade/Central. Alternatives are I–currently planned use of ocean outfalls, II–limited use of ocean outfalls, and III–use of ocean outfalls as backups. (Freshwater savings are expressed as percent of treated flow not discharged to Class I injection wells at the Broward/North WWTP.)

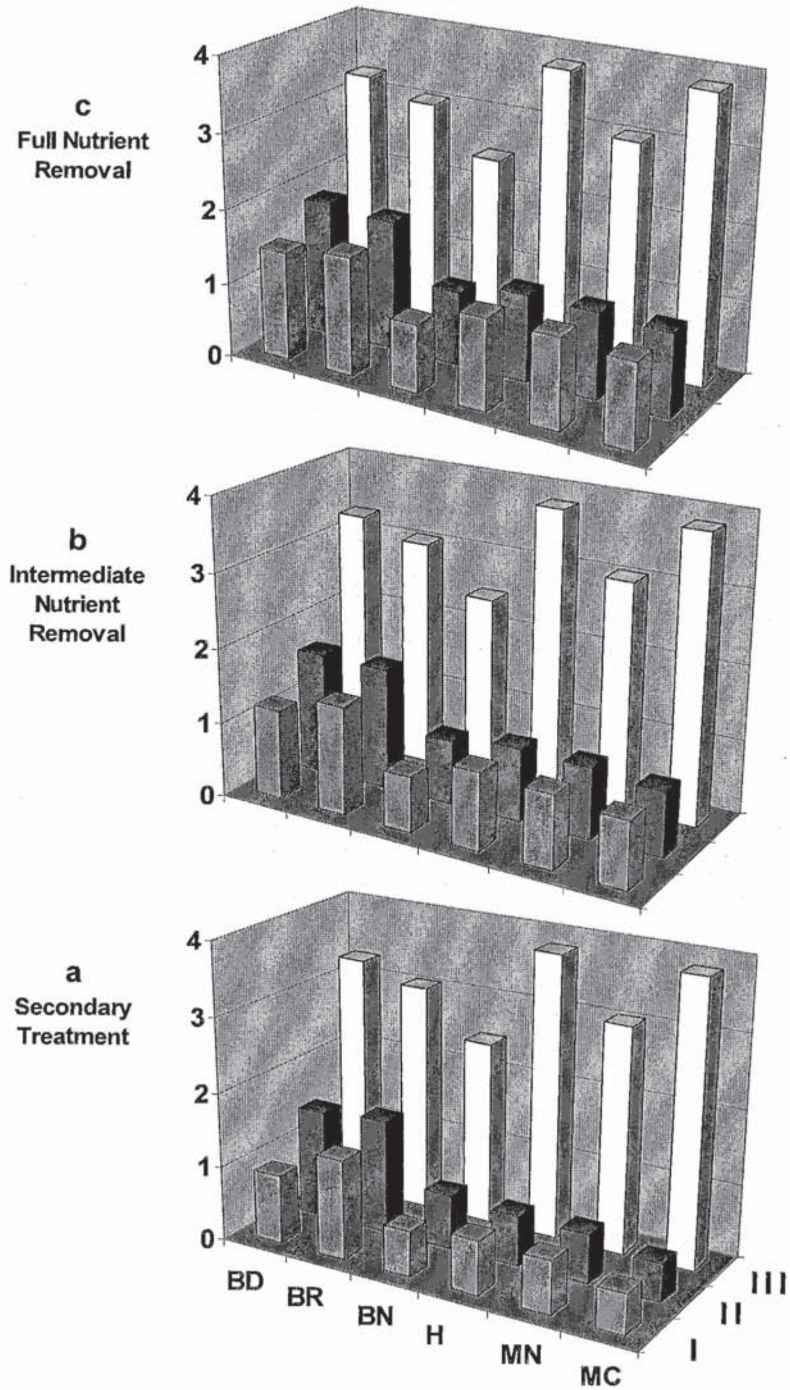

Figure 9-9. Costs for Ocean Outfall Alternatives in $/1,000 gal. BD = Boynton-Delray, BR = Boca Raton, BN = Broward/North, H = Hollywood, MN = Miami-Dade/North, MC = Miami-Dade/Central. Alternatives are I–currently planned use, II–limited use, and III–backup use.

Very little flow reaches the outfalls under alternative III; therefore, the costs of this alternative are only slightly influenced by the level of treatment applied for ocean outfall disposal. The costs are highest ($3.80/1,000 gal) at the Miami-Dade/Central and Hollywood WWTPs. Both of these facilities have limited traditional reuse; therefore, most of the flow is handled by groundwater recharge under alternative III. The sites of recharge are very far (up to 35 miles) from the Miami-Dade/Central facility and hence high reclaimed water transmission costs are incurred. The Hollywood facility has a long transport distance to the recharge site and also has relatively high costs for concentrate disposal. Costs at the Broward/North WWTP are relatively low ($2.50/1,000 gal) because of relatively close proximity of recharge sites and a moderate level of traditional reuse. Costs at the other three facilities are in the range of $3.10 to $3.30/1,000 gal.

As shown earlier, the full nutrient control scenario under alternative II can achieve nitrogen load reductions that are on the same order as those achieved by alternative III. It is therefore interesting to express the cost of this scenario relative to that of alternative III. Costs of the full nutrient removal scenario at the Broward and Miami-Dade County WWTPs range from 29–40% of the costs of alternative III, while achieving nitrogen load reductions of 83–84%. At the Palm Beach County plants, the full nutrient removal scenario has costs that are 55–57% those of alternative III, while achieving nitrogen load reductions of 93–94%. However, corresponding phosphorus load reductions are less impressive, ranging from 18 to 74% at the six WWTPs.

9.9 Summary

Four alternative ocean outfall strategies were examined under the defined scope of this study. Under the Currently Planned Use alternative (Alt I), ocean outfalls would be used at currently planned levels. Under the Limited Use Alternative (Alt II), ocean outfall disposal would be limited to flows remaining after traditional reuse options were maximized and underground injection flows reached full 2005 permitted capacity. Under the Ocean Outfalls as Backups alternative (Alt III), ocean disposal would only be used during wet weather periods to handle flow that would otherwise go to traditional reuse. Complete elimination of ocean outfalls was considered under the No Use alternative (Alt IV). Varying degrees of treatment (secondary, intermediate nutrient removal, full nutrient removal) were considered for wastewater that is destined for ocean disposal. Secondary treatment with no disinfection vs. secondary treatment with filtration and high-level disinfection was considered for disposal through Class I injection wells. Four indicators (performance measures) were evaluated for each alternative: 1) amount of freshwater saved relative to a base case with no reuse, 2) reductions in nitrogen and phosphorus discharged via ocean outfalls relative to the base case, 3) public acceptance, and 4) costs. The results are given in a series of 13 tables and 9 figures.

The following conclusions and recommendations were reached from evaluation of the ocean outfall alternatives:

- Traditional (public access) reuse for the Boynton-Delray and Boca Raton WWTPs could substantially reduce nutrient loads to the ocean. Substantial reduction of nutrient loads from the other four facilities can be achieved through groundwater recharge, since traditional reuse opportunities are more limited in these areas.

- Substantial reductions in nitrogen loads are achievable through intermediate and full nutrient removal technologies. Given the relatively low total phosphorus concentrations in effluents from the WWTPs, only full nutrient removal technology can reduce phosphorus loads. Substantial reductions in phosphorus load will require moving toward either traditional reuse or groundwater recharge.
- The average freshwater savings are essentially equal to traditional reuse volumes under alternatives I (currently planned use of ocean outfalls) and II (limited use of ocean outfalls) and range from 24 to 64% at the Boynton-Delray and Boca Raton WWTPs and from 1 to 18% at the other four facilities.
- Under alternatives III (use of ocean outfalls as backups) and IV (no use of ocean outfalls), average freshwater savings range from 64 to 87%.
- Public acceptance of alternatives I and II is expected to be high at all of the facilities because the reclaimed water is used primarily for irrigation.
- Public acceptance of alternatives featuring large-scale groundwater recharge could be moderate or lower. However, public education programs and community involvement throughout the planning, implementation, and continued use of water reuse projects should help mitigate public concerns.
- Trends between costs and the percent average of freshwater savings and nutrient load reduction indicate that alternatives emphasizing traditional reuse and nutrient control technology are somewhat more cost effective than those emphasizing groundwater recharge. The ability to generate revenues from traditional reuse further increases the attractiveness of this approach.
- At the facilities with lesser densities of consumptive use permittees (Hollywood, Miami-Dade/North and Miami-Dade/Central), extensive groundwater recharge would be required to achieve a 50% average of freshwater savings and nutrient load reduction unless industries and residential users are added to the reclaimed water customer base.
- The costs of liquid treatment, reuse, and disposal to achieve a 50% average of freshwater savings and nutrient load reduction would range from $1.00/1,000 gal at the Boca Raton WWTP to $1.90/1,000 gal at the Hollywood WWTP, averaging $1.50/1,000 gal. Increasing this average to 75% would raise the average cost to $2.60/1,000 gal.

References

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Reuse Coordinating Committee and the Water Conservation Initiative Water Reuse Work Group (2003) Water Reuse for Florida: Strategies for Effective Use of Reclaimed Water. Florida Department of Environmental Protection, Tallahassee, Florida. June 2003. Accessed 28 February 2006 at http://www.dep.state.fl.us/water/reuse/flprog.htm.

10. Summary and Conclusions

The purpose of the study was to evaluate the status and efficacy of effluent management options for the six municipal facilities in Florida's Palm Beach, Broward and Miami-Dade Counties that discharge secondarily treated wastewater through ocean outfalls (Fig. 10-1). Urban water requirements in this region are rising due to rapid population growth, while water supply problems loom due to uncertainties in the time-phasing and funding of water resources projects. Southeast Florida's natural and artificial reef resources—some located near the outfalls—provide habitat and protection for marine organisms and contribute over 61,000 jobs and $1.9 billion in yearly income for residents of the three counties. An underutilized water management option in the region is water reuse, which could help Southeast Florida meet its water requirements while decreasing or eliminating reliance on ocean outfalls. The State has a reuse capacity of 1.2 BGD and expects to reclaim and reuse 65% of all domestic wastewater by 2020, up from 40% today. The study reviewed previous work describing the effects of ocean wastewater disposal on ocean biota and human health risks as well as past examples of obstacles and successes of water reuse in Florida, the U.S. and abroad. Four alternative ocean outfall strategies—involving varying degrees of reuse, nutrient removal and ocean outfall use— were considered. The alternatives were evaluated at each wastewater treatment plant according to four performance measures: 1) amount of freshwater saved relative to a base case with no reuse, 2) reduction in nitrogen and phosphorus discharged via ocean outfalls relative to the base case, 3) public acceptance, and 4) costs. Management recommendations based on these evaluations are presented.

Figure 10-1. Florida Counties with Ocean Outfalls. Photo from Google Earth (2005).

Current and projected flows at the six wastewater treatment plants (WWTPs) are compared to their permitted capacities in Table 10-1. The 2025 wastewater influent flow exceeds the 2005 permitted capacity at each WWTP; thus all of the facilities face important decisions regarding their future wastewater management options. According to current plans of the utilities, 7% of the total wastewater handled by the facilities will be reclaimed for traditional (public access) reuse in 2025, up from 4% currently.

Table 10-1. Permitted, 2005, and Projected 2025 Flows at WWTPs with Ocean Outfalls

	Boynton-Delray	**Boca Raton**	**Broward/ North**	**Hollywood**	**M-D/ North**	**M-D/ Central**	**Total**
Permitted flow (MGD)	24.0	17.5	84.0	42.0	112.5	143.0	423
2005 flow (MGD)	19	16	84	40	108	129	396
2005 reuse[1] (MGD)	3.7	5.2	2.4	2.6	0.1	0	14
2005 reuse[1] (%)	19	33	3	7	< 1	0	4
2025 flow (MGD)	27	22	94	54	126	151	474
2025 reuse[1,2] (MGD)	7.5	15.9	5.3	3.6	0.1	0	32.4
2025 reuse[1,2] (%)	28	73	6	7	0.1	0	7

[1]Excluding onsite reuse for process

[2]Based on utilities' plans extending to 2025

The primary source of potable water in Palm Beach County is the Surficial or the Biscayne Aquifer and in Broward and Miami-Dade Counties it is the Biscayne Aquifer. Population growth in the region should lead to a continued upward trend in demands, resulting in an aggregate water demand of 606 MGD by the year 2025. The Lower East Coast Water Supply Plan developed options for meeting future water supply needs, including Everglades National Park as part of the Everglades restoration, but did not make a detailed evaluation of reuse options. Ideally, the planned update of the 2000 Plan will address reuse in more detail.

Each of the service areas within the three counties was analyzed to determine the future water demand in relation to the available and planned potable water design capacity. The difference between water demand and potential water supply (design capacity) for the study period is termed "new water" demand. New water is the water demand in excess of the existing or planned water supply (design capacity) of the water treatment facility.

Palm Beach County has sufficient water treatment plant design capacity to meet its needs until at least 2025 (Table 10-2). Broward County has insufficient design capacity to meets its 2025 water demand; however, the water utilities within the County are planning five improvement programs during the study period to increase the design capacity by 26.9 MGD for a total of 426.8 MGD by the year 2008, which is sufficient to meet water demands throughout the study period. After three planned improvements to increase its design capacity by 86.3 MGD for a total of at least 554 MGD by the year 2025, Miami-Dade County will still need to identify sources for an additional 26.7 MGD by 2025.

Table 10-2. Summary of Projected Water Demands and WTP Design Capacities for the Study Area

County	2005 Water Demand (MGD)	% of 2005 Total	2025 Water Demand (MGD)	% of 2025 Total	2005 Design Capacity (MGD)	2025 Design Capacity (MGD)	Demand in Excess of Capacity (MGD)
Palm Beach	62.5	13.3	87.4	14.4	124.0	124.0	0
Broward	167.3	35.7	226.7	37.4	399.9	426.8	0
Miami-Dade	238.9	51.0	292.4	48.2	467.7	554.0	26.7
Total	468.7	100.0	606.5	100.0	991.6	1104.8	26.7

The Southeast Florida Outfall Experiment I (SEFLOE I), initiated by utilities in Broward, Miami-Dade and Palm Beach Counties, characterized the impacts of ocean outfall wastewater disposal in Southeast Florida. Englehardt et al. (2001) present a comparative assessment of the human and ecological impacts from municipal wastewater disposal in Southeast Florida. Their assessment includes ocean disposal from the six WWTPs. Field investigations revealed that surfacing plumes were present at all six WWTP outfalls throughout the year (Englehardt et al. 2001). All of the outfalls are in at least 28 meters (92 ft) of water and 2 miles offshore. They are located in the westerly boundary of the strong Florida Current, a tributary of the Gulf Stream. Wanninkhof et al. (2006) evaluated farfield dilution of sewage outfall discharges in southeast Florida. Their studies indicate that the rapid dilution observed in the immediate vicinity of the outfall continues to occur in the 10 to 66 km (6 to 41 mi) downstream distances. These authors do not address issues of reef impacts or pollutant control. A 2003 US EPA relative risk assessment study involved deep well injection, aquifer recharge, discharge to ocean outfalls and surface waters as disposal options (US EPA 2003). One of the conclusions of this study was that:

> Human health risks are of some concern, both within the 400-m mixing zone and outside of it, primarily because treatment of effluent prior to discharge via ocean outfalls does not include filtration to remove *Cryptosporidium* and *Giardia.* The most probable human exposure pathways include fishermen, swimmers, and boaters who venture out into the Florida Current and experience direct contact, accidental ingestion of water, or ingest fish or shellfish exposed to effluent. Otherwise, there is a very small, but not nonzero, chance for onshore or nearshore recreational or occupational users to be exposed to effluent constituents, since there is a small (10%) chance that currents will change direction to east or west.

Natural and artificial reefs near the six ocean outfalls contribute significantly to the tourist business in South Florida (2001). Recent studies by Tichenor (2004a; 2004b) suggest that the outfall discharge at Boynton Beach may be having an adverse effect on Lynn's Reef, but did not establish a link between pollutant discharges and the relative importance of pollutant concentrations at a specific reef. A biomarker study by Fauth et al. (2006) indicates that the reefs have been impacted in some cases. Based on $\delta15N$ analyses of macroalgae, sponges and gorgonian corals recently collected from reefs in Palm Beach and Broward counties, Lapointe and Risk (undated) believe that sewage nitrogen is a contributor to the nitrogen pool in the area's coastal waters. No complete report is available for this ongoing study. These recent and ongoing studies could provide valuable new insights into the extent of the cause-effect linkage between outfall discharges and impaired reefs in Southeast Florida and indicate whether or not current wastewater treatment levels are sufficient to protect water quality in general and the reefs in particular.

The highly urbanized nature of Southeast Florida has been cited as an obstacle to water reuse. However, successes of water reuse systems in large urban areas are well documented. The West Basin Water Management District in the Los Angeles area provides 118 MGD of reclaimed water for traditional reuse. The Irvine Ranch Water District in California has 300 miles of reclaimed water distribution piping in place. The Pinellas County, St. Petersburg, Florida, and Rouse Hill, Australia systems each have upwards of 10,000 connections to their reclaimed water distribution systems, while the City of Cape Coral, Florida has 33,000 residential customers—the world's largest residential reuse system. Orange County, California, is building a 62.5 MGD system to supply highly treated reclaimed water for groundwater augmentation and limitation of seawater intrusion. Satellite water reclamation facilities offer a cost-effective means of serving users that are distant from regional water reclamation facilities. They vary in size from the 100 MGD San Jose Creek Water Reclamation Plant in Los Angeles County to 0.01 MGD units demonstrated in Melbourne, Australia. Satellite facilities can achieve higher reclaimed water qualities than regional facilities—with the same degree of treatment—in collection systems impacted by saline groundwater.

Spatial analysis of the consumptive permit user database in Southeast Florida indicates that large users[1] with individual permits in Palm Beach County and northern Broward County have the highest demands for landscape irrigation. These large users are typically golf courses, parks, and other recreational areas. Miami-Dade County has the highest potential industrial demand. The Turkey Point Power Plant is an example of an industrial user not currently being supplied with reclaimed water. A case study of the area near the Broward/North WWTP indicates that reclaimed water can be cost effectively supplied to larger irrigation users within 12 metropolitan miles (measured along streets) of the reclamation facility. A relationship between reclaimed water flow for traditional reuse and cost was developed for this system. Expressions for the cost of transporting and injecting highly treated reclaimed water for groundwater recharge and for disposing of concentrate from reverse osmosis were also determined.

Four alternative ocean outfall strategies were examined under the defined scope of this study. Under the Currently Planned Use alternative (Alt I), ocean outfalls would be used at currently planned levels. Under the Limited Use Alternative (Alt II), ocean outfall disposal would be limited to flows remaining after traditional reuse options were maximized and underground injection flows reached full 2005 permitted capacity. Under the Ocean Outfalls as Backups alternative (Alt III), ocean disposal would only be used during wet weather periods to handle flow that would otherwise go to traditional reuse. Complete elimination of ocean outfalls was considered under the No Use alternative (Alt IV). Florida's 1.2 BGD reuse capacity clearly indicates that reuse is feasible within Florida and state statutes (403.064 and 373.250, F.S.) encourage and promote water reuse. Therefore, it was assumed that unaccounted for flows would be directed to reuse in alternatives that involve some level

[1] Users of 0.05 MGD more are categorized as large users for the purposes of this study.

of curtailment of ocean outfalls. The assumption was made that permitted capacities of the ocean outfalls would be maintained at 2005 levels and that no additional ocean outfalls would be permitted. It was also assumed that Class I injection control wells for effluent disposal would be held at 2005 permitted capacities and, furthermore, that Class I injection wells for effluent disposal that were in testing or under construction during 2005 would not receive permits. Current and potential treatment requirements employed in the evaluation of ocean outfall alternatives are summarized in Table 10-3. Generalized process trains capable of achieving these treatment requirements are shown in Figure 10-2.

Four indicators (performance measures) for the various alternatives at each of the WWTPs were evaluated: 1) amount of freshwater saved relative to a base case with no reuse, 2) reductions in nitrogen and phosphorus discharged via ocean outfalls relative to the base case, 3) public acceptance, and 4) costs. Indicators were evaluated based on the complete data set throughout the projection period.

Table 10-4 gives averages of flows, freshwater savings, public acceptance, and costs over the 20-year projection period (2005–2025) for all scenarios considered at the six WWTPs. Costs in the table include the costs of liquid treatment, reuse and disposal. Table 10-5 gives average values for nutrient loads to the ocean under the base case as well as in all scenarios considered for the WWTPs. Percentage reductions in nutrient load achieved in the scenarios are also given.

Table 10-3. Current and Potential Treatment Requirements of Wastewater Management Options*

Option	Treatment requirements	
	Current	Potential
Ocean outfalls	Secondary with basic-level disinfection (T2)	Intermediate or full nutrient control w/ basic-level disinfection (T4/T5)
Class I injection wells	Secondary with no disinfection (T1)	Secondary w/ filtration & high-level disinfection (T3)
Traditional reuse	Secondary w/ filtration & high-level disinfection (T3)	
Groundwater recharge	Full treatment and disinfection (T6)	

*Treatment trains (T1, T2, etc.) capable of meeting the requirements are described in Figure 10-2

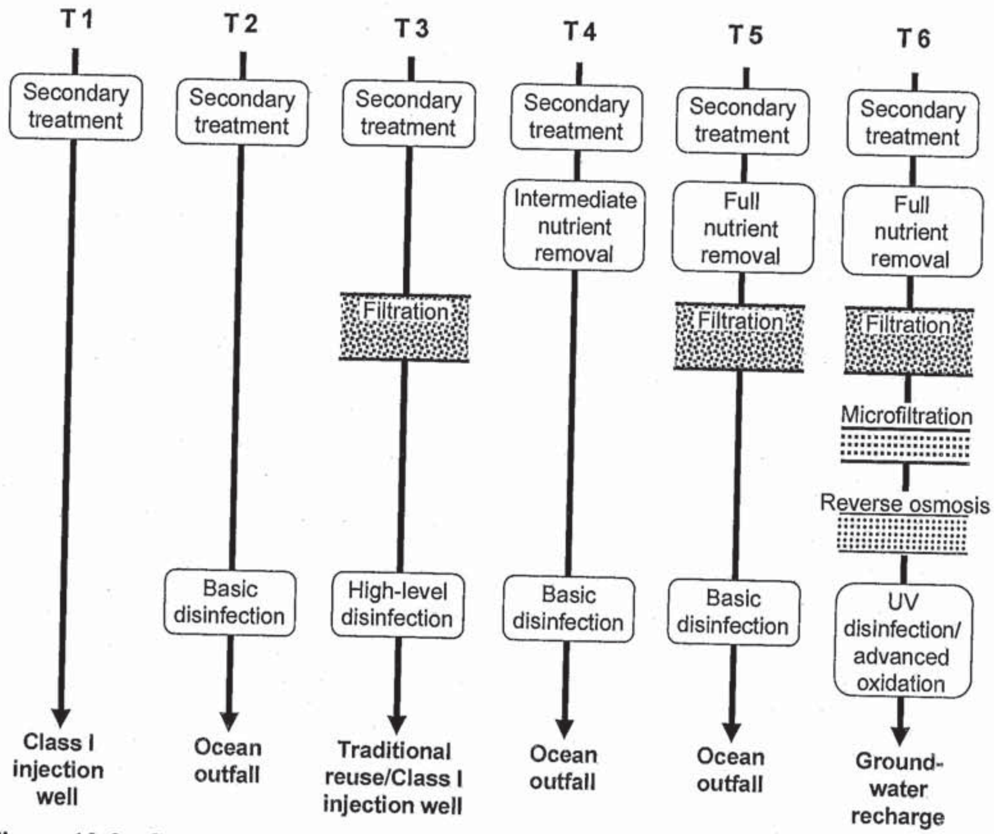

Figure 10-2. Generalized Process Trains Capable of Meeting Current and Potential Treatment Requirements of Wastewater Management Options

The averages of freshwater savings and nutrient load reductions and costs of the ocean outfall alternatives for the six WWTPs with ocean outfalls are compared in Figure 10-3. As the figure indicates, there are no maxima in the averages with respect to cost. Furthermore, the results for specific scenarios tend to lie near the general trend for each facility, indicating no substantial cost advantage of one scenario over another for a given level of freshwater savings and nutrient load reduction. The costs do not take into account the revenues that could be generated from providing reclaimed water to users as part of a traditional reuse system. When the potential for revenue generation is considered, scenarios emphasizing traditional reuse are likely to be more cost effective than those that do not.

The following conclusions and recommendations were reached from the present study:

- Water reuse (traditional and groundwater recharge) offers advantages to Southeast Florida—in terms of conserving water, augmenting available water resources, and reducing discharges to the ocean environment.
- Considering impending water shortages in Southeast Florida, continued use of ocean outfalls and deep injection wells for effluent disposal represents an unsustainable export of freshwater from the region.

Table 10-4. Flows, Freshwater Savings, Public Acceptance and Costs for Ocean Outfall Alternatives over the Period 2005–2025

WWTP	Inflow (MGD)	Alt	Flows as % of inflow: Ocean outfall	UIC wells[1]	Trad. Reuse	GW re-charge	Concen-trate	% Freshwater Savings: Total	From GWR	Public acceptance[2]	Cost ($/1000 gal) Scenarios[3]: A	C	E
Boynton-Delray	23.2	I	75.6	0.0	24.4	0.0	0.0	24	0	H	0.92	1.20	1.46
		II	43.5	0.0	56.5	0.0	0.0	56	0	H	1.46	1.65	1.82
		III	6.1	0.0	56.5	29.9	7.5	80	24	L/M to M/H	3.29	3.29	3.29
		IV	0.0	0.0	56.5	34.8	8.7	84	28	L/M to M/H		3.41	
Boca Raton	18.7	I	41.4	0.0	58.6	0.0	0.0	59	0	H	1.34	1.46	1.60
		II	35.7	0.0	64.3	0.0	0.0	64	0	H	1.53	1.63	1.75
		III	6.7	0.0	62.5	24.6	6.1	82	20	L/M to M/H	3.06	3.06	3.06
		IV	0.0	0.0	64.3	28.5	7.1	87	23	L/M to M/H		3.22	
Broward/ North	90.0	I	61.6	33.3	5.0	0.0	0.0	8	0	H	0.61	0.75	0.92
		II	54.5	33.3	12.2	0.0	0.0	18	0	H	0.73	0.86	1.00
		III	1.3	33.3	12.2	42.6	10.6	69	51	L to M	2.47	2.47	2.47
		IV	0.0	33.3	12.2	43.6	10.9	71	52	L to M		2.48	
Hollywood	47.2	I	90.4	0.0	7.2	1.9	0.5	9	1	H	0.73	1.04	1.24
		II	89.9	0.0	9.2	0.7	0.2	10	1	H	0.67	0.97	1.18
		III	1.0	0.0	9.2	71.8	18.0	67	57	L to M	3.82	3.82	3.82
		IV	0.0	0.0	9.2	72.6	18.2	67	58	L to M		3.83	
Miami-Dade/ North	116.8	I	95.4	0.0	0.1	3.6	0.9	3	3	H	0.71	0.99	1.22
		II	95.3	0.0	1.5	2.6	0.6	4	2	H	0.66	0.95	1.17
		III	0.2	0.0	1.5	78.7	19.7	64	63	L to M	3.05	3.05	3.05
		IV	0.0	0.0	1.5	78.8	19.7	65	63	L to M		3.05	
Miami-Dade/ Central	140.0	I	98.5	0.0	0.0	1.2	0.3	1	1	H	0.53	0.90	1.15
		II	98.3	0.0	0.9	0.7	0.2	1	1	H	0.51	0.88	1.13
		III	0.1	0.0	0.9	79.2	19.8	64	63	L to M	3.84	3.84	3.84
		IV	0.0	0.0	0.9	79.3	19.8	64	63	L to M		3.84	

[1] Class I [2] L = low, M = moderate, H = high

[3] The scenarios for ocean outfall treatment are: A--secondary, C--intermediate nutrient removal, and E--full nutrient removal. These scenarios are applicable to alternatives I, II, and III, which involve use.

Table 10-5. Averages for Nutrient Loads to the Ocean in Comparison to the Base Case over the 20-Year Projection Period

		Average Nutrient Loads to Ocean (tons/yr)								% Reductions in Nutrient Loads					
		Base case		Secondary		Inter. nut. rem.		Full nut. rem.		Secondary		Inter. nut. rem.		Full nut. rem.	
WWTP	Alt*	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
Boynton-Delray	I	661	60	500	45	267	45	80	27	24	24	60	24	88	56
	II	661	60	287	26	154	26	46	15	56	56	77	56	93	74
	III	661	60	40	3.7	22	3.7	6.5	2.2	94	94	97	94	99	96
Boca Raton	I	480	20	199	8.2	118	8.2	35	8.2	59	59	75	59	93	59
	II	480	20	171	7.1	101	7.1	30	7.1	64	64	79	64	94	64
	III	480	20	32	1.3	19	1.3	5.7	1.3	93	93	96	93	99	93
Palm Beach County	I	1,141	80	698	54	385	54	115	35	39	33	66	33	90	56
	II	1,141	80	459	33	255	33	77	22	60	58	78	58	93	72
	III	1,141	80	73	5.0	41	5.0	12	3.5	94	94	96	94	99	96
Broward/ North	I	1,351	119	1,249	110	844	110	253	84	8	8	38	8	81	29
	II	1,351	119	1,104	97	746	97	224	75	18	18	45	18	83	37
	III	1,351	119	26	2.3	18	2.3	5.3	1.8	98	98	99	98	100	99
Hollywood	I	1,193	79	1,079	71	650	71	195	65	10	10	46	10	84	18
	II	1,193	79	1,072	71	646	71	194	65	10	10	46	10	84	18
	III	1,193	79	12	0.8	7.0	0.8	2.1	0.7	99	99	99	99	100	99
Broward County	I	2,543	198	2,328	181	1,494	181	448	149	8	8	41	8	82	24
	II	2,543	198	2,176	168	1,392	168	418	139	14	15	45	15	84	30
	III	2,543	198	38	3.1	25	3.1	7	2.5	99	98	99	98	100	99
Miami-Dade/ North	I	3,111	302	2,968	288	1,696	288	509	170	5	5	45	5	84	44
	II	3,111	302	2,966	288	1,695	288	508	169	5	5	46	5	84	44
	III	3,111	302	5.5	0.5	3.1	0.5	0.9	0.7	100	100	100	100	100	100
Miami-Dade/ Central	I	3,580	341	3,525	336	2,098	336	629	210	2	2	41	2	82	38
	II	3,580	341	3,518	335	2,094	335	628	209	2	2	42	2	82	39
	III	3,580	341	3.8	0.4	2.3	0.4	0.7	0.2	100	100	100	100	100	100
Miami-Dade County	I	6,691	643	6,493	624	3,794	624	1,138	379	3	3	43	3	83	41
	II	6,691	643	6,484	623	3,789	623	1,137	379	3	3	43	3	83	41
	III	6,691	643	9	0.9	5	0.9	2	0.9	100	100	100	100	100	100

*A nutrient load of zero and nutrient load reduction of 100% are achieved under Alternative IV at each WWTP

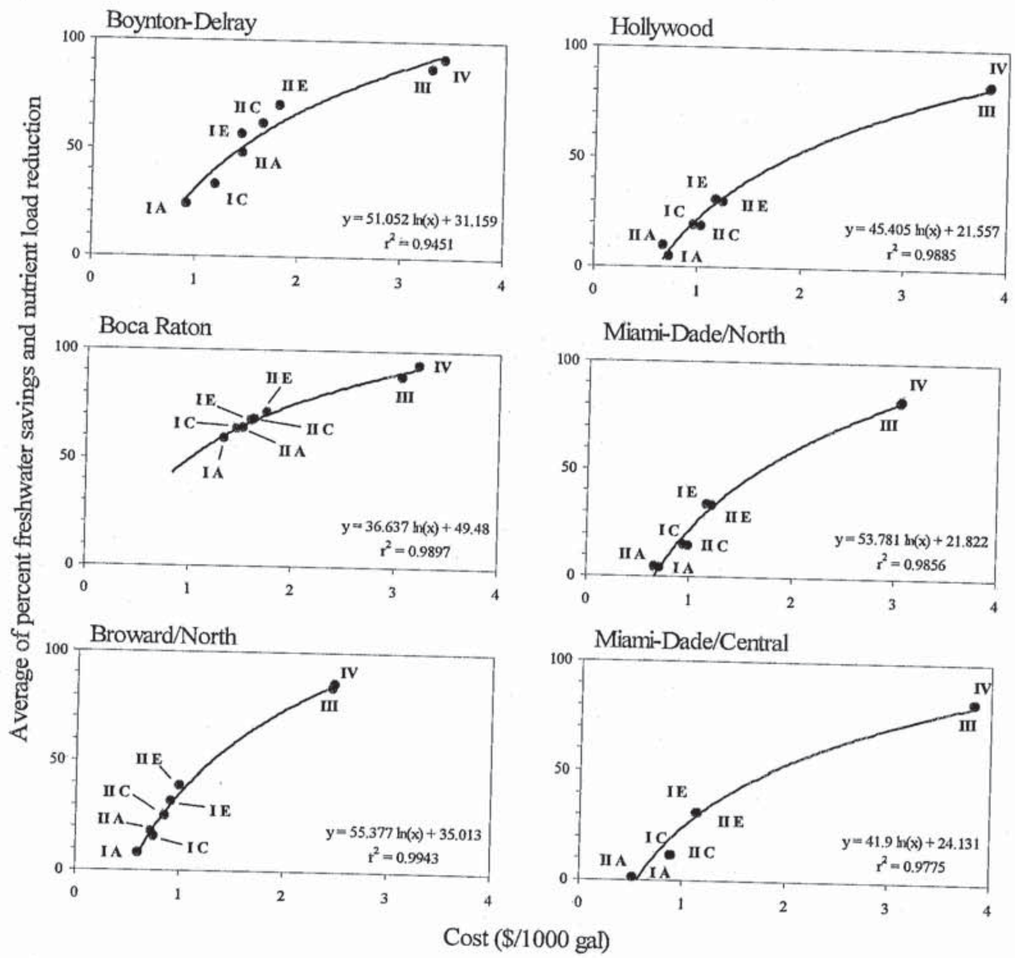

Figure 10-3. Averages of Percent Freshwater Savings and Nutrient Load Reduction versus Cost of Ocean Outfall Alternatives for WWTPs in Southeast Florida over the Period 2005–2025. Alternatives are Currently Planned Use (I), Limited Use (II), Ocean Outfalls as Backups (III) and No Use (IV). The scenarios for ocean outfall treatment are: A–secondary, C–intermediate nutrient removal, and E–full nutrient removal.

- The weight of indirect evidence of reef damage by ocean outfalls is cause for concern and justification for additional actions to address these issues.
- The success of water reuse in large urban areas in the U.S. and abroad indicates that difficulties to reuse posed by the highly urbanized nature of Southeast Florida can be overcome.
- Satellite water reclamation facilities can effectively serve distant users of reclaimed water in regional wastewater systems and improve reclaimed water quality in collection systems impacted by saltwater intrusion.

- Traditional (public access) reuse for the Boynton-Delray and Boca Raton WWTPs could substantially reduce nutrient loads to the ocean. Substantial reduction of nutrient loads from the other four facilities can be achieved through groundwater recharge, since traditional reuse opportunities are more limited in these areas.
- Substantial reductions in nitrogen loads are achievable through intermediate and full nutrient removal technologies. Given the relatively low total phosphorus concentrations in effluents from the WWTPs, only full nutrient removal technology can reduce phosphorus loads. Substantial reductions in phosphorus load will require moving toward either traditional reuse or groundwater recharge.
- The average freshwater savings are essentially equal to traditional reuse volumes under alternatives I (currently planned use of ocean outfalls) and II (limited use of ocean outfalls) and range from 24 to 64% at the Boynton-Delray and Boca Raton WWTPs and from 1 to 18% at the other four facilities.
- Under alternatives III (use of ocean outfalls as backups) and IV (no use of ocean outfalls), average freshwater savings range from 64 to 87%.
- Public acceptance of traditional reuse is expected to be high at all of the facilities because the reclaimed water is used primarily for irrigation.
- Public acceptance of alternatives featuring large-scale groundwater recharge could be moderate or lower. However, public education programs and community involvement throughout the planning, implementation, and continued use of water reuse projects should help mitigate public concerns.
- Trends between costs and the average of percent freshwater savings and nutrient load reduction indicate that alternatives emphasizing traditional reuse and nutrient control technology are somewhat more cost effective than those emphasizing groundwater recharge. The ability to generate revenues from traditional reuse further increases the attractiveness of this approach.
- At the facilities with lesser densities of consumptive use permittees (Hollywood, Miami-Dade/North and Miami-Dade/Central), extensive groundwater recharge would be required to achieve a 50% average of freshwater savings and nutrient load reduction unless industries and residential users are added to the reclaimed water customer base.
- The costs of liquid treatment, reuse and disposal to achieve a 50% average of freshwater savings and nutrient load reduction would range from $1.00/1,000 gal at the Boca Raton WWTP to $1.90/1,000 gal at the Hollywood WWTP, averaging $1.50/1,000 gal. Increasing this average to 75% would raise the average cost to $2.60/1,000 gal.

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Tijuana River Sewage Raises Ocean Pollution Levels

POSTED BY ALEKSANDRA KONSTANTINOVIC ON DECEMBER 14, 2014 IN LIFE | 458 VIEWS | LEAVE A RESPONSE

Aerial photo of coast south of Imperial Beach. Photo courtesy U.S. Fish & Wildlife Service

Sewage-contaminated runoff from the Tijuana River has flowed into the Pacific Ocean south of Imperial Beach, and temporarily raised ocean pollution levels.

The affected water stretches from the end of Seacoast Drive in Imperial Beach south to the International Boundary.

San Diego Coastkeeper receives daily water quality information from the County of San

Diego, Department of Environmental Health and posts it on its Swim Guide.

The website called this area the number one location to witness urban runoff pollution.

"The river carries large amounts of raw sewage as well as trash and sediment straight through the estuary and onto the beaches near Imperial Beach," the list reads. "This location slots into #1 because of the severity of the polluted runoff, the amount of the water flowing in this spot and the complicated matter of finding solutions to polluted runoff that starts in the U.S., flows through Mexico and completes it journey back in America."

—City News Service contributed to this report.

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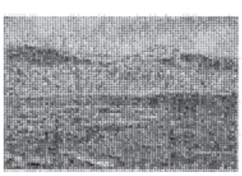

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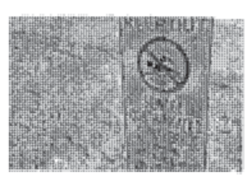

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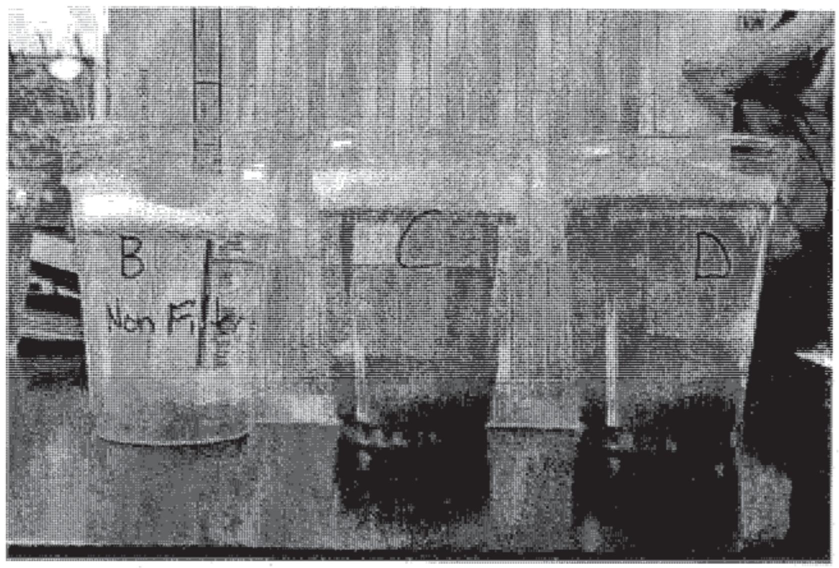
ELECTROCOAGULATION REPORT



9/2/2010

Coagulation and Harvesting of Microalgae

On Aug 11, 2010, with the assistance of a leading equipment vendor and the generous cooperation of laboratory staff at the Napa Sanitation District, Aquagy personnel tested the efficacy of electrocoagulation (EC) equipment for coagulating, flocculating, settling, and harvesting microalgae from pond water. This report summarizes the results and findings from that experience, provides a brief summary of electrocoagulation as it applies to wastewater treatment, and a brief outline of EC's applications to primary, secondary, and tertiary treatment.

Electrocoagulation Report

COAGULATION AND HARVESTING OF MICROALGAE

Background

Electrocoagulation is the passing of electric current through water to induce strong oxidation and reduction reactions. Consumable metal plates, such as iron or aluminum, are used as sacrificial electrodes to continuously produce ions in the water. These ions neutralize the charges of particles suspended in the water, thereby initiating coagulation and either precipitation or flotation. The contaminants can thereafter be filtered out for beneficial reuse or disposal.

EC has been successfully used to treat a wide range of municipal, industrial, and commercial waste streams contaminated with heavy metals, virus, bacteria, pesticides, arsenic, MTBE, cyanide, BOD, TDS, TSS, nitrogen, phosphate, and others.

Electrocoagulation acts on a principle similar to that of chemical coagulation, by using cations to neutralize the charge on the surface of the suspended solids, so that they no longer repel one another and can coagulate (clump together). **However, EC offers certain advantages over chemical coagulation:**

- Simple and reliable operation with little maintenance
- Effective at smaller doses of metal cation
- More consistent results despite seasonal variations
- Colorless and odorless water produced
- Larger flocs
- It does not add salts or costly polymers to the water or to the separated biosolid;
- Whereas polymer coagulants produce a biosolid that is gelatinous and difficult to dewater, electrocoagulation produces a biosolid that repels water, dries easily, and facilitates subsequent handling. This drying property is readily evident even just a few hours following treatment.
- Finally, in most cases electrocoagulation is far more economical than chemical coagulation

Description and Methods

Four municipal wastewater districts from diverse parts of Central California chose to participate in this study by providing pond water samples that were high in algal solids. These four source ponds represent a wide range of hydraulic residence times, from a low of about 5 days to a high of several months, and this fact – along with the geographical and climatic variation represented – ensures that the study included a wide variety of algal species. To maintain confidentiality, the actual names of the sources are coded.

The algal concentrations, expressed as measurements of Total Suspended Solids (mg/L) and turbidity (NTU), also covered a wide range, with raw sample TSS ranging from 15 mg/L to 434 mg/L, and turbidity ranging from 18 to 124 NTUs.

We tested two types of anode for dosing the samples with metal ions: aluminum and iron. There is nothing unique or special about the blades themselves, and replacement pieces can be obtained locally from a metal shop or mill and are therefore the least expensive form of metal.

The sample waters were exposed to approximately one minute of hydraulic residence time (HRT) during treatment, at about 100 volts and 2-4 amps. The amperage measured is affected by the conductivity (salinity) of the water, such that water with higher conductivity can be successfully treated at lower voltage.

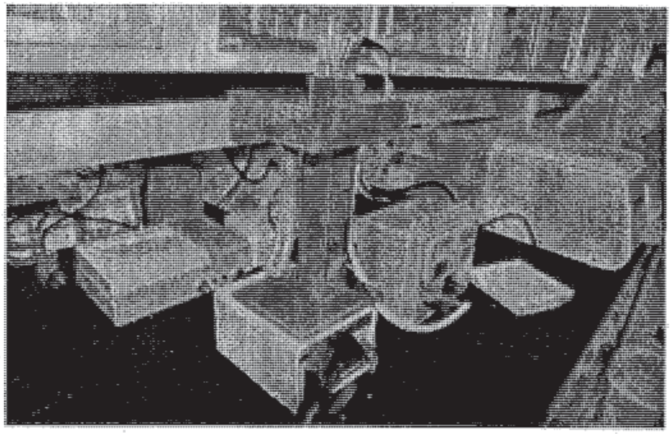


Figure 1. The bench-top electrocoagulation set-up, with capacity of 1 liter per minute, continuous flow.

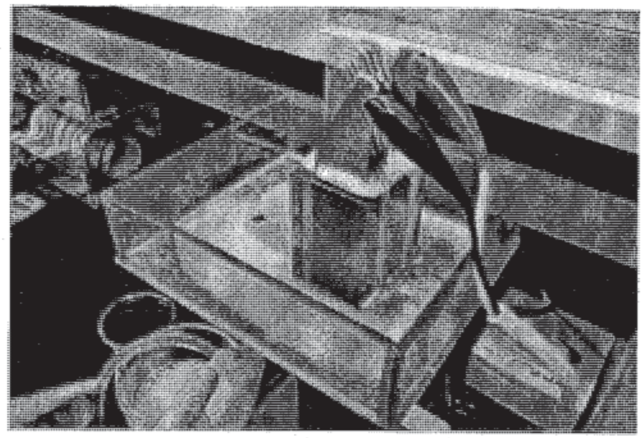


Figure 2. DC electrodes attached to the metal blade anodes. Treated water spills out the top of the tower-shaped treatment chamber in center.

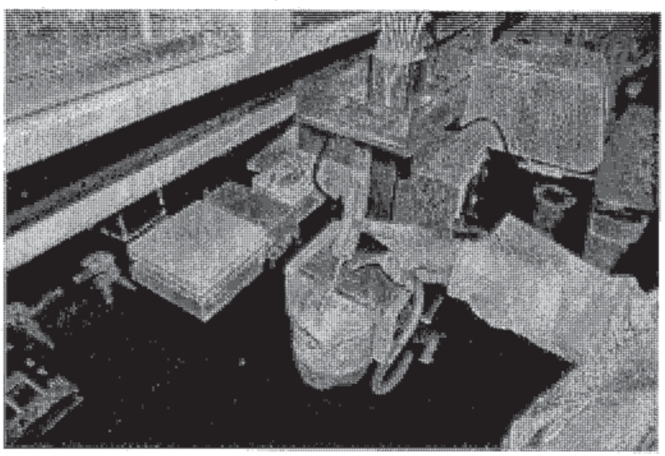


Figure 3. Electrocoagulated water exiting the bench-scale unit.

There is nothing unique about the iron or aluminum blades. Replacements can be purchased from the local mill and are the least expensive form of metal.

Results

After passing through the electrocoagulation chamber (approximately 1 min HRT), the microalgae immediately started to clump and flocculate. Initially, the majority of the flocs floated, apparently due to air bubbles adsorbing to the surface of the flocs. When the treated water was subjected to mild stirring so as to dissipate these bubbles, or if allowed to sit quietly for about 45-90 mins, the algal flocs began to settle to the bottom.

The quantitative results of the electrocoagulation testing are presented in Table 1. In all cases, EC treatment alone reduced turbidity to less than 9 NTU. A subsequent filtration step reduced turbidity to less than 2 NTU, and usually to less than 1 NTU.

Table 1: Results of Electrocoagulation Testing on Aug 11, 2010

	Turbidity (NTU)			TSS (mg/L)		
Sample	Raw	EC-Treated[1]	EC+Filtered[2]	Raw	EC+Filtered[2]	Notes
Aluminum blades:						
Sample A	41	7.0	0.43	28	n.d.	102 Volts, 2.5 amps
Sample B	18	1.6	0.23	15	n.d.	102 Volts, 2 amps
Sample C	72	1.7	1.15	128	n.d.	102 Volts, 3 amps
Sample D	124	8.2	0.50	434	n.d.	102 Volts, 4 amps
A, double amperage	40	1.3	1.72			100 Volts, 7 amps
Iron blades:						
Sample B	18		0.62			102 volts, 3 amps
Sample B (50% volt)	16	4.5	0.23			50 volts, 1.5 amps
Sample B (25% volt)	16		0.23			25 volts, 0.5 amps
Sample D	124	5.5	0.16	434	n.d.	100 volts, 4 amps
Sample D (50% volt)	123		0.70	434	n.d.	50 volts, 2 amps

n.d. = non-detect

[1] Unfiltered turbidities were measured after about 1-2 hours of settling.

[2] Filtration was through a Whatman #1 filter paper of nominal pore size = 11 microns to simulate the clarification achieved by passing through the sludge blanket in a conventional clarifier.

Qualitative Results

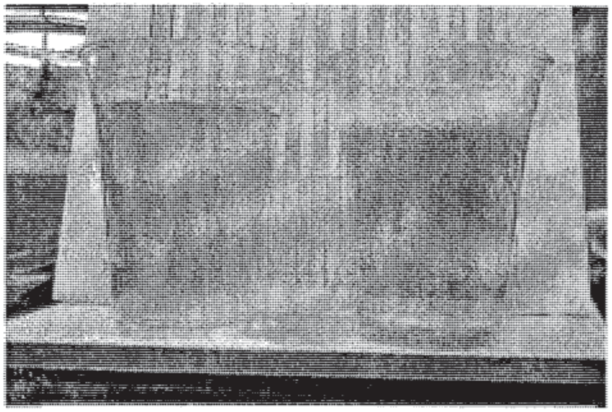


Figure 4. Immediately after EC treatment, coagulated solids tend to float.

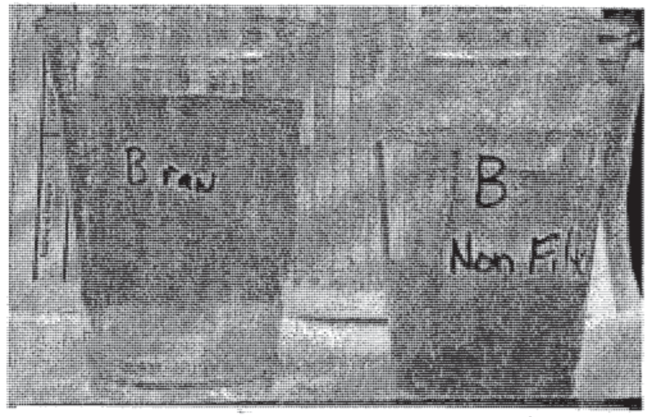


Figure 5. After about 1 hour of settling, solids settle to the bottom, leaving a clear supernatant.

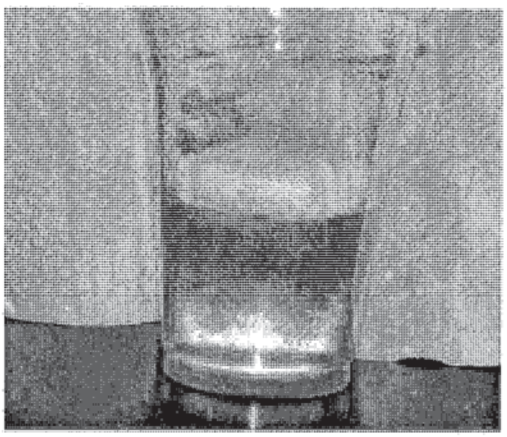


Figure 6. Coagulated microalgae (Sample A) immediately following EC treatment

Figure 7. Raw pond water (left) from Sample C and coagulated algae after about 1 hour of settling (right). Very similar results were obtained with Sample D (see photo on cover page.)

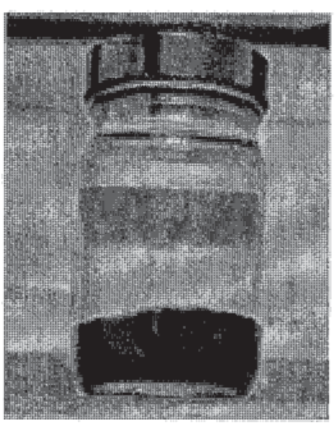


Figure 8. Treatment of Sample B with full voltage and iron blades yielded rapid and complete settling.

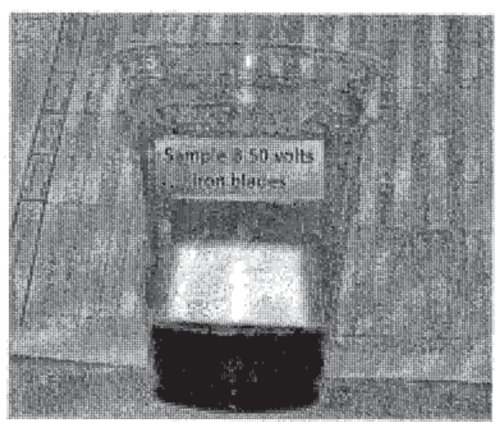
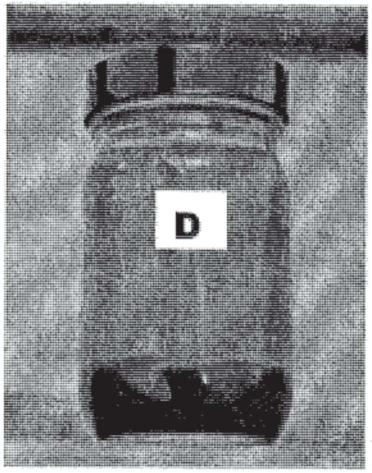
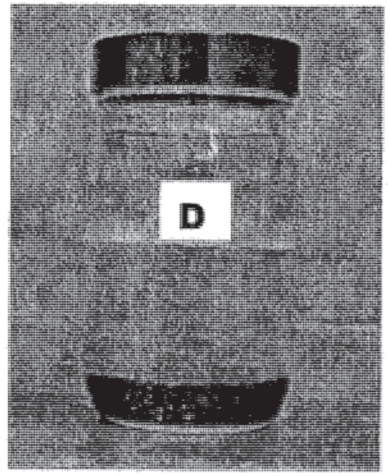


Figure 9. Treatment of Sample B at half voltage still yielded turbidity less than 5 NTU without filtration.





Figures 10 and 11. Following treatment at half voltage, settling after 24 hours (left photo) and 96 hours (right photo) in Sample D, illustrating the trade-off between power consumption and time required for adequate treatment.

Discussion

The vast majority of metal ions added during treatment precipitates out and is removed from the water along with the algal biosolids. Added iron may be beneficial for soil, plants or animal diet (depending on the final disposition of the biosolids), but causes the algae to take on a blue-black coloration and may contribute to temporary formation of orange bubbles at the water surface. Iron is not known as a biological toxin at these concentrations and has no known inhibition on anaerobic digestion processes.

In general, treatment with aluminum blades tends to yield very clean, clear water that has a certain sparkling quality to it. Aluminum is more expensive than iron, but is still affordable, readily available, and is low toxicity. Some treatment applications may require the use of blades made of more specialized metals such as titanium for the selective removal of particular contaminants, such as fluoride.

The cost of the metal consumed per volume of water treated is relatively low – iron cost is on the order of $0.04 to $0.07 per 1,000 gallons treated – especially compared to chemical polymers, which routinely cost $0.40 but can reach $1.00 per 1,000 gallons treated. The total cost of treatment with EC, including electricity, is typically less than one-half the cost of chemical coagulation.

Time constraints prevented us from doing a thorough study, but spot-testing indicated that satisfactory results may be attainable at significantly lower power consumption than the levels tested. Performance is specific to each of the source waters and depends largely on its conductivity. We obtained excellent clarification of Sample B water at 50% of the applied voltage, and even at 25% of the initial voltage. In Sample D, treatment at half voltage resulted in bulk settling, but with a persistent cloudiness left in the supernatant. This cloudiness eventually cleared, but it took several days, illustrating the trade-off between power (expense) and time.

When the voltage is decreased, the amperage decreases proportionately, so at 50% voltage, the actual power consumption is just 25% of the baseline.

It is worth noting that when we decrease the voltage, the amperage also decreases proportionately (Ohm's Law), so at 50% of the original voltage, there is also about 50% of the original amperage, and the actual power consumption is just 25% of the original baseline.

EC makes an excellent pre-treatment for gross solids removal before going through a microfilter. The coincidental formation of microbubbles at the cathode site in the EC chamber initially floats most solids, making EC also suitable for subsequent treatment in a dissolved air flotation (DAF) unit, although this is probably overkill for most applications. Gravity settling in a simple clarifier or settling pond is an economical and effective step for separation of the coagulated solids.

Applications

Electrocoagulation has applications in wastewater treatment during the primary, secondary and tertiary treatment stages. Because algae removal is of importance in meeting California discharge regulations, the application of EC to pond effluent can be used to economically increase the efficiency of settling and in the reduction of biosolids.

When given adequate residence time, effluent from the EC unit will naturally settle by gravity to the bottom of a settling pond constructed as the last segment of a treatment train. Such application will greatly enhance the removal of BOD, TDS, TSS, nitrogen and phosphate, providing an excellent secondary or tertiary effluent and an economical pre-treatment step for final filtration of recycled water, greatly improving the life and performance of the filter and aiding subsequent disinfection.

In treatment trains not employing ponds, standard clarifiers can be used to achieve similar removal efficiency and comparable enhancements to the tertiary process.

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Water Reuse Eliminates Government Required Treatments for Wastewater Discharges

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Abstract

The only way to eliminate the intrusion of continual government wastewater inspectors is to eliminate the water discharge. Clean electricity properly applied will cause a multitude of water contaminates to become separable from water. Electrocoagulation causes emulsified oil, textile dyes, heavy metals, turbidity, pesticides, bacteria, suspended solids, arsenic, phosphates, nitrates, zinc, biochemical oxygen demand, chrome, nickel, lead, copper, PCB's, chemical oxygen demand, sewage, and more to become separable from water, making the water suitable for reuse.

Background

Government discharge standards have been established for water discharge to the environment. The discharge standards are established to meet political needs and seem to be lowered as technology advances detection limits. The government regulators may enforce the discharge limits by fines, public humiliation, or by shutting down the production facility. The required water testing, monitoring, reporting, and spot inspections by the regulators consume valuable time and resources.

Water reuse on site is the best way to save this most precious natural resource. The recycled water can be cleaned up and conditioned to meet the specific reuse need. Water recycling can eliminate water discharge. With out water discharge the expense of testing, monitoring, reporting and spot government inspections is greatly reduced or eliminated. The cost of water purchases and water disposal is reduced.

Cleaning the water sufficiently to be reused can be accomplished in several ways including reverse osmosis, ion exchange, evaporation, chemical coagulation, and or electrocoagulation (EC). Each of the treatment methods, or a combination of the methods, has advantages and disadvantages depending upon the type of water to be reclaimed and the intended use of the reclaimed water. Water recovery on site allows the selection of the treatment based on the specifics of the water content to be recovered and the specific quality of water needed in the reclaimed water process.

Reverse osmosis separates contaminants from the portion of the water that permeates the membrane and concentrates contaminates in the reject water that does not pass through the membrane. The permeate water quality can be controlled by the type of membranes used. The reject water may be 30% of the total water stream. In addition to wasting the reject water, the disposal cost for the reject water may cost more that the reverse osmosis operating cost. The reverse osmosis process is not very effective in mixed streams containing oil, grease, bacteria, and silica, which cause membrane fouling.

Ion exchange captures specific ions in the water. Ion exchange adds one type of ion to water as a second type of ion is removed. A common type of ion exchange adds two sodium ions to the water in the process of removing one calcium ion from the water. The cost of ion exchange resin regeneration is significant in terms of water loss. When regulated heavy metal ions like chrome are removed from the water, the regeneration liquid is high in acid and metal content creating a costly hazardous waste.

Evaporation or distillation produces clean water. The solids separated during the distillation process can be concentrated in the bottoms. Energy consumption and capital cost are the main drawbacks.

Coagulation caused by altering the charge on metal ions, organics, and colloidal particles creates a large particle that can be settled or filtered out. Chemical coagulation typically uses a dissolved salt. Part of the salt will attach to the material in the water to be coagulated. The other part of the ion typically remains in the solution. Chemical coagulation creates a hydroxide sludge that attracts water. The hydrophilic sludge holds water, which increases the volume of sludge generated and increases the dewatering time.

Electrocoagulation adds electrons to the solution by passing alternating current or direct current through the solution from the power grid. The electrons destabilize the material in the water creating oxide sludge when sufficient activation energy is present. The oxide sludge repels water and filters well. The oxide sludge dewaters well, eliminating the bogging problem associated with polymer treated sewage sludges in landfills, which will stick a tractor for years. Heavy metal ions converted to metal oxides will pass the leach tests making them non hazardous. Metal oxides can be smelted to recover the metals in a usable form.

Steam cleaner wash water reclamation case study:

Valley Detroit Diesel Allison, Bakersfield, California, assembles Detroit Diesel Allison engines and performs semi tractor repair. The engines are covered with oil, dirt, grease, and normal road grime. The engines are steam cleaned prior to assembly or repair.

The steam cleaning is performed over a pad. The spent steam cleaner wash water is collect in a pit. The dirty steam cleaner wash water is designated as a hazardous waste due to the heavy metal content. During the rainy season, rain runoff water from the parking lot would also collect in the pit and mix with the dirty steam cleaner wash water.

The hazardous wastewater had to be measured, tested, and accounted for to the local government inspector. The hazardous wastewater was hauled off by vacuum trucks for disposal at a cost of $0.60 per gallon in the dry season and $2.30 per gallon in the rainy season. The government inspector would physically inspect the water volume and truck hauling records monthly at the facility.

Valley Detroit Diesel Allison decided to reclaim the steam cleaner wash water in 1988. A containment facility was built to store diesel fuel, motor oil, antifreeze, used motor oil for recycling, and water treatment. A 26,000-gallon holding tank stores the surges of parking lot rain run off water and used steam-cleaning water from the pit. The water is processed through a 2 gpm EC unit and clarifier. The oil, grease, dirt, and heavy metal solids separated from the clarifier are placed in the used oil storage tank for recycling. The clear water from the clarifier passes through a swimming pool. The reclaimed water is stored in a 1,000-gallon clean water storage tank for reuse in the steam cleaner. A float switch control system in the dirty water storage tank and clean water storage tank turn the unit on when there is dirty water to treat and room for clean water storage.

The clear water met all federal secondary drinking water standards with the exception of surfactants (soap) (Table 1). The recycled surfactants reduced the need to add soap at the steam cleaner. The sludge from the EC process contained 90 mg/kg oil and grease. The heavy metals were converted into oxides. The sludge passed the California states TTLC and STLC leach tests as required by CAC title 22 (Table 2). As a result the State Health Board approved the EC processed sludge as a non hazardous waste suitable for landfill disposal.

The government inspector stopped visiting the site after the first three months of water recycling. Because the water is recycled there is no water disposal records, no continual water testing, and no vacuum trucking fees. The EC unit requires about one hour of maintenance per forty hours of operation. The operating cost for electricity and blade replacement is less than one cent per gallon. The company purchased EC systems for each of their three locations.

Lab results:

Table 1. The recycled Steam cleaner wash water lab analysis follows: (004-263).

Constituent	Wastewater ppm	EC water ppm	% Removal
Antimony	<0.01	0.014	
Arsenic	0.30	<0.01	96.7% +
Barium	8.0	<0.10	98.7% +
Beryllium	<0.01	<0.01	
Cadmium	0.141	0.031	78.0%
Chromium	7.98	0.05	99.4%
Cobalt	0.13	<0.05	61.5% +
Copper	6.96	<0.05	99.3% +
Lead	7.4	1.74	76.5%
Mercury	0.003	<0.001	66.7% +
Molybdenum	0.18	0.035	80.7%
Nickel	0.4	<0.05	87.5%
Selenium	<0.005	<0.005	
Silver	<0.01	<0.01	
Thallium	<0.10	<0.10	
Vanadium	0.23	<0.01	95.7% +
Zinc	19.4	1.20	93.8%

Table 2. The dry sludge separated from the Steam cleaner wastewater listed above was tested for leach ability as follows (005-462):

Element	TTLC Raw mg / kg	Max State	STLC Raw mg / l	Max State
Antimony	2.4	500		
Arsenic	3.85	500		
Barium	307	10,000		
Beryllium	nd	75		
Cadmium	nd	100		
Chromium	59.2	2,500		
Cobalt	10.4	8,000		
Copper	498	2,500	3.8	25
Lead	790	1,000		
Mercury	0.15	20		
Molybdenum	21.3	3,500		
Nickel	25.5	2,000		
Selenium	nd	100		
Silver	2.7	500		
Thallium	14.2	700		
Vanadium	42.1	2,400		
Zinc	1,798	5,000	60	250
Oil & Grease	89,780			

Conclusion:

Electrocoagulation provides a cost effective, onsite way to recondition water for reuse. Water reconditioning for on site use eliminates governmental discharge concerns. Peace of mind results because proposed changes to government discharge regulation no longer apply. The water reconditioning equipment capital and operating cost is offset by water reuse, timesavings with government inspectors, discharge lab testing, and fines.

water

MDPI

Article

Removal of Six Estrogenic Endocrine-Disrupting Compounds (EDCs) from Municipal Wastewater Using Aluminum Electrocoagulation

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Abstract: Conventional wastewater treatment plant (WWTP) processes are primarily designed to reduce the amount of organic matter, pathogens, and nutrients from the incoming influent. However, these processes are not as effective in reducing the concentrations of micropollutants, including endocrine-disrupting compounds (EDCs), which notoriously evade traditional wastewater treatment technologies and are found even in tertiary-treated effluent. For WWTPs practicing deep-well injection or surface-water discharge, EDCs in the treated effluent are discharged into groundwater or the aquatic environment where humans and wildlife may potentially suffer the effects of chemical exposure. In the current laboratory-scale study, we tested a bench-top electrocoagulation (EC) unit utilizing aluminum blades for the removal of six estrogenic EDCs [estrone (E1), 17β-estradiol (E2), estriol (E3), 17α-ethinylestradiol (EE2), bisphenol-A (BPA), and nonylphenol (NP)]. Samples of municipal wastewater influent and tertiary-treated effluent were spiked with the six EDCs in order to test the removal efficiency of the EC unit. The mean concentration of each EDC component was statistically lower after EC treatment (removal range = 42%–98%). To our knowledge, this is the first study to investigate aluminum electrocoagulation for removal of these specific EDCs, including nonylphenol (without the ethoxylate chain), as well as natural and synthetic estrogens.

Keywords: micropollutant; endocrine disruption; chemical contaminants; pharmaceutical; water treatment; wastewater; estrogen; electrocoagulation

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1. Introduction

Micropollutants are chemical contaminants found in the aquatic environment in the μg/L (ppb) or ng/L (ppt) concentration range that are considered to be potential threats to environmental ecosystems [1,2]. Both domestic and industrial wastewaters contain micropollutants, which are not entirely removed by conventional wastewater treatment plant (WWTP) processes and are, therefore, continually discharged into the aquatic environment [3]. The origin of micropollutant contamination is predominantly anthropogenic and the aquatic environment becomes the final resting place for the majority of these chemical compounds [4,5].

Endocrine-disrupting compounds (EDCs) are an important class of micropollutants that are defined as exogenous chemicals, or mixtures of chemicals, that can interfere with any aspect of hormone action [6]. EDCs are a particularly troublesome subset of micropollutants, due to their diverse nature, persistence in the environment, and ability to cause metabolic and reproductive disturbances at very low concentrations. EDCs can enter the aquatic environment directly (e.g., through effluent discharge) or indirectly (e.g., storm-water runoff), but the major transport of EDCs to the aquatic environment is through treated and untreated municipal wastewater discharge to rivers, streams, and surface waters [1,7,8]. Potable water resources, including both surface water and groundwater, can become contaminated through surface-water discharge or deep-well injection of WWTP effluent [4]. Effects of EDCs on wildlife (invertebrates, fish, amphibians, reptiles, birds, and mammals) include: abnormal blood hormone levels, altered gonadal development (e.g., imposex and intersex), induction of vitellogenin gene and protein expression in juveniles and males, masculinization/feminization, hermaphroditism, and decreased fertility and fecundity [9–12].

Estrogenic EDCs specifically target estrogen signaling. These include natural steroidal estrogens, synthetic estrogens, and industrial compounds which mimic estrogen. 17β-estradiol (E2) is the primary natural estrogen and has the greatest potency. Estrone (E1), a metabolite of E2, is a slightly weaker estrogen. Estriol (E3), considered to be the final metabolite, is the weakest natural estrogen, with only 10% of E2's potency. 17α-ethinylestradiol (EE2) is the synthetic steroidal estrogen component of contraceptives [13]. The overall estrogenicity of EE2 in effluent overshadows that of both E1 and E2 combined, due to its high estrogenic potency [14]. Bisphenol-A (BPA) is a monomer used in industry to produce lacquers, food-can liners, and thermal paper [15]. It has high water solubility and enters WWTPs through industrial discharges and leaching from BPA-based products. Nonylphenol (NP) is the persistent and estrogenic final product of the biodegradation of the non-ionic surfactant nonylphenol ethoxylate (NPEO) [16].

Conventional WWTP processes are designed primarily for the removal of organic matter, nitrogen, phosphorus, and pathogens; therefore, it is not surprising that the effluent from conventional WWTPs still contains EDCs at levels ranging from a few ng/L to several μg/L, which are sufficient to cause endocrine disruption in some species [17]. The concentrations of EDCs in WWTP influent vary according to geographic location and population served, while the level of EDC removal during treatment varies according to the WWTP processes employed [18,19]. Monitoring studies have demonstrated that some wastewater treatment processes are more effective than others for reducing EDCs and ultimately a combination of approaches may be necessary to reduce this diverse class of micropollutants. This manuscript focuses solely on the potential of electrocoagulation (EC) for EDC removal in municipal wastewater, since the efficacy of various WWTP processes (e.g., biological treatment with activated sludge, activated carbon treatment, nanofiltration, reverse osmosis, ozonation, and advanced oxidative processes) for reducing EDC concentrations has been reviewed extensively [20–22].

Electrocoagulation technology reduces contaminant levels by passing an electrical current through water, which generates coagulant precursors by electrolytic oxidation of sacrificial anode material—usually aluminum or iron. During the EC process, amorphous insoluble polymeric metal hydroxides and oxides are formed, which adsorb pollutants (particulate and dissolved) during precipitation, making them easily separable [23,24] (Figure 1). The most widely used electrode materials, aluminum and iron, are both inexpensive and effective against a wide range of pollutants, including soluble organic pollutants [25,26]. Patented over a century ago, EC has a long history as a water treatment technology. However, EC was abandoned by the 1930s due to high operation costs, as well as the availablilty of inexpensive chemicals for chemical coagulation treatment [27]. Recent technical and design improvements, combined with a growing need for cost-effective water treatment processes, have led to a re-evaluation of EC technology [27]; however, to our knowledge no studies have tested the efficacy of EC with aluminum blades for reducing EDCs from municipal wastewater. This study therefore sought to determine the removal efficiency of a laboratory-scale electrocoagulation unit with respect to six estrogenic endocrine-disrupting compounds in WWTP influent and tertiary-treated effluent.

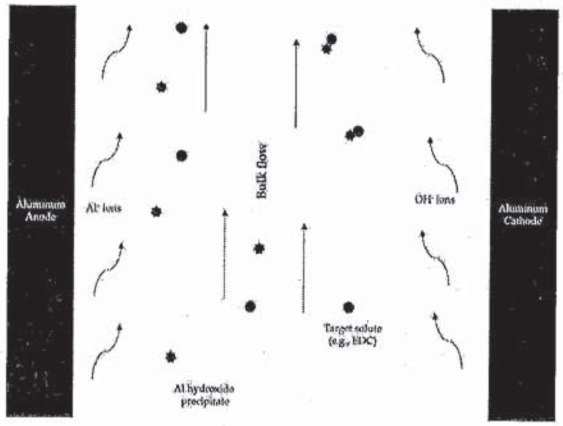


Figure 1. Representative schematic of water flow and interactions inside the reaction chamber. The two black vertical bars represent the electrodes where the power is attached, and the white in between them represents the sample solution flowing past the electrodes. Metal dissolution occurs at the anode which generates aluminum ions. Reduction reactions occur at the cathode which form hydroxide ions. The precipitation reaction occurs when the aluminum and hydroxide ions combine to form aluminum hydroxide (dark circles). The aluminum hydroxides form structures which adsorb contaminants (dark stars), enabling their removal.

2. Materials and Methods

2.1. *Electrocoagulation Unit*

The EC unit (Figure 2) is a 110-volt demonstration unit manufactured and supplied by Powell Water Systems, Inc. (Centennial, Colorado, USA; United States patent number 7211185 B2). The configuration used in this study has been previously examined for its ability to reduce concentrations of nutrients, personal care products, and microbial pathogens and indicators [28]. The power source is a 110-volt alternating current (AC) to direct current (DC) power converter (allowing direct line voltage to be converted from AC to DC) with voltage control. The pump is a Cole-Parmer®Masterflex Peristaltic Pump System (Vernon Hills, IL, USA) equipped with a 1/20-horsepower unidirectional motor and a separate single-turn speed control. The EC unit chamber (35.6 cm × 5.4 cm × 2.5 cm) is made of a non-conductive acrylic resin and has a total volume of 487.5 mL. Nine aluminum reaction blades (30.5 cm × 2.5 cm × 0.3 cm) were arranged vertically inside the chamber with an electrode gap of 3.18 mm. This vertical arrangement promotes a vertical flow of liquid through the chamber. The volume of one blade is 24.6 cm^3 and the volume of all nine blades equals 221.2 cm^3, leaving a residual chamber volume of 266.3 mL. The EC unit was operated with a three-lead arrangement of electrical connections (power attached to blades 1, 5 and 9; Figure 3) which results in a configuration of two anodes and one cathode. The inflow tube measures 1.2 m.

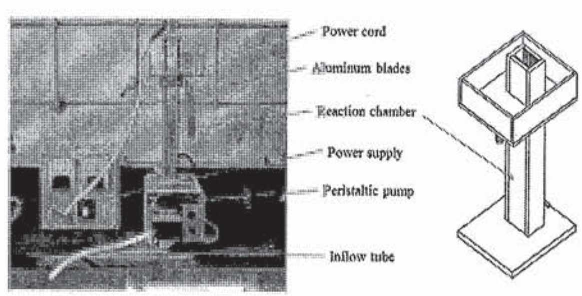


Figure 2. Schematic of laboratory-scale electrocoagulation unit.

Figure 3. Diagram and close-up picture of the nine aluminum blades showing the electrical connections to blades 1, 5, and 9. Anodes are indicated in blue by (+), cathode is indicated in red by (−), and arrows show the flow of electrons.

2.2. *Preliminary Tests and Optimization of Parameters*

The parameters used for this laboratory-scale study were chosen based upon a series of tests performed to evaluate EDC removal efficiency using different EC conditions and configurations (Supplementary Tables S1 and S2). The optimal parameters used for this study (Supplementary Table S3) were as follows: aluminum blades as the sacrificial electrodes, three-lead arrangement of electrical connections, sample retention time of 2 min/L in the EC reaction chamber, volts held in the range of 85 to 98, and amperes held in the range of 8.5 to 15.5. Inclusion of a precise cleaning step was important in the preliminary testing, as EDCs were found to "stick" to the walls of the unit and tubing. To ensure against cross-contamination between replicates, the EC unit was cleaned in between each run to remove any residual EDCs. The EC unit was cleaned by first removing the blades and rinsing the unit with tap water. The blades were scrubbed with steel wool in order to remove the build-up of the oxidizing layer. The scrubbed blades were then reset and the unit was flushed with 1 L ACS methanol to remove residual EDCs and 2 L deionized (DI) water to rinse the unit of residual methanol. Once the unit was cleaned, DI water laboratory blanks were passed through the unit (no power) to ensure that no EDCs remained in the unit. Polarity reversal of the electrodes was implemented between runs to help prevent the build-up of an oxidizing layer on the blade surface.

2.3. *Chemical Standards*

Analytical standards E1, E2, E3, EE2, BPA, NP, and 5α-androstanol (internal standard) were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol (HPLC grade and Certified ACS) and pyridine (Certified ACS) were purchased from Fisher Scientific (Pittsburg, PA, USA). *N,O*-bis(trimethylsilyl)trifluoroacetamide (BSTFA) with 1% trimethylchlorosilane (TMCS) was purchased from Regis Technologies (Morton Grove, IL, USA). Ultrapure (DI) water was acquired from a US Filter PureLab Plus system.

2.4. *Wastewater*

Wastewater samples for the experiment were collected from South Cross Bayou Water Reclamation Facility, a tertiary treatment plant located in St. Petersburg, Florida (USA) which serves a population of approximately 260,000. The average wastewater flow per day is 20 million gallons (rated for 33 million gallons per day), and 85% of the wastewater is domestic in origin, while less than 15% is industrial in origin. South Cross Bayou's wastewater treatment processes follow the graphic in Figure 4.

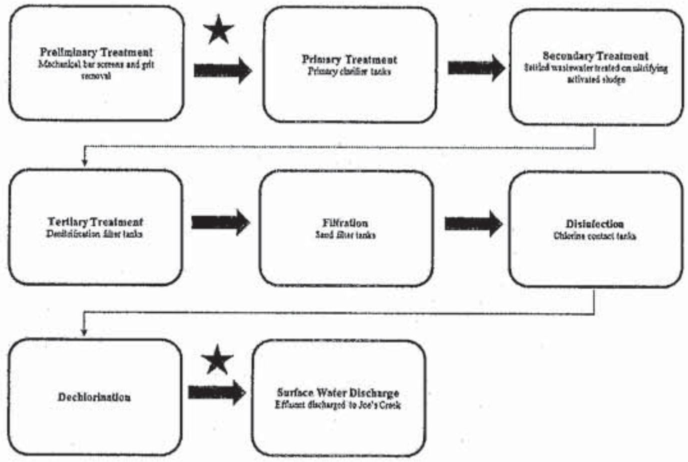


Figure 4. Illustration of the wastewater treatment processes at South Cross Bayou. Stars indicate the points of the raw influent and tertiary-treated effluent samples.

2.5. Blanks

Field blanks were taken at the sample site. Laboratory blanks (DI water spiked with internal standard) were extracted with each batch of samples. Gas chromatography-mass spectrometry (GCMS) instrument blanks (blank solvent injections) were performed every eight samples. All EDCs were undetectable in all the blank samples, including the DI water blanks that were run through the EC unit in between replicate runs, illustrating the effectiveness of the solvent cleaning step performed between runs.

2.6. Experimental Design/Electrocoagulation Processing

Both raw WWTP influent and tertiary-treated effluent were tested in this study in order to determine not only if the effectiveness of EC for reducing EDCs is matrix-dependent, but also to assess the possibility of using EC as a post-treatment addition to traditional WWTPs. Samples were collected the morning of the experiment in methanol-cleaned, 20 L high-density polyethylene carboys. Influent samples were taken at the headworks of the plant while effluent samples were collected after the dechlorination step. After sampling, the carboys were immediately transported to the lab and refrigerated at 4 °C until processing. In the lab, eight spiked-wastewater replicates (outlined below) were created. Half of the spiked-wastewater replicates (n = 4) went straight to analysis (pre-EC) and the other half (n = 4) were processed via electrocoagulation (post-EC). Due to the threat of BPA leaching from the Tygon tubing used in the experiment, BPA removal assays were conducted separately from the remaining EDCs.

Since background concentrations in the WWTP influent and effluent were too low to demonstrate significant removal potential by the EC unit, it was necessary to spike both with EDCs. High concentrations of EDC spikes were used to challenge the efficiency of the EC unit for removal. Stock standards were made up in methanol and, due to the low water solubility of steroids, were added to the pre-EC samples via methanol. Spikes were prepared for the four estrogens (estrone (E1), estradiol (E2), estriol (E3), ethinylestradiol (EE2)) at a concentration of 5 μg estrogen/250 μL methanol. Spikes were also prepared for the two industrial compounds (bisphenol-A (BPA) and nonylphenol (NP)) at a concentration of 20 μg industrial compound/250 μL methanol. Due to their relatively higher concentrations in wastewater, NP and BPA were added at higher levels than the estrogens. Three liters of WWTP influent were spiked with the estrogens and nonylphenol after being filtered through a 1.5 μm pore size, glass microfiber filter (Whatman 934-AH; Fisher Scientific, Pittsburgh, PA, USA). This resulted in a final concentration of 1.7 ppb for the estrogens in wastewater and 6.7 ppb for the industrial compounds in wastewater. Similarly, 3 L of WWTP effluent were spiked with the aforementioned EDCs.

In order to test the removal efficiency of the EC unit, 3 L of spiked WWTP influent ($n = 4$) and effluent ($n = 4$) were separately processed through the EC unit via a recirculation method, where the original sample was passed through the unit, discharged from the unit and then circulated back through the unit. The pump speed was set at eight which corresponded to a retention time of 2 min/L. The voltage fluctuated between 85 and 98 and the ampere readings fluctuated between 9 and 15.5 during EC treatment. Once the sample was collected from the EC unit, it was allowed to sit while coagulation began. After approximately 20 minutes, the EC-treated sample was filtered through two Whatman Grade 1 filters (pore size 11 μm) in order to separate the flocculent (sludge phase) from the treated water (aqueous phase). The final volume captured for analysis was 1 L.

For the BPA experiment, 3 L of WWTP influent ($n = 4$) and effluent ($n = 4$) were spiked with BPA and processed through the EC unit via a one-time flow-through method where the sample would not retouch the Tygon inflow tube (manufactured with BPA). Since the temperature of the EC effluent could get as hot as 69 °C, a one-time flow-through method was essential in order to prevent BPA leaching from the Tygon inflow tube. The pump speed was set at 2.2 which still corresponded to a retention time of 2 min/L. The voltage fluctuated between 94 and 98 and the ampere readings fluctuated between 8.5 and 14.5. The post-EC samples were collected as previously described after the flocculent was separated from the treated water.

2.7. *Solid Phase Extraction*

In order to determine the concentration of EDCs, the pre-EC and post-EC 1 L samples were processed via solid phase extraction (SPE) within 24 hours and subsequently analyzed via GCMS. An Evolute ABN (Acid, Base, Neutral) column (6 mL/200 mg, Biotage; Charlotte, NC, USA) was conditioned with methanol and equilibrated with DI water. The sample was then loaded onto the column at a flow rate of 15 mL/min using a large volume extraction tank (Biotage, USA) and an SPE vacuum pump. EDCs retained in the column matrix were eluted with 6 mL methanol. The eluate was spiked with 5 μg internal standard and evaporated to dryness under a gentle stream of nitrogen. Recoveries of all compounds were documented and accounted for in the final quantification.

2.8. *Determination of EDC Concentrations*

Samples were derivatized to their trimethylsilyl ethers by adding 250 μL of BSTFA + 1% TMCS and 250 μL of pyridine, followed by heating in a 60 °C water bath for 40 min in order to drive the derivatization reaction to completion. Samples were then transferred to a 2 mL vial via low volume insert for analysis by GCMS. The GCMS system (Bruker; Fremont, CA, USA) consisted of a Varian 3800 gas chromatograph coupled with a Varian 320 mass spectrometer. The GCMS was equipped with a 30 m × 0.25 mm (internal diameter) ZB-5MS (Phenomenex; Torrance, CA, USA) fused silica capillary column coated with a 5% phenyl arylene/95% dimethylpolysiloxane stationary phase (film thickness 0.25 μm). Helium (high purity) was used as the carrier gas at a flow rate of 1 mL/min. The GC oven temperature was programmed to begin at 150 °C with an initial hold time of 2 min, followed by a temperature ramp of 6 °C/min until reaching 310 °C. The final hold time was 6 min for a total run time of 35 min. The MS was operated in selected ion monitoring (SIM) mode for quantitative analysis using electron impact (EI) ionization at 70 electron volts (eV). The dwell time per atomic mass unit (amu) was 0.5 seconds, and the quantitative and confirmatory ion fragments are outlined in Table 1. Method detection limits (MDLs) were based on standard deviate protocol and were evaluated using GCMS at a signal-to-noise ratio between 5 and 10. Nine replicates were spiked near the detection limit (S/N between 5 and 10) and carried through the entire analytical procedure. Based upon the variability of the replicates, the MDL for each compound was calculated as the standard deviation multiplied by the t-value for nine observations (eight degrees of freedom; t-value = 2.896). MDLs were in the range of 1 to 3 ng/L (Table 1).

Table 1. Characteristics of estrogenic endocrine-disrupting compounds and internal standard.

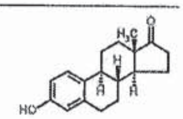
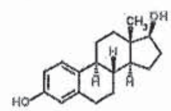
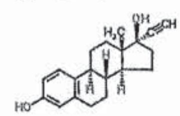
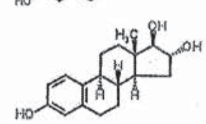
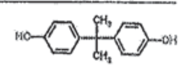
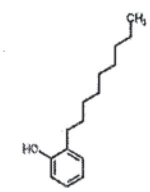
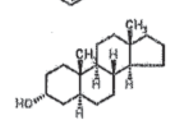
Compound	Type	Retention Time (min)	Quantitative Ion	Confirmatory Ion(s)	Method Detection Limit (ng/L)	Structure
Estrone (E1)	Natural estrogen	21.9	342	218, 257	2	
17β-Estradiol (E2)	Principal natural estrogen	22.4	416	129, 285	1	
17α-Ethinylestradiol (EE2)	Synthetic estrogen	23.8	425	440	1	
Estriol (E3)	Natural estrogen	24.8	504	386	3	

Table 1. *Cont.*

Compound	Type	Retention Time (min)	Quantitative Ion	Confirmatory Ion(s)	Method Detection Limit (ng/L)	Structure
Bisphenol-A (BPA)	Industrial estrogen mimic	16.2	357	358, 372	1	
Nonylphenol (NP)	Industrial estrogen mimic	11.8	179	180, 292	2	
5α-androstanol	Internal standard	18.0	333	258	N/A	

2.9. Statistical Analysis

SAS version 9.4 (SAS Institute Inc.; Cary, NC, USA) was used for statistical analysis of data retrieved from GCMS analysis. All values are reported as mean ± SD. MANOVA was run with four groups (raw influent not treated, raw influent EC-treated, effluent not treated, and effluent EC-treated) with the 6 quantitative variables (E1, E2, EE2, E3, BPA, and NP) using Pillai's Trace statistic. If the MANOVA results showed statistical significance, then *post hoc* testing was run between the raw influent groups (not treated and EC-treated) and between the effluent groups (not treated and EC-treated) for each EDC.

3. Results and Discussion

3.1. Removal of EDCs from Spiked-WWTP Influent by EC

The mean removal achieved for each of the six EDCs from spiked-WWTP raw influent samples is illustrated in Figures 5 and 6. The mean removal efficiency ranged from 56% (estriol, E3) to 81% (nonylphenol, NP). Furthermore, each EDC post-EC had a statistically lower mean concentration than pre-EC (Table 2) obtained from the post hoc test of the statistically significant MANOVA result. NP was removed to the greatest extent (81% removal). Other studies [29,30] have investigated the removal of nonylphenol ethoxylates (NPEOs), but to our knowledge this is the first study to test the removal of the estrogenic breakdown product, NP, by electrocoagulation.

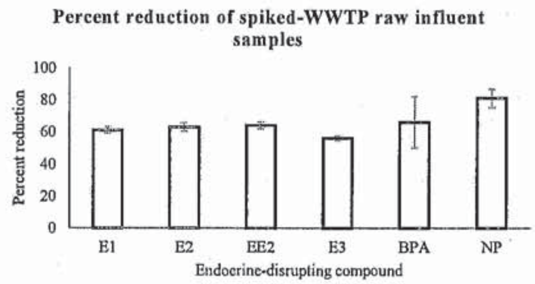


Figure 5. Percent reduction of endocrine-disrupting compounds from spiked-WWTP raw influent samples after electrocoagulation treatment. Error bars are mean +/- standard deviation.

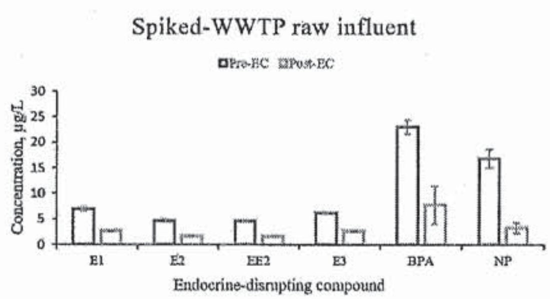


Figure 6. Mean concentrations plus or minus the standard deviation of six endocrine-disrupting compounds in spiked raw influent samples before and after electrocoagulation.

A significant finding was the 64% removal of EE2, which is important for two reasons: (1) this synthetic component of contraceptive products exhibits potent estrogenicity in the environment, with evidence of endocrine disruption at levels around 1 ng/L [10]; and (2) the removal of EE2 by other treatment processes has been historically problematic due to the recalcitrant nature of this compound [14].

Table 2. Percent removal of endocrine-disrupting compounds from spiked-WWTP raw influent samples.

EDC	Mean Pre-EC Conc ± SD (μg/L)	Mean Post-EC Conc ± SD (μg/L)	Test Statistic	*p* Value	% Removal
E1	7 ± 0.3	3 ± 0.1	F = 1194.45	<0.0001	61
E2	5 ± 0.2	2 ± 0.1	F = 954.56	<0.0001	63
EE2	5 ± 0.1	2 ± 0.1	F = 2079.79	<0.0001	64
E3	6 ± 0.2	3 ± 0.1	F = 1021.31	<0.0001	56
BPA	23 ± 1	8 ± 4	F = 85.15	<0.0001	66
NP	17 ± 2	3 ± 1	F = 133.28	<0.0001	81

E3 was removed to a lesser extent (56%) than any of the other compounds, which could be explained by its physico-chemical properties and its lower affinity for sorption onto organic solids. The octanol-water partition coefficient (K_{ow}) describes the partitioning behavior of a compound between water and organic phases. The higher the K_{ow}, the more hydrophobic the compound and the more likely it is to be removed from solution. Most EDCs are hydrophobic compounds with similar log K_{ow} values (e.g., log K_{ow} values of 3.5–4). Since these hydrophobic compounds readily adsorb onto sludge solids, sorption plays an important role in their removal from the aqueous phase [31]. However E3, with its three hydroxyl groups, is only weakly hydrophobic (log K_{ow} = 2.45–2.81) and is, therefore, less apt to bind to sludge [32]. Due to this, E3 likely does not have the same affinity for the flocculent produced during EC treatment. With more E3 in the aqueous phase (*i.e.*, not bound to the EC flocculent), more of it withstands filtration and passes into the EC-treated water sample.

BPA concentrations were reduced by 66%, which is important since BPA is one of the most highly produced chemicals in the world. BPA enters the WWTP at levels in the low ug/L range (concentration can be greatly increased if industrial discharges contribute to WWTP influent). Our findings support those of Govindaraj, *et al.* [33] who achieved 65% removal of BPA from aqueous solutions using aluminum electrocoagulation. Compared with NP, BPA is a more polar compound which explains its lower levels of removal. BPA does not tend to adsorb to sludge particles/sediment as much as NP.

Estrone and estradiol had similar removal levels at 61% and 63%, respectively. Of the natural estrogens, E2 has the greatest potency yet E1 still retains high estrogenicity. For this reason, it is important that both of these natural estrogens are reduced to a significant extent at the level of the WWTP. Since E1 retains estrogenicity and the amount of E1 discharged from WWTPs is more than ten times greater than that of E2, it has been suggested that E1 is the most important natural EDC [3].

3.2. *Removal of EDCs from Spiked-WWTP Tertiary-Treated Effluent by EC*

The mean removal achieved for each of the six EDCs from tertiary-treated effluent samples is illustrated in Figures 7 and 8. The removal efficiency ranged from 42% (BPA) to 98% (NP), and again each EDC post-EC had a statistically lower mean concentration than pre-EC (Table 3) obtained from the *post hoc* test of the statistically significant MANOVA result.

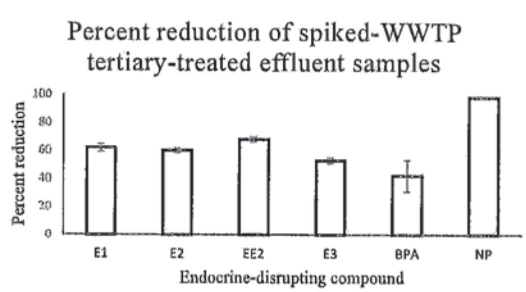


Figure 7. Percent reduction of endocrine-disrupting compounds from spiked-WWTP tertiary-treated effluent samples after electrocoagulation treatment. Error bars are mean +/- standard deviation.

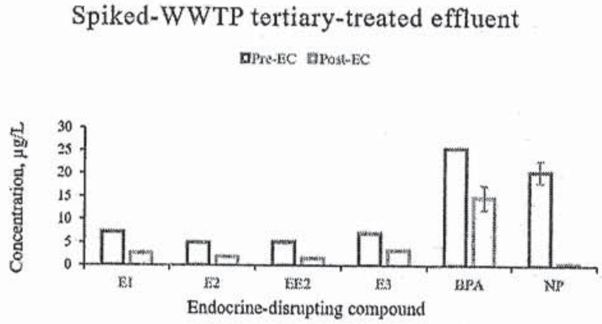


Figure 8. Mean concentrations plus or minus the standard deviation of six endocrine-disrupting compounds in spiked tertiary-treated effluent samples before and after electrocoagulation.

Table 3. Percent removal of endocrine-disrupting compounds from spiked-WWTP tertiary-treated effluent samples.

EDC	Mean Pre-EC Conc ± SD (μg/L)	Mean Post-EC Conc ± SD (μg/L)	Test Statistic	*p* Value	% Removal
E1	7 ± 0.1	3 ± 0.2	F = 1125.53	<0.0001	62
E2	5 ± 0.1	2 ± 0.1	F = 803.89	<0.0001	60
EE2	5 ± 0.1	2 ± 0.1	F = 2304.72	<0.0001	68
E3	7 ± 0.2	3 ± 0.1	F = 984.47	<0.0001	53
BPA	26 ± 0.2	15 ± 3	F = 36.01	<0.0001	42
NP	21 ± 2	0.4 ± 0.1	F = 250.89	<0.0001	98

Higher levels of removal were achieved for NP (98%) in the effluent than in the raw influent samples. However, even with 98% removal, the amount of NP in the final treated sample may still retain estrogenicity. This will be an important question in future testing of EC at environmentally-relevant concentrations. The amount of NP in our post-EC sample, 367 ng, may still be high enough to cause endocrine disruption due to the high initial spike. However, if 98% removal is still achieved at environmentally-relevant concentrations, it will be important to determine if the post-EC concentration is estrogenic or not. *In vitro* bioassays have the advantage of screening for estrogenicity without *a priori* knowledge of the pollutant present, and this will be a useful tool in future EC testing.

EE2 was removed to a high extent (68%) which again is important considering the potent estrogenicity of this compound in the environment as well as its recalcitrant behavior concerning most treatment processes. Estriol was reduced by 53% which is comparable to the raw influent. A lower removal was seen with BPA (42%) than in the raw influent samples. Estrone and estradiol were similarly removed (62% and 60%, respectively) as in the raw influent samples. Since the combination of E1 and E2 contribute largely to the estrogenicity of a sample, their removal is of considerable importance in water treatment processes.

3.3. *Implementation Considerations and Concluding Remarks*

A detailed comparison of the EDC removal results obtained using EC with typical removal levels achieved using other existing technologies has been presented in Cook *et al.* [34]. While it is clear that additional technologies are needed to reduce micropollutant concentrations, the decision to implement EC treatment requires a cost-benefit analysis, with the main costs of EC being energy consumption [35] and consumable blade materials. EC utilizes fairly simple equipment and can be easily integrated into existing WWTPs without extensive reorganization of the plant's structure and design. The lack of moving parts reduces the required maintenance [23], and the unit can be inserted into any point in the WWTP process, since the effectiveness of EC for reducing EDCs in this study did not depend on the matrix (water) type. For WWTPs that utilize tertiary treatments, like ozonation or filtration, EC could be incorporated as an additional pre-cleaning step before tertiary treatment. The effects of EC (e.g., reducing the amount of metal ions, heavy metals, colloids, oil wastes, dyes, suspended particles, *etc.*) would produce an effluent amenable to tertiary treatment and should reduce the fouling of these latter steps [25,36]. For WWTPs with no tertiary treatment, the EC process could be used to coagulate the raw sewage before going into the existing plant clarification unit. Not only would it reduce levels of chemical oxygen demand, turbidity and many contaminants [37], but it would also have the added benefit of EDC removal. EC can also be used to replace conventional chemical coagulation in plants where that technology is in use, since EC reduces the direct handling of corrosive chemicals and does not produce any secondary pollution caused by added chemical substances [35,37]. Furthermore, EC is a low-sludge producing technique, and the sludge formed tends to be readily settleable and easy to de-water [23].

Future testing should include environmentally-relevant concentrations in WWTP influent and effluent. Since these concentrations, especially for the natural and synthetic estrogens, are on the order of low ng/L, detection limits of analytical instruments used will need to be pushed to the pg/L range. Bioassays will also be an important tool in future testing to determine the final estrogenicity of samples due to the fact that pollutants rarely occur as isolated compounds in environmental matrices, but rather in complex mixtures where pollutants can act synergistically, antagonistically, or additively. Finally, future research should continue to explore the potential synergy of combining EC with additional emerging treatment technologies. For example, a recent study demonstrated that combining electro-enzymatic catalysis with EC results in efficient removal of BPA from water [38].

4. Conclusions

In conclusion, the electrocoagulation of wastewater (WWTP raw influent and tertiary-treated effluent) spiked with six estrogenic EDCs was tested for efficiency of removal using a laboratory-scale unit. EC, with the optimal operating parameters determined in this study, enabled statistically significant removal of all EDCs in both WWTP raw influent (56%–81% removal) and tertiary-treated effluent (42%–98% removal). Although determining the mechanisms responsible for EDC removal is beyond the scope of this study, it is likely that these compounds were removed through sorption onto the amorphous aluminum hydroxide flocs followed by filtration. These flocs, termed "sweep flocs", have large surface areas which promote rapid adsorption of soluble organic compounds [39]. In this study, all samples were spiked with EDCs to challenge the EC instrument with removal of significant quantities of contaminants. Overall, this study demonstrated that aluminum EC can reduce EDC concentrations in municipal wastewater influent and effluent, a property that merits further exploration in anticipation of future regulations regarding EDC discharge into the environment.

Supplementary Materials: The following are available online at www.mdpi.com/2073-4441/8/4/128/s1. Table S1: Preliminary Testing, June 2012; Table S2: Preliminary Testing, November 2012; Table S3: Replicate Experiment for Verification of Optimal Parameters.

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Author Contributions: All authors conceived and designed the experiments; Monica M. Cook, Erin M. Symonds, Bert Gerber and Armando Hoare performed the experiments and analyzed the data; Monica M. Cook wrote the paper; Monica M. Cook, Erin M. Symonds, Bert Gerber, Armando Hoare, Edward S. Van Vleet and Mya Breitbart edited and approved the final manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

WWTP	Wastewater treatment plant
EDC	Endocrine-disrupting compound
EC	Electrocoagulation
E1	estrone
E2	17β-estradiol
E3	estriol
EE2	17-ethinylestradiol
BPA	bisphenol-A
NP	nonylphenol
NPEO	nonylphenol ethoxylate
BSTFA	N, O-bis(trimethylsilyl)trifluoroacetamide
DI	deionized
GCMS	gas chromatography-mass spectrometry
MDL	method detection limit
TMCS	trimethylchlorosilane
EI	(electron impact)

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August 7, 2010

Dear Mr. Hamilton,

The purpose of this letter is to inform you of the results we have recently obtained from our tests of the Powell Water Systems Electrocoagulation unit for removal of biological pathogens and indicators from sewage.

We performed a trial using a single sample of raw sewage obtained from a municipal wastewater treatment facility in southwest Florida. Samples were tested to determine the abundance of two types of bacteria and four types of viruses before and after treatment with the electrocoagulation unit. The electrocoagulation process resulted in significant decreases in the concentration of all microorganisms tested, and in several cases reduced the concentration of the pathogens to below the detection limits of our assays. Electrocoagulation led to an approximately 4 log reduction in the concentrations of both fecal coliforms and Enterococci (approximately 99.999% decrease). Concentrations of phages (viruses that infect bacteria) infectious for *Eschericia coli* and *Bacillus subtilis* decreased from several thousand plaque forming units (pfu) per milliliter to less than one pful per milliliter. In addition, concentrations of human polyomaviruses were reduced from approximately 10,000 copies per milliliter to below assay detection limits, demonstrating that electrocoagulation removed human pathogenic viruses.

In addition, we determined the efficiency of electrocoagulation for removing *Pepper mild mottle virus* (PMMoV), which is a plant pathogen that has recently been found at extremely high concentrations in human sewage. PMMoV was found in the raw sewage at approximately 60,000 copies per milliliter and electrocoagulation reduced the PMMoV concentrations to below detection limits. This is extremely encouraging since we typically see PMMoV concentrations in excess of 10,000 copies per milliliter in final effluent from most commercial treatment plants.

My laboratory has spent several years studying the types of viruses and bacteria present in raw sewage and treated wastewater, with the goals of identifying pathogens that present a risk to public health as well as effective indicators that can be used for water quality testing. In our preliminary experiment, the Powell Electrocoagulation unit reduced all the tested biological agents (including both bacteria and viruses) with greater efficacy than current wastewater treatment practices.

Thank you for facilitating this trial, and I hope that we can continue to work together in the future to further evaluate this very promising treatment process.

Sincerely,

Mya Breitbart

Dr. Mya Breitbart

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Water Reuse Eliminates Government Required Treatments for Wastewater Discharges

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Abstract

The only way to eliminate the intrusion of continual government wastewater inspectors is to eliminate the water discharge. Clean electricity properly applied will cause a multitude of water contaminates to become separable from water. Electrocoagulation causes emulsified oil, textile dyes, heavy metals, turbidity, pesticides, bacteria, suspended solids, arsenic, phosphates, nitrates, zinc, biochemical oxygen demand, chrome, nickel, lead, copper, PCB's, chemical oxygen demand, sewage, and more to become separable from water, making the water suitable for reuse.

Background

Government discharge standards have been established for water discharge to the environment. The discharge standards are established to meet political needs and seem to be lowered as technology advances detection limits. The government regulators may enforce the discharge limits by fines, public humiliation, or by shutting down the production facility. The required water testing, monitoring, reporting, and spot inspections by the regulators consume valuable time and resources.

Water reuse on site is the best way to save this most precious natural resource. The recycled water can be cleaned up and conditioned to meet the specific reuse need. Water recycling can eliminate water discharge. With out water discharge the expense of testing, monitoring, reporting and spot government inspections is greatly reduced or eliminated. The cost of water purchases and water disposal is reduced.

Cleaning the water sufficiently to be reused can be accomplished in several ways including reverse osmosis, ion exchange, evaporation, chemical coagulation, and or electrocoagulation (EC). Each of the treatment methods, or a combination of the methods, has advantages and disadvantages depending upon the type of water to be reclaimed and the intended use of the reclaimed water. Water recovery on site allows the selection of the treatment based on the specifics of the water content to be recovered and the specific quality of water needed in the reclaimed water process.

Reverse osmosis separates contaminants from the portion of the water that permeates the membrane and concentrates contaminates in the reject water that does not pass through the membrane. The permeate water quality can be controlled by the type of membranes used. The reject water may be 30% of the total water stream. In addition to wasting the reject water, the disposal cost for the reject water may cost more that the reverse osmosis operating cost. The reverse osmosis process is not very effective in mixed streams containing oil, grease, bacteria, and silica, which cause membrane fouling.

Ion exchange captures specific ions in the water. Ion exchange adds one type of ion to water as a second type of ion is removed. A common type of ion exchange adds two sodium ions to the water in the process of removing one calcium ion from the water. The cost of ion exchange resin regeneration is significant in terms of water loss. When regulated heavy metal ions like chrome are removed from the water, the regeneration liquid is high in acid and metal content creating a costly hazardous waste.

Evaporation or distillation produces clean water. The solids separated during the distillation process can be concentrated in the bottoms. Energy consumption and capital cost are the main drawbacks.

Coagulation caused by altering the charge on metal ions, organics, and colloidal particles creates a large particle that can be settled or filtered out. Chemical coagulation typically uses a dissolved salt. Part of the salt will attach to the material in the water to be coagulated. The other part of the ion typically remains in the solution. Chemical coagulation creates a hydroxide sludge that attracts water. The hydrophilic sludge holds water, which increases the volume of sludge generated and increases the dewatering time.

Electrocoagulation adds electrons to the solution by passing alternating current or direct current through the solution from the power grid. The electrons destabilize the material in the water creating oxide sludge when sufficient activation energy is present. The oxide sludge repels water and filters well. The oxide sludge dewaters well, eliminating the bogging problem associated with polymer treated sewage sludges in landfills, which will stick a tractor for years. Heavy metal ions converted to metal oxides will pass the leach tests making them non hazardous. Metal oxides can be smelted to recover the metals in a usable form.

Steam cleaner wash water reclamation case study:

Valley Detroit Diesel Allison, Bakersfield, California, assembles Detroit Diesel Allison engines and performs semi tractor repair. The engines are covered with oil, dirt, grease, and normal road grime. The engines are steam cleaned prior to assembly or repair.

The steam cleaning is performed over a pad. The spent steam cleaner wash water is collect in a pit. The dirty steam cleaner wash water is designated as a hazardous waste due to the heavy metal content. During the rainy season, rain runoff water from the parking lot would also collect in the pit and mix with the dirty steam cleaner wash water.

The hazardous wastewater had to be measured, tested, and accounted for to the local government inspector. The hazardous wastewater was hauled off by vacuum trucks for disposal at a cost of $0.60 per gallon in the dry season and $2.30 per gallon in the rainy season. The government inspector would physically inspect the water volume and truck hauling records monthly at the facility.

Valley Detroit Diesel Allison decided to reclaim the steam cleaner wash water in 1988. A containment facility was built to store diesel fuel, motor oil, antifreeze, used motor oil for recycling, and water treatment. A 26,000-gallon holding tank stores the surges of parking lot rain run off water and used steam-cleaning water from the pit. The water is processed through a 2 gpm EC unit and clarifier. The oil, grease, dirt, and heavy metal solids separated from the clarifier are placed in the used oil storage tank for recycling. The clear water from the clarifier passes through a swimming pool. The reclaimed water is stored in a 1,000-gallon clean water storage tank for reuse in the steam cleaner. A float switch control system in the dirty water storage tank and clean water storage tank turn the unit on when there is dirty water to treat and room for clean water storage.

The clear water met all federal secondary drinking water standards with the exception of surfactants (soap) (Table 1). The recycled surfactants reduced the need to add soap at the steam cleaner. The sludge from the EC process contained 90 mg/kg oil and grease. The heavy metals were converted into oxides. The sludge passed the California states TTLC and STLC leach tests as required by CAC title 22 (Table 2). As a result the State Health Board approved the EC processed sludge as a non hazardous waste suitable for landfill disposal.

The government inspector stopped visiting the site after the first three months of water recycling. Because the water is recycled there is no water disposal records, no continual water testing, and no vacuum trucking fees. The EC unit requires about one hour of maintenance per forty hours of operation. The operating cost for electricity and blade replacement is less than one cent per gallon. The company purchased EC systems for each of their three locations.

Lab results:

Table 1. The recycled Steam cleaner wash water lab analysis follows: (004-263).

Constituent	Wastewater ppm	EC water ppm	% Removal
Antimony	<0.01	0.014	
Arsenic	0.30	<0.01	96.7% +
Barium	8.0	<0.10	98.7% +
Beryllium	<0.01	<0.01	
Cadmium	0.141	0.031	78.0%
Chromium	7.98	0.05	99.4%
Cobalt	0.13	<0.05	61.5% +
Copper	6.96	<0.05	99.3% +
Lead	7.4	1.74	76.5%
Mercury	0.003	<0.001	66.7% +
Molybdenum	0.18	0.035	80.7%
Nickel	0.4	<0.05	87.5%
Selenium	<0.005	<0.005	
Silver	<0.01	<0.01	
Thallium	<0.10	<0.10	
Vanadium	0.23	<0.01	95.7% +
Zinc	19.4	1.20	93.8%

Table 2. The dry sludge separated from the Steam cleaner wastewater listed above was tested for leach ability as follows (005-462):

Element	TTLC Raw mg / kg	Max State	STLC Raw mg / l	Max State
Antimony	2.4	500		
Arsenic	3.85	500		
Barium	307	10,000		
Beryllium	nd	75		
Cadmium	nd	100		
Chromium	59.2	2,500		
Cobalt	10.4	8,000		
Copper	498	2,500	3.8	25
Lead	790	1,000		
Mercury	0.15	20		
Molybdenum	21.3	3,500		
Nickel	25.5	2,000		
Selenium	nd	100		
Silver	2.7	500		
Thallium	14.2	700		
Vanadium	42.1	2,400		
Zinc	1,798	5,000	60	250
Oil & Grease	89,780			

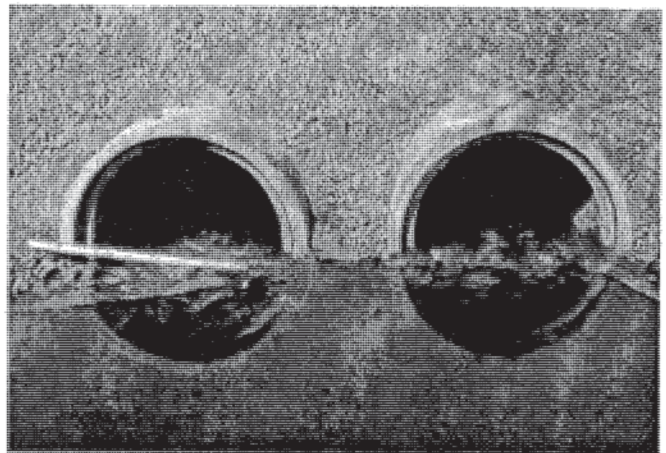
Conclusion:

Electrocoagulation provides a cost effective, onsite way to recondition water for reuse. Water reconditioning for on site use eliminates governmental discharge concerns. Peace of mind results because proposed changes to government discharge regulation no longer apply. The water reconditioning equipment capital and operating cost is offset by water reuse, timesavings with government inspectors, discharge lab testing, and fines.

ENVIRONMENT & GREEN LIVING

The Effects of Sewage on Aquatic Ecosystems

by Contributing Writer



Despite considerable effort to reduce sewage pollution, sewage is still a common pollutant of marine and fresh waters.

Treatment of municipal sewage has significantly reduced pollution of aquatic ecosystems, but the problem of sewage pollution persists. Sources of sewage pollution are overflow of raw sewage from over-burdened or poorly designed systems, inefficient treatment of sewage by treatment facilities, and farm effluent. Although widely acknowledged as a major problem, few countries strictly enforce rules regarding the discharge of farm effluent. Sewage pollution alters the balance of marine and freshwater ecosystems, causing them to function less efficiently.

Eutrophication

Sewage contains very high quantities of nutrients, primarily nitrogen and phosphorous. Under natural conditions, low concentrations of these nutrients limit the productivity of aquatic ecosystems. Sewage promotes excess growth of aquatic primary producers -- plants, algae and cyanobacteria -- in a process known as eutrophication. With increasing biomass of primary producers comes an increase in the number of primary consumers, such as zooplankton and herbivorous fish. Extra productivity is transferred up the food chain in this manner, eventually reaching predatory fish and mammals at the top of the food chain.

Community Dynamics

Physical habitat changes that arise from excess plant growth can dramatically change community dynamics. For instance, excess growth of aquatic plants can reduce available habitat for animals that require open water to live, such as filter feeding invertebrates. Plant growth can also change species dynamics, for example by creating more refuge for prey animals and thus reducing the feeding efficiency of predators. The availability of extra food may result in competitive inequality at all levels of the food chain, with animals that are more efficient at using the extra food source becoming dominant in the ecosystem. This typically results in aquatic ecosystems with high biomass but low species diversity.

Hypoxia

Sewage pollution promotes hypoxia, or oxygen depletion, in aquatic ecosystems in two ways. Firstly, sewage itself contains large amounts of organic matter which is directly available to bacteria in the water. Secondly, it promotes growth of plants and algae that become a source of organic matter when they die. When bacteria consume organic matter they also consume dissolved oxygen from the water. Hypoxia can kill animals or cause physiological stress that stunts growth and reproduction. A famous example of an aquatic ecosystem that suffers from hypoxia is the Gulf of Mexico Dead Zone. Many invasive species, like Asian carp, can tolerate low-oxygen conditions. Sewage pollution therefore facilitates the spread of invasive species by creating suitable habitat for them and eliminating competition.

Antibiotics and Hormones

Antibiotics and hormones are excreted by livestock and humans in urine and feces. Major sources of sewage containing these compounds are hospitals, intensively managed farms, and slaughterhouses. Once in the water, antibiotics can inhibit the growth of bacteria that play an important role in removing nitrogen from water. Antibiotics also promote the growth of resistant bacteria, upsetting the balance of bacterial communities. Synthetic hormones are known to disrupt the endocrine system -- a group of glands that produce hormones and control their release -- of mammals, fish, reptiles, amphibians and invertebrates. Synthetic versions of hormones, such as estradiol, can mimic natural hormones and alter the sensitivity of hormone receptors, causing abnormal growth and reproduction of exposed animals.

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- EPA: Endocrine disruption: Aquatic effects(http://www.epa.gov/ord/endocrinedisruption/aqueff.htm)
- ScienceDirect: Sewage impacts coral reefs at multiple levels of ecological organization(http://www.sciencedirect.com/science/article/pii/S0025326X09001775)
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- JSTOR: Effects of Pollution on Freshwater Organisms(http://www.jstor.org/discover/10.2307/25045285?uid=2&uid=4&sid=21102198644761)

Resources

- Microbial Life: The Gulf of Mexico Dead Zone(http://serc.carleton.edu/microbelife/topics/deadzone/index.html)
- EPA: Endocrine disruption: Aquatic effects(http://www.epa.gov/ord/endocrinedisruption/aqueff.htm)
- USGS: Eutrophication(http://toxics.usgs.gov/definitions/eutrophication.html)
- Hypox: Consequences of hypoxia(http://www.hypox.net/upload/infomaterial/hypox0120706_policybriefs_on02.pdf)
- YouTube: Human Water Pollution | Biology | Ecology(http://www.youtube.com/watch?v=ACgv19b-n5E)

About the Author

Based in Vancouver, Kirsten Campbell has been a professional ecologist since 2006. She has worked with various governmental agencies and in the private sector. Campbell holds a Master of Science in ecology and conservation.

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HEAL THE OCEAN

California Ocean Wastewater Discharge Report and Inventory

Prepared by Heal the Ocean

March 15, 2010

A compilation and review of information by Heal the Ocean on wastewater treatment and wastewater facilities discharging into the Pacific Ocean along the coast of California.

Online "Google Fly-To" and Interactive Mapping
www.healtheocean.org/research/wdi/resources

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University of California, Santa Barbara

"The ocean! People don't understand the sustaining capacity and capability of the sea, the necessity of having clean water. There will be consequences."

Dr. Howard Kator, Environmental Microbiologist, University of Virginia, College of William & Mary, 1998.

"California is facing an unprecedented water crisis. The collapse of the Bay-Delta ecosystem, climate change, and continuing population growth have combined with a severe drought on the Colorado River and failing levees in the Delta to create a new reality that challenges California's ability to provide the clean water needed for a healthy environment, a healthy population, and a healthy economy, both now and in the future."

State of California Recycled Water Policy (adopted 5/14/2009).

"Based on the potential for additional recycled water..., recycled water could free up enough fresh water to meet the household water demands of 30 to 50 percent of... 17 million Californians. To achieve this potential, an investment of $11 billion would be needed"

Water Recycling 2030: Recommendations of California's Recycled Water Task Force," 2003.

About Heal the Ocean

Heal the Ocean is a highly regarded non-profit citizens' action group with nearly 3,000 members organized to halt practices that pollute the ocean. Since its formation in 1998, Heal the Ocean has hired engineers, scientists, hydrologists, and researchers to assess problem areas, to conduct testing, and to perform engineering and cost/feasibility studies to find better technological methods of handling human waste.

Heal the Ocean's accomplishments include:

- Successfully lobbying the County of Santa Barbara to establish Project Clean Water;
- Assisting in passage of Measure B to assure robust local funding for water quality programs in the city of Santa Barbara;
- Initiating bacterial DNA typing studies at Rincon Creek;
- Initiating successful septic to sewer projects along seven miles of beach in the Rincon and Carpinteria areas, and in certain areas of the city of Santa Barbara;
- Conducting virus sampling studies at popular swimming beaches;
- Successfully campaigning to end an official waiver at a major sewage treatment plant on the Santa Barbara south coast; and
- Completing of a revolutionary oceanographic/microbiology study of the transport and fate of sewage discharge in shallow water off a popular swimming beach in Montecito, California.

For further details, visit: www.healtheocean.org

Acknowledgments

Heal the Ocean wishes to acknowledge the help of our 3,000 supporters, and in particular, we thank the following people and foundations for the generous support that has funded our report on *Ocean Wastewater Discharge in the State of California:* The Johnson Ohana Family Charitable Foundation; Brian and Laurence Hodges of the WWW Foundation; the Ann Jackson Family Foundation; Adam and Kara Rhodes of the WWW Foundation; Yvon Chouinard; Julia Louis-Dreyfus and Brad Hall of The Hall Charitable Fund; Patagonia; the Tomchin Charitable Foundation, and last but not least, our numerous anonymous donors and foundations who have stuck with us through thick and thin.

We would also like to thank the many facility operators and City and State officials who contributed generously of their time to help provide the data necessary to produce this report.

Hillary Hauser, Executive Director
Heal the Ocean

EXECUTIVE SUMMARY

California's water supply involves complicated and challenging issues, including population increase (1), drought conditions (2), rising salinity (3), and climate change threats (4) (5) such as reduced snow pack (6) and ocean acidification (7). The use of potable (safe for drinking) water for waste disposal and its discharge to the ocean have become outdated practices and stand out as unwise uses of both our freshwater and ocean resources. Already known to carry a health risk (8), ocean wastewater discharge has become even more questionable as wastewater contains a growing number of contaminants of emerging concern (CECs). The State is taking steps to investigate new and newly suspected pollution problems related to wastewater and may make necessary updates to water quality standards for discharges. A recycled water policy is now in place as a measure to help extend the State's limited water supplies. These efforts must now be focused on solving the problems of ocean pollution and water shortages that come together in the subject of wastewater treatment.

California's coastal wastewater facilities need to increase their contribution toward these aims by reclaiming and reusing a much higher percent of wastewater rather than releasing it to the ocean. Yet before they can increase water reclamation, many plants will need improvements in order to address the problems of salinity and CECs. Successful prioritization and financing of improvements, and effective monitoring and reporting protocols, rely on a clear assessment of ocean discharging wastewater treatment and plants. However, the picture has remained unclear even as the State's wastewater administration has grown more integrated. Lack of a full and detailed overview makes it difficult to pursue coordinated statewide policies and plans. This *Report and Inventory* attempts to bring the picture into better focus.

In producing this work, Heal the Ocean hopes to provide a tool for use in understanding the big picture of wastewater disposal in the ocean and recommendations that will inspire political and financial support for infrastructure and administrative improvements to end ocean wastewater discharges in California. In doing so, we hope to contribute to the resolution of two major problems: pollution of the ocean and insufficient water to sustain California's social, economic and environmental future.

Key Points

1. In California, 43 wastewater treatment facilities discharge approximately 1.35 billion gallons daily (~1.5 million acre feet per year (AFY)) of treated effluent directly into the Pacific Ocean.[1]
2. These facilities reclaim or divert for reclamation only approximately 312 million gallons daily (MGD) (~ 200,480 AFY) for beneficial reuse.[2] Based on the volume discharged daily by the 43 facilities, about four times more than this amount could be reclaimed.
3. Increasing reclaimed water for reuse would decrease the demand on locally available water as well as dependence on imported supplies, reduce (or in some cases eliminate) ocean discharges, and reduce the stress on the environment that is caused by diversion of water from its natural flows.
4. Wastewater treatment facility discharges into the Pacific Ocean contain substantial volumes of materials known or suspected to cause environmental damage and/or to pose a risk to human health (8). Their discharge is monitored on an individual rather than integrated system-wide basis, which could potentially ignore or create cumulative environmental effects and human health risks.
5. Most CECs are not currently regulated and require research to better determine their risks to human health and to the environment. This is true particularly for those CECs that are not removed from most wastewater streams.
6. Existing treatment technology – including extended secondary treatment using longer retention times – is capable of removing some CECs (9), but many of the plants studied would need improvements or upgrades to achieve the treatment levels necessary.[3]

1 Source: treatment plant wastewater discharge requirements mainly for 2005, some for different year closest to time of data collection.
2 Source: responses from treatment plant operators with information on 38 (88%) of the 43 facilities surveyed; additional information from plant websites.
3 For a review of treatment processes needed to remove certain CECs, see Wastewater Treatment to Control CECs, Part two.

7. Institutional and financial barriers exist to increasing reclaimed water. Improved treatment methods make some regulations on reuse unnecessarily restrictive. However, funds for wastewater treatment plant improvements and upgrades to ensure high quality reclaimed water have been limited and difficult to obtain. This has resulted in a significant funding gap identified by the U.S. Environmental Protection Agency (U.S. EPA)(10). If substances presently identified as CECs become regulated, further wastewater plant improvements and upgrades would be needed to meet new water quality requirements.

8. Wastewater treatment plant standards are set on an individual basis in order to account for local conditions. However, reporting requirements are not standardized within California. Therefore it is: 1) difficult to compare wastewater treatment plant operations statewide; and 2) difficult to understand the magnitude of challenges and opportunities presented by the current status of wastewater treatment plant operations. The highly beneficial services provided by wastewater treatment plants are literally invisible to and barely understood by most of the public. Statewide, coordinated educational measures are needed to help raise public awareness about wastewater treatment plant processes, proper disposal of household chemicals (which include many CECs), and effects of consumer product choice on wastewater treatment plant operations and cost. Such measures, in addition to increased pretreatment by large scale and key sources (e.g., hospitals and industrial operations) would lead to fewer pollutants being added to wastewater and result in greater conservation of water.

Recommendations

Wastewater treatment plants are a key part of efforts to end ocean pollution and the release of pollutants into the environment in general. Although the State requires treatment plants to remove high percentages of numerous pollutants, it has not yet created legislation for the removal of CECs. Due to the potential risks of these contaminants, it is essential to advance wastewater plant operations and bring standards, source control, infrastructure, treatment, and public awareness up to date across California. In light of the information in this *Report and Inventory*, Heal the Ocean makes the following recommendations:

Recommendation 1:
Improve and upgrade existing wastewater treatment plants.

- Ensure optimum treatment levels with the aim of maximum removal of contaminants and in a manner that allows for efficient additional modifications in the future.
    - Apply best methods to do so on a case-by-case basis depending on influent, site location, populations served, types of reuse, etc., tailoring treatment accordingly.
    - Emphasize advanced secondary treatment (mainly longer holding times) as a means to decrease the necessity for and maximize the efficiency of advanced treatment.
- Capture methane to offset costs of improvements and increase energy efficiency.
- Utilize potential for treatment plant sites to generate non-waste fuel alternative energy.
- Prioritize the upgrade of ocean discharging plants ahead of inland plants, given the proximity of ocean discharges to major protected areas and areas of recreation and economic ocean uses, such as fishing, and given that less discharge to the ocean will help to balance natural water flows within watersheds.

Recommendation 2:
Increase the use of reclaimed water as a more economic alternative to potable water for non-potable uses.

- Create financial incentives to utilize reclaimed over potable water for non-potable uses.
- Use reclaimed water as a major supply for toilet flushing and irrigation--two significant ways in which potable water is wasted where recycled water can be easily substituted, recognizing that initial costs may be high, but that non-action will cost far more.
- Use reclaimed water as a major source for ground water recharge and other indirect potable use, where highly treated municipal water is discharged directly into groundwater or surface waters in order to augment water

supplies. In this application, treatment must remove all contaminants (including CECs).

- Increase storage and delivery capacity for reclaimed water.

- Reclaim all wastewater presently discharged to the ocean.

Recommendation 3:
Make public education and consumer awareness a priority

- Improve public education about wastewater treatment plant processes and effects of consumer product choice on wastewater treatment plant operations and cost.

- Aid consumers in making smart decisions about their choice and disposal of personal care products, chemicals, pharmaceuticals, and sodium and potassium-based water softeners.

- Educate the public about the benefits of high quality recycled water and the facts about its safety. Demonstrate its potential to be cleaner than many drinking water supplies in order to increase water conservation, support for needed legislative and regulatory changes, and public acceptance of reclaimed water.

Recommendation 4:
Support and increase efforts to prevent pollution at source.

- Make it easy for the public to dispose of products in ways that lessen the burden on wastewater treatment plants.

- Support and expand adequate pretreatment of wastewater from industrial, medical, and similar sources as another important way to lessen the burden on treatment plants.

- Increase and/or establish restrictions on manufacturing uses of contaminants of emerging concern and on products containing these substances, especially where better alternatives exist.

- Increase restrictions on the use of sodium and potassium-based water softeners to prevent an unnecessary increase in the salinity or chloride content of wastewater reaching the treatment plant and the resulting increased expense of reclaiming high quality water.

Recommendation 5:
Revise legislation and regulation as soon as possible to overcome barriers to use.

- Legislative revisions at the State level should be introduced and structured to accommodate new standards for safe levels of contaminants of emerging concern in water and wastewater.

- Make legislation and regulation consistent throughout the State.

- Tailor revisions deliberately to ensure the existence of outlets for reclaimed water throughout California and to avoid situations where restrictions on reuse lead to wasteful discharge, particularly of tertiary-treated wastewater.

Recommendation 6:
Support and expand collaborative planning and research.

- Support a State-funded assessment of the toxicity of contaminants of emerging concern through continued research on their effects on humans, other organisms, and the environment.

- Encourage further research exchange and partnerships at and across international, national, state, regional, and local levels by water, wastewater, and public health authorities, research scientists, political representatives, engineers, and additional stakeholders, such as the U.S. Department of Fish & Game, environmental groups, and public and corporate water users.

- Establish pilot projects in a range of locations to test the viability of new monitoring techniques, equipment, treatment, etc.

Recommendation 7:
Provide government support and funding mechanisms.
The $11.1 billion bond bill proposed during fall 2009 in the California legislature demonstrates political recognition of the State's water resource problems. However, carefully crafted and more focused legislation could help to secure California's water supply over the long term, and provide better incentives for water reclamation without measures that would be harmful to the environment, such as dam building and other projects which would divert natural water supplies.

- Maximize State funding mechanisms including those noted in the State's new Recycled Water Policy.

- Increase State, regional, and local aid for treatment plant upgrades to expand and ensure usable reclaimed water supplies.

- Provide adequate funding to increase storage and delivery capacity, including recycled water pipes needed to reach consumers.

Recommendation 8:
Revise the reporting protocols of the State Water Resources Control Board (SWRCB) and attendant regional boards.
Statewide reporting revisions are needed to address inconsistencies in levels and types of reporting by wastewater treatment plants. Reporting changes are also needed in order to address the fragmentation, incompleteness, and lack of reliability of the State's sources of information on wastewater operations and compliance.

- Continue measures to implement reliable statewide reporting, free of potentially distorting features, in formats that are easy to access and analyze.

- Require uniform statewide reporting formats to ensure consistency and clarity.

- Include reporting requirements that shed clearer light on treatment plant operations, measures to enhance water quality, and water reclamation.

- Revise wastewater standards to impose limits on contaminants of emerging concern, particularly to ensure the safety of recycled water.

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PART 3

INVENTORY

Additional Online Resources

Can be found on the Heal the Ocean's Website: http://www.healtheocean.org/research/map and include:

- Online Summaries and Sources
- Interactive Maps:

  Google Earth Map:

  California Ocean Discharging Treatment Plant and Outfall Locations

  Heal the Ocean Interactive Online Site:

  Produced in ArcGIS Online by David Greenberg, Ph.D.

PART ONE

California Ocean Discharges and Wastewater Treatment

Introduction

In 2005, Heal the Ocean began an inventory of the amount of wastewater being discharged into the Pacific Ocean throughout the State of California. Our aim was simple: we wanted to create a perspective, as accurately as possible given the resources and technology we had at the time, about what goes into the ocean from coastal communities along the Pacific Ocean shoreline of California. The figures reported in the original *Ocean Wastewater Discharge Inventory for the State of California* turned out to be staggering, showing that over a billion gallons of treated effluent are discharged daily into ocean waters.

We discovered that two small treatment plants were discharging into the intertidal zone with no dilution of effluent, while other plants discharged into a marine sanctuary or an area of special biological significance (ASBS) under exemption from policies to protect such areas. We noted the coastal outfalls that discharge into shallow areas, close to shore, very near to the places where people swim in the ocean. As a result of these findings, Heal the Ocean contracted with environmental microbiologist Howard Kator to produce a report, "The dangers of swimming in secondary sewage," (included in the National Resources Defense Council's 2004 report to U.S. Congress, "*Swimming in Sewage,*" and provided in the Additional Online Resources for this report).

Almost immediately after distributing the *Inventory* we received comments pointing out errors and omissions. We took these constructive criticisms seriously and this newly revised *Ocean Wastewater Discharge in the State of California Report and Inventory* addresses those criticisms and other issues that have emerged since that earlier publication.

Heal the Ocean prepared this *Report and Inventory* for another important reason: the information it contains (including the compilation of treatment plant information) has not existed in any one place, including within any California agency, such as the State Water Resources Control Board (SWRCB). Our aim is to provide a resource to the SWRCB, State officials, related agencies, and researchers, to call out the risks and opportunities of the ongoing discharge of treated effluent, and also to make it easier to examine the environmental pressure these discharges put on the Pacific Ocean, including nearshore areas where people swim and surf. We have produced this report also to examine the opportunities to reclaim the wastewater presently discharged to the ocean. Reclaiming wastewater would help California to end the dangerously outdated practice of wasting enormous amounts of water while searching for new sources of water and devising expensive means of transporting water around the State. Diverting water from new sources instead of reclaiming water also makes little sense when a large proportion of fresh supplies ends up similarly discharged and therefore wasted.

California is divided into a total of nine regions administered by individual regional water quality control boards (RWQCBs) in the State (see Figure 1.1). The facilities included in this report are located within the six coastal regions. The wastewater treatment plants range from Crescent City, about 20 miles south of the Oregon border, to the International Wastewater Treatment Plant on the San Diego/Tijuana international boundary. Populations served by these treatment plants range from 12 people to over five million. This report shows that roughly half of the treated solids released into the ocean every day (more than 70 tons of the total 134 short tons released) receive only primary or secondary treatment <u>without disinfection</u>. These solids are suspended in 629 million gallons of the 1.35 billion gallons of treated effluent discharged daily.

The objective of eliminating ocean pollution by wastewater treatment plants clearly converges with the need to conserve California's water supply. Advanced treatment technologies can serve as mechanisms to help to achieve both. Extended and thorough treatment at all levels offers the best protection of the ocean and recreational beaches against the full set of contaminants, particularly those of emerging concern, and produces water that can be reclaimed for many beneficial uses.

Research for this report reveals a correlation between a measure of the relative efficiency (of removal of solids) of individual wastewater treatment plants[4] and their

4 Treatment plant efficiency calculated as a measure of total suspended solids divided by population (figures mainly from 2005; population used as a proxy for measure of influent).

ability to treat water at a tertiary level. Nine of the ten plants found to be most efficient (based on 2005 data) were processing at least a portion of their influent at a tertiary level. Presently, 20 of the 43 ocean-discharging facilities along the California coast have at least some tertiary capacity. This raises the need to research additional factors affecting efficiency and the potential for further improvements in water quality. Many plants lacking tertiary capacity divert a portion of their influent for tertiary treatment by other, more advanced, plants. While cost and site constraints act as obstacles, the lack of an overall State strategy for sewage treatment must also contribute to the variation of treatment capacity and persistence of large-scale discharge, including undisinfected effluent.

Aims:
In light of the wide range of treatment levels, and of the depth, distance, and quantities of treated wastewater discharges, this *Report and Inventory* aims to contribute to a broader perspective by:

- **Providing a complete statewide overview of specific features of coastal wastewater treatment plants and their ocean outfalls:**
    - Outfall location (depth & distance from shore), treatment plant processes, and amount of treated effluent and total suspended solids discharged.
- **Presenting a summary of important pollutant issues posing a challenge to wastewater treatment and water reclamation and reuse.**
- **Reviewing methods and issues related to assessment of plant performance in order to achieve:**
- Consistent and expanded reporting formats and support of continued work toward a reliable statewide reporting system;
    - Further coordination and alignment of treatment plant awards toward State policy and goals particularly for water reclamation.
- **Mapping and reporting on the spatial relationship[5] between wastewater discharge locations and beaches adjacent to 303(d) listed impaired water bodies and other sensitive ocean ecosystems throughout California.**

In this way, this *Report and Inventory* may help to: 1) provide a comparative perspective of current sewage treatment practices; 2) show where reporting of treatment plant data could be improved; 3) help to direct future research into controlling and eliminating human sources of ocean pollution; and 4) assist efforts by various stakeholders, such as facility managers, policy makers, community leaders, and environmental groups to improve California's water quality and supply.

Heal the Ocean regards the online interactive mapping and our recommendations as two of the most important elements of this report. We note the increasing attention paid to the potential risks posed by CECs and how to address those risks. Our recommendations support the need for ongoing research but also call for immediate action–action that amounts to the adaptive management needed now to meet the challenges of wastewater treatment and water supply in the State of California.

Wastewater Treatment and Ocean Discharges on the Coast of California

Every day, California coastal wastewater treatment plants discharge approximately 1.35 billion gallons of treated effluent into the Pacific Ocean (1.5 million acre feet per year (AFY)). This is about the amount of fresh water used every year by about two million average California households.[6] This is also the amount that California's Recycled Water Task Force estimates the State could potentially recycle in total (11), which shows that this estimate is feasible and possibly low. The effluent discharged includes approximately 270,000 pounds, or 135 short tons, of treated solid matter, all of it delivered daily to the Pacific Ocean off California. Annually, this amounts to 50,000 tons of treated solids dumped into the ocean – the equivalent of the weight of 16,000 Cadillac Hybrid Escalades.[7] The pollutants in treatment plant discharges have been drastically reduced since the introduction of the Clean Water Act (CWA) in 1972. Nevertheless, sewage treatment plants discharging off the coast of California remain a major source of ocean pollution from identifiable ("point") sources (12). The adaptation of treatment plants to new and future conditions could provide an opportunity to end the wasteful and polluting practice of ocean discharge and to decrease the climate impact of plants through increased energy efficiency and decreased emissions.

The treatment facilities included in this *Report and Inventory* receive wastewater collected from homes, businesses, and industrial premises, with pipelines used to transport the wastewater to and from the facilities. Household waste is generally not regulated at its source,

5 The spatial analysis produced for Heal the Ocean by David Greenberg, Ph.D. supplements the *Report and Inventory*.

6 Based on Water Use Facts, U.S. Department of Agriculture website (accessed October 2009). "An average California household uses between one half-acre foot and one-acre foot of water each year."
http://www.fs.fed.us/r5/publications/water_resources/html/water_use_facts.html

7 Based on curb weight, manufacturer claim: 6,016 lb, 2009 Cadillac Escalade Hybrid 4WD Full Test. Edmunds InsideLine website (accessed September 2009).
http://www.insideline.com/cadillac/escalade-hybrid/2009/2009-cadillac-escalade-hybrid-4wd-full-test.html

California Ocean Discharging Wastewater Treatment Plants by Region

	California Ocean Discharging Wastewater Treatment Plants by Region			
	Wastewater treatment facility		Location served	NPDES* Permit
	Regional Board 1 – North Coast			
1	Crescent City Wastewater Treatment Facility		Crescent City	CA0022756
2	Arcata Municipal Wastewater Treatment Facility		Arcata	CA0022713
3	Greater Eureka Area / Elk River Wastewater Treatment Facility		Eureka	CA0024449
4	Humboldt County Resort Improvement District No. 1, Shelter Cove Wastewater Treatment Facility		Shelter Cove	CA0023027
5	Fort Bragg Municipal Improvement District No. 1 Wastewater Treatment Facility		Fort Bragg	CA0023078
6	Mendocino City Community Services District Wastewater Treatment Facility		Mendocino	CA0022870
7	Mendocino County Water Works District No. 2, Anchor Bay Wastewater Treatment & Disposal Facility		Anchor Bay (Gualala)	CA0024040
	Regional Board 2 – San Francisco Bay			
8	City & County of San Francisco Oceanside Water Pollution Control Plant *(sole combined plant in CA)*		San Francisco	CA0037681
9	Daly City (North San Mateo County Sanitation District) Wastewater Treatment Plant		Daly City	CA0037737
10	Half Moon Bay (Sewer Authority Mid-Coastline) Wastewater Treatment Plant		Half Moon Bay	CA0038598
	Regional Board 3 – Central Coast			
11	Santa Cruz Wastewater Treatment Plant		Santa Cruz	CA0048194
12	Watsonville Wastewater Treatment Facility		Watsonville	CA0048216
13	Monterey Regional Water Pollution Control Agency Regional Treatment Plant		Marina	CA0048551
14	Carmel Area Wastewater District WWTP & the Pebble Beach Community Services District		Carmel	CA0047996
15	Ragged Point Inn Wastewater Treatment Facility		Ragged Point	CA0049417
16	San Simeon Community Services District Wastewater Treatment Plant		San Simeon	CA0047961
17	Morro Bay and Cayucos Sanitary District Wastewater Treatment Plant		Morro Bay	CA0047881
18	Avila Beach Community Services District		Avila Beach	CA0047830
19	Pismo Beach Wastewater Treatment Facility		Pismo Beach	CA0048151
20	South San Luis Obispo County Sanitation District		Oceano	CA0048003
21	Goleta Sanitary District Wastewater Treatment Facility		Goleta	CA0048160
22	Santa Barbara (El Estero) Wastewater Treatment Facility		Santa Barbara	CA0048143
23	Montecito Sanitary District Wastewater Treatment Facility		Montecito (Santa Barbara)	CA0047899
24	Summerland Sanitary District Wastewater Treatment Plant		Summerland	CA0048054
25	Carpinteria Sanitary District Wastewater Treatment Facility		Carpinteria	CA0047364
	Regional Board 4 – Los Angeles			
26	Oxnard Wastewater Treatment Plant		Oxnard	CA0054097
27	City of Los Angeles (Hyperion Treatment Plant)		Los Angeles	CA0109991
28	County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant		Carson	CA0053813
29	Terminal Island Treatment Plant		San Pedro	CA0053856
30	Avalon Wastewater Treatment Facility		Avalon	CA0054372
31	US Naval Auxiliary Landing Field, San Clemente Island Wastewater Treatment Plant		San Clemente Island	CA0110175
	Regional Board 8 – Santa Ana			
32	Orange County Sanitation District, Reclamation Plant No. 1		Fountain Valley	CA0110604
	Orange County Sanitation District, Treatment Plant No. 2		Huntington Beach	CA0110604
	Regional Board 9 – San Diego			
33	SOCWA Joint Regional Treatment Plant**	*51 Permitted facility:* Aliso Creek Ocean Outfall	Laguna Niguel	CA0107611
34	SOCWA Coastal Treatment Plant**		Aliso Canyon, Laguna Niguel	
35	Irvine Ranch Water District Los Alisos Water Reclamation Plant**		Lake Forest	
36	El Toro Water District Water Recycling Plant**		Laguna Woods	
37	SOCWA JB Latham Treatment Plant**	*52 Permitted facility:* San Juan Creek Ocean Outfall	Dana Point	CA0107417
38	SOCWA Plant 3A**		Laguna Niguel	
39	Santa Margarita Water District Chiquita Water Reclamation Plant**		Rancho Santa Margarita	
40	San Clemente Reclamation Plant**		San Clemente	
41	Oceanside (San Luis Rey & La Salina Wastewater Treatment Plants)		Oceanside	CA0107433
42	Fallbrook Public Utility District WWTP No. 1		Fallbrook	CA0108031
43	US Marine Corps Base Camp Pendleton *(completely offline from March 2009)*		Camp Pendleton	CA0109347
44	Southern Region Tertiary Treatment Plant** *(replaced the Camp Pendleton plants)*			CA0109347
45	Encina Wastewater Authority Water Pollution Control Facility		Carlsbad	CA0107395
46	Escondido Hale Avenue Resource Recovery Facility		Escondido	CA0107981
47	San Elijo Powers Authority Water Reclamation Facility		Cardiff	CA0107999
48	E.W. Blom Point Loma Metropolitan Wastewater Treatment Plant		San Diego	CA0107409
49	South Bay Water Reclamation Plant		San Diego	CA0109045
50	International Boundary & Water Commission International Wastewater Treatment Plant		San Diego	CA0108928

**NPDES: National Pollutant Discharge Elimination System **Indirect discharge via outfall facility; No effluent data collected for the Discharge Inventory*

Table 1.1 California Ocean Discharging Wastewater Treatment Plants by Region, indicating location served and National Pollutant Discharge Elimination System permit number. Direct to ocean discharge by 43 facilities.

Ocean Discharging Wastewater Treatment Plants in California

Figure 1.1. Location of Coastal Regional Water Quality Control Board Jurisdictions and Treatment Plants Discharging into the Pacific Ocean

but industrial and certain business waste must meet standards that may require pre-treatment (treatment before delivery to a wastewater treatment plant). Removal of fats and oils from restaurant waste is a typical example. With a few exceptions, source control requirements have been mainly to protect collection and treatment operations of the plant, not to improve overall quality of effluent.
In general, current sewage treatment technology and standard practices focus on removal of solid materials, elimination of pathogenic bacteria, and in some cases reduction of nutrients or other chemical constituents.

Wastewater treatment is typically described as occurring in three stages (13).

- **Primary – removal of solids: initial sedimentation and clarification to remove suspended material that settles or floats.**
- **Secondary – biological treatment: use of microorganisms to convert dissolved and suspended organic waste into stabilized compounds. Secondary processes decompose and/or transform the organic matter and kill off bacteria.**
- **Tertiary – treatment beyond secondary processes to increase the removal of dissolved pollutants like sodium and chloride, and nutrients: tertiary level treatment uses advanced processes that can at best remove 99% of known pollutants, and the nutrients nitrogen and phosphorous, which can contribute to algae blooms (13, p.600).**

Today's typical wastewater treatment involves primary and/or secondary treatment but is not 100% effective in removing pollutants. Since regulations anticipate less than 100% effectiveness, discharges of treated effluent contain solids, bacteria, and dissolved contaminants, but generally at a level below requirements. Requirements are established by balancing technical, environmental, and financial factors. Waste treatment byproducts include microorganisms, brine (containing nutrients and salts), methane gas and biosolids – the modern and more accurate term for treated sewage sludge. Following stabilization in "digesters" (a unit in which bacterial action is induced and accelerated in order to breakdown organic matter) and sometimes with chemicals, biosolids are commonly disposed of as soil amendment. However, fertilizing and composting with biosolids may be unwise practices if CECs are not properly removed. Some wastewater treatment plants use biosolids to generate energy for the running of the plant. Unused biosolids may also be delivered to landfills for burial or for use as daily cover.[8] As the salinity management plans for areas such as Calleguas and Santa Ana show, discharge of brine waste directly into the ocean from treatment plants remains a standard practice.

8 Daily cover is the compressed soil laid on top of a day's deposition of waste at a landfill site in order to reduce odors and help stabilize the waste.

Opportunities and Challenges for Wastewater Treatment on the Coast of California

Collection, treatment, and discharge of wastewater are regulated under both State and federal law. Within infrastructure and financial limits, plant operators carry out extensive monitoring of pollutants and apply typically sophisticated technology to ensure permit limitations are not exceeded. But the standards under which they operate need critical overhaul for the following reasons:

- **CECs–including pharmaceuticals, personal care products, estrogenic compounds, and genetic material from bacteria that have become resistant to antibiotics–are now of significant concern to researchers, particularly as some can escape standard treatment and most are not monitored in waste streams;**
- **Current monitoring techniques do not employ tests for viruses;**
- **The movement of discharged effluent is not usually tracked. Its ultimate fate is unclear, and when discharged in relatively shallow water, wastewater may migrate to shore with limited dilution;**
- **Relatively high salinity levels in treated wastewater can and often do prevent its most common use: irrigation.**
- **No composite picture exists of the total load of pollutants from different wastewater treatment plants that discharge into the same areas of the ocean. This means that cumulative impacts are unknown.**

Key areas of challenge and opportunity

Meeting the substantial institutional, technical, social, and financial challenges related to wastewater treatment will bring opportunities not only to expand the use of reclaimed water, but also to reduce demand on local and other imported water supplies in key areas of the State.

Bacteria/viruses/pathogens

Current treatment focuses on eliminating risk from pathogenic bacteria and, to some extent, viruses. Treatment systems are generally effective in meeting this objective. However, the proliferation and widespread use of chemicals has increased the load of chemicals entering the waste stream, and reaching the wastewater treatment plant. Current State approved wastewater treatment standards do not require monitoring of most of these chemicals. Therefore, the potential exists for these substances to be released untreated into groundwater, drinking water supplies, and the ocean. Drugs passing through the human body or disposed of by toilet flushing, as well as antibiotics used to promote the growth of livestock have led to the development of MDRB (multi-drug resistant bacteria) and forms of antibiotic resistance, such as MRSA (methicillin-resistant staphylococcus aureus) (14) (15).

Contaminants of Emerging Concern

The term "CEC" has become increasingly accepted by scientists and researchers as their knowledge of the toxicity and sub-lethal effects of these substances has expanded and as the search has intensified for improved monitoring and ability to detect pollutants. National efforts to act on CECs are now underway, but guidelines and legislation are clearly lagging (16) (17). The quantity of such compounds in wastewater has been increasing while researchers have begun to understand the complexity of the interaction and degradation of CECs, and the dangers posed by new chemicals resulting from their degradation or exposure to ultra-violet treatment and/or sunlight. (18). As elsewhere, California wastewater treatment must address all aspects of CECs, particularly since water recycling has become a priority for the State.

Wasted nutrients

Wastewater typically contains nitrogen and phosphorous compounds. Although these soil nutrients and organic matter can serve as soil amendment, they are instead discharged. Because of the large overall quantity of wastewater discharge, the volume of these nutrients impacting the ocean is high. Nutrients at high levels can cause eutrophication – the over-stimulation of plant or algae growth that depletes the oxygen necessary to maintain other forms of life (19). As listed in the California National Pollution Discharge Elimination System (NPDES) Code of Regulations, nutrients are considered as non-priority pollutants (20). An SWRCB presentation[9] on "Water Quality Criteria: Nitrogen & Phosphorus Pollution" outlines how the U.S. Environmental Protection Agency (EPA) has concluded that "Nutrient Criteria cannot be developed as a single number for the Nation due to variability in background conditions and the role of other risk co-factors which affect nutrient processing within ecosystems" (21).

While a case-by-case pollutant assessment is needed for nutrients, the total quantities discharged off the coast of California need to be calculated. Nutrient loading of the total amount discharged would be prohibited if this amount were discharged from a single site. But situations of cumulative discharge by several plants into adjacent or overlapping ocean areas are escaping regulatory attention. No additional studies or monitoring programs would be needed to begin the reclamation of nitrogen and phosphorous for deliberate and controlled beneficial use. This would make more sense than nutrient discharge (frequently with water that could be reclaimed) in treated effluent. Advanced treatment could allow either capture of the nutrients or ensuring they are diverted specifically in water reclaimed for irrigation. In either case, the nutrients should not be discharged to the ocean with the attendant risk of ecosystem imbalance

9 Date unknown, but circa 2005.

Infrastructure investment

In 2002, the U.S. EPA concluded that if investment in water and wastewater systems remained flat, the United States would face a gap of $122 billion (the mid-range estimate) between the current funding available to the treatment plants and what is needed to bring them up to acceptable levels of treatment over the 2000-2019 period (10). The California and national budgets have been hit hard since this projection. But in 2009, the State Water Resources Control Board (SWRCB) began to take full advantage of national stimulus funds and other funding sources to kick-start treatment plant infrastructure projects, including water recycling facilities. The State Recycled Water Task Force concluded that, *"... recycled water could free up enough fresh water to meet the household water demands of 30 to 50 percent of... 17 million Californians. To achieve this potential, an investment of $11 billion would be needed"* (11).

Current financing methods based on population sizes, areas served, and the official requirements set for waste discharges lead to competition among wastewater treatment plants for State and national funding and loans. The regional and local district administrative system produces a case-by-case assessment of treatment plants, their needs, and pollution records. While such methods for evaluation provide a tight focus on day-to-day operations, pollution incidents, and performance goals, this narrow perspective bypasses opportunities for cooperation and information-sharing. Prioritization and research become more difficult, and awareness and communication among different stakeholders remains low (22).

Wasted water

When wastewater is treated to the highest possible level, producing essentially fresh water, and is then discharged into the ocean, the opportunity for reuse and conservation of water resources is lost. Sewage treatment plants discharge large volumes of such potentially re-usable water from areas that depend on imported supplies and that face shortages during drought. The San Diego region is an example: it discharges about 26 million gallons daily (MGD) (see Table 3.5) while simultaneously seeking new water sources. As water supplies diminish and demand increases, the production of high quality water through wastewater treatment presents a significant opportunity to decrease the use of drinking water for secondary uses such as irrigation and toilet flushing.

Demand for reclaimed water

The cost of recycled water is still higher than tap water, and there is a significant initial expense to install dual plumbing (a second pipe to convey recycled water for reuse). As a result, the use of reclaimed water has not kept pace with recycled water supplies. The lack of demand acts as a disincentive to treatment plant upgrades and improvements necessary to meet standards for reclaimed water. Demand also falls for other reasons:

- Demand for direct reclaimed water use is less in wet-weather months and leads plants to discharge highly treated water.
- Low demand in general can stem from an unwillingness of potential consumers to pay the full price of reclaimed-water production.
- Lack of public acceptance poses an obstacle in some cases to the use of reclaimed water for indirect potable reuse.
- Lack of delivery and storage structure can lead to underutilization of highly treated water.
- Local regulation that unduly constrains or does not permit reuse can result in a waste of water that could be recycled. However, a delay in changes to regulations is necessary until new standards have been developed for CECs.

Taken together, these issues could appear to support delaying wastewater treatment plant upgrades until treatment technology improves and demand for water reuse increase. However, careful engineering design could allow facility modifications in a manner that would expedite subsequent upgrades that are sure to come. Given the known effects of pollutant discharges and existing constraints on State water supplies, there appears to be little benefit in delaying treatment plant upgrades that would increase reuse of water and/or address the known discharge of pollutants.

(See Part Two of this report for further details on key issues relating to reclaimed water.)

Ocean Wastewater Discharge Inventory Research Methods

The Inventory of wastewater discharge to the ocean and other aspects of wastewater treatment was completed in two phases. Phase 1 focused on collection of data and preparation of three data bases. Phase 2 comprised calculation of average flows, evaluation of compliance data, and selection of aspects for comparative presentation.

Phase 1 – Data Collection and Compilation

Data were compiled on outfall features, plant operation, and effluent characteristics for each of the California sewage treatment facilities that discharge into the Pacific Ocean. Information regarding regulatory compliance and water reclamation was also collected.

Database 1 – Wastewater treatment plant characteristics

Wastewater Discharge Requirement permits (WDRs) and other documents that provided data for the inventory were obtained from websites of the U.S. EPA, the SWRCB or from regional boards within California. Data came mainly from WDRs for 2005 and a few from slightly earlier or later years. From these reports, the following information was compiled:

- **Area receiving service and the size of the population receiving service;**
- **EPA classification of plants as a major or minor facilities;**
- **Treatment and disinfection process;**
- **Facility design and permit capacity;**
- **Longitude and latitude coordinates of the discharge and plant location;**
- **Depth below the water surface and distance from shoreline of ocean outfalls;**
- **Issuance and expiry dates of the WDR;**
- **Expected dilution ratio (seawater : effluent); and**
- **Type of wastewater (e.g., municipal or industrial).**

The WDR for each plant generally contained the data listed, but in some cases alternative sources had to be consulted. For example, census data, direct consultation with regional board staff and treatment plant managers, individual plant websites, U.S. EPA Facility Registry System, and Google Earth were all used to complete the data set. These alternative sources were necessary to provide missing information and coordinates or corrections to coordinates that are recorded in the WDRs for several treatment plants. Furthermore, the EPA online information about California wastewater treatment plants did not prove reliable in several cases. During completion of the *Report and Inventory*, more information has become available online, reflecting a trend toward greater access of data.

Database 1 Additions – Water reclamation and improvements made by wastewater treatment plants

After compilation of the two main databases, plant operators were surveyed in August 2009 by phone and email in order to collect current information and figures on water reclamation and on details of plant improvements made since 2005. Information was gathered from responses from 30 operators regarding 34 (79%) of the 43 facilities surveyed for the *Report and Inventory*.

Database 2 – Treated effluent

A second database was created to calculate the average amount and concentration of treated effluent that wastewater treatment facilities are discharging into the Pacific Ocean.

Data on specific pollutants were obtained from three sources:

- **the annual self monitoring reports (SMRs) compiled by each facility and submitted to the appropriate regional board;**
- **a few monthly SMRs provided by the treatment plants; and**
- **monthly SMR data collected and provided for the *Inventory* by the Southern California Coastal Water Research Project (SCCWRP).**

Annual SMRs were typically obtained directly from individual wastewater treatment plant managers, others were obtained by contacting regional board staff, and in a few cases a formal Public Records Act request was necessary. Data from the SCCWRP are for those plants within the Southern California Bight (the ocean area from Point Conception to the north to the US/Mexican border to the south). Parameters were chosen based on the existence of data for consistent comparison and based on parameters associated with 2006 303(d) listed impaired water bodies. This made it possible to identify any relationship between pollutants in effluent and the pollutants identified for beaches adjacent to water bodies on the CWA 303(d) list as impaired.

Database 3: Regulatory violations

The "Facility-at-a-Glance" online reports of the California Integrated Water Quality System (CIWQS) database provided a summary of the number of violations and enforcement actions. The CIWQS Interactive Violations Reports were also consulted to obtain detailed descriptions of the specific causes of violations and enforcement action taken. Large discrepancies were identified between the data reported on Facility-at-a-Glance and the data found on the Interactive Violations Reports. In addition, staff at some Regional Boards knew of certain cases involving court settlement proceedings but could not locate the enforcement documents. Heal the Ocean efforts to obtain the documents from the Superior Court were also unsuccessful. Difficult access and the inconsistencies in record keeping make it very difficult to track the regulatory compliance of the State's wastewater treatment plants. Heal the Ocean correspondence and conversation with plant operators confirmed that data recorded in the CIWQS were not always reliable.

Phase 2: Analysis & Calculations of Annual Discharge and Mass Emissions.

Annual average concentrations and mass emissions estimates were calculated based on the annual or monthly SMR results as available for a calendar year. Efficiency was calculated using effluent data and population served. The population served by each plant was used as a proxy for influent in calculations.[11] However, the lack of information about contributing factors such as historic storms renders unreliable any comparative assessment of a single year of treatment plant efficiency. Several plants, such as Morro Bay/Cayucos and Point Loma,[12] report their efficiency in percentage removal of total suspended solids (TSS), a practice that may be valuable to include as standard for treatment plant reporting as an indicator of overall plant efficiency. Without standardized, easily accessible presentation and uniform requirements for the inclusion of influent, effluent, and TSS figures in routine reporting, the tasks of identifying or calculating measures of efficiency are problematic.

Energy efficiency for wastewater treatment plants is reported in the CIWQS reporting system on a comparative basis, although it is possible that this information may be as unreliable as that for regulatory compliance, given the problems with the CIWQS reporting system at the time of research for the Report and Inventory. However, the inclusion of efficiency information in CIWQS shows how an online reporting system can accommodate various categories of information so that plant performance can be assesses in various ways.

The following equations represent the calculations used to determine the amount of treated water discharged annually by plants and their mass emissions as total suspended solids.

Annual Discharge (V) for each faculty

$$V = \sum_{i=1}^{12} aF_iD_i$$

F_i= Average Daily Flow for month i
D_i= # of days discharge occurred during month i
a = appropriate unit conversion factor for calculating volume in Gallons

Mass Emissions (ME) for each faculty

$$ME = \sum_{i=1}^{12} bF_iC_iD_i$$

F_i = average daily Flow for month i
D_i = # of Days discharge occurred during month i
C_i = constituent Concentration for month i
b = appropriate unit conversion factor for calculating ME in metric

Discharger Permits, Facility Information, Performance, and Reporting

Regulatory Framework

Wastewater treatment is regulated by the federal Clean Water Act (CWA) and California State law. The coastal facilities reviewed for this report each apply to their relevant regional board for an individual permit to discharge. Permits must be consistent with the federal National Pollution Discharge Elimination System (NPDES) and with the California Ocean Plan.[10]

The NPDES program rests on three major actions at the state level:

- **In California, ocean water quality standards are set by the California Ocean Plan in accordance with the CWA and the California Water Code.**
- **Under the CWA, states must make a list of water bodies that exceed pollutant limits designated in the Act.**
- **States must then list the Total Maximum Daily Load (TMDL) for pollutants in the water bodies identified as impaired. The resulting list is known as the 303(d) List of Impaired Waters.**

TMDLs are set at the level necessary to achieve the applicable water quality standards. NPDES permits must be consistent with the approved TMDLs and are issued to entities that discharge into an impaired body of water. Establishment of a TMDL may result in progressively stricter limitations of such discharges with time.

The U.S. EPA administers the NPDES and delegates regulatory authority to the California EPA. The California EPA in turn tasks the SWRCB with the administration of the nine regional water quality control boards that regulate water quality issues throughout the State. The regional boards under the SWRCB issue the individual WDRs to the plants.[11]

Wastewater treatment plants implement their permit requirements by meeting their WDR. WDRs set specific limits on the amount of various pollutants an individual plant is permitted to discharge. The plants are required to carry out periodic monitoring of these pollutants in their influent and treated effluent.

10 For NPDES Permit Program Basics, see: http://cfpub.epa.gov/npdes/home.cfm?program_id=45

11 For a brief history and description of the SWRCB see: http://www.waterboards.ca.gov/about_us/water_boards_structure/history.shtml

Discharger Information Sources

Information relating to permits, discharge requirements, and violations for all permitted sewage treatment facilities is made available to the public. The U.S. EPA operates the national Enforcement and Compliance History Online (ECHO) (23). At the State level, systematized and electronic reporting of compliance and monthly monitoring has long been adopted as a goal by the SWRCB. However, apart from all the treatment plants in Region Three, only a minority of wastewater treatment plants in other regions have adopted the present CIWQS. Technical, institutional, and financial problems have slowed the State's development of the System and have complicated electronic reporting. However, the CIWQS Review Panel believes the System can succeed under strong leadership and with a revised, narrower scope if it reflects user practices "down to the level of data entry," with constraints to ensure data integrity, and if subject to sufficient testing (24).

Work is underway through the CIWQS to develop the capacity to transfer needed data among dischargers and the federal NPDES system, and to make the data available to the public. As part of its recommendations, the CIWQS Review Panel recommends that: "... the State Water Board evaluate available alternatives for transferring needed data among dischargers, CIWQS, and the federal ICIS [Integrated Compliance Information System]-NPDES system. Because state and federal reporting and decision-making requirements differ, this interface should accommodate both state and federal needs and be developed in cooperation with the [U.S. EPA]."

Public reporting through ICIS-NPDES and ECHO, as well as the CIWQS, has emphasized access to permit violation information rather than to monitoring data itself. No interlinked comparative aspect has yet been included in these reporting systems. The move toward a much needed overview of wastewater treatment information for a region, or even California as a whole, has been encouraged by non-governmental organizations like Heal the Ocean and the SCCWRP.

Problems with existing information sources

During Heal the Ocean's data gathering and confirmation for compliance, it became clear that in addition to discrepancies in regulatory records, some violations had been recorded inaccurately. This *Report and Inventory* therefore leaves aside the regulatory information and uses the data collected only on the characteristics of each plant and outfall.[12]

12 California ocean dischargers include the San Francisco Oceanside plant, the only "combined' plant in the state that treats both sewage from the sanitary system and storm water runoff. It is the sole California plant that removes 100% of "first flush" storm water and treats the pollutants in this runoff. This major dual feature of the plant places it outside comparison

Thus, based on efforts associated with preparation of this report, Heal the Ocean has identified both a lack of integrated reporting and of significant data within the systems in place in the State of California. As a result, it is very difficult for any governing agency to assess the comparative operation, efficiency, and compliance of ocean-discharging treatment plants in California. The following problems arise:

1) Difficult access to information
Data is retrieved from waste discharge requirement documents, monthly monitoring reports, and annual reports. The lack of a complete and fully reliable online reporting system extends the time needed to gather the reports. Incomplete data also delay or prevent any measurement of plant efficiency.

- Electronic versions of reports have frequently been in a form that cannot be electronically searched (e.g., searching for key words), extending the time needed to find specific data.

2) Lack of consistency
While the unique characteristics in receiving waters produce a necessary and valuable variation in the standards set for each plant, unnecessary variation in reporting also occurs as follows:

- Reporting scope, style, format, depth, and occasionally units of measurement, vary considerably among regions and sometimes within regions. This raises obstacles of time and complexity to data gathering for any agency overseeing the comparative operations of wastewater treatment plants in California.

3) Data reliability
Heal the Ocean has learned from wastewater plant managers that on-line violation reports collected and administered by the SWRCB have also not always been accurate and therefore do not yet form a reliable basis for assessing compliance:

- Some violations have been incorrectly linked to plants where the violations did not occur;The online reporting database includes a number of violations resulting from errors or problems at contract analytical labs. The laboratory errors remain in the database and prevent a correct assessment of treatment plant operational errors;

- Multiple violations have been recorded for a single incident;

- Some violations may be under appeal by treatment plants whose staff believes they can prove the violations occurred for reasons unrelated to the actual operation of the plant;

- Violations remain on record even after investigation and dismissal after a finding that the treatment plant was not responsible or that the violation did not occur (as distinguished from violations confirmed and corrected).

Opportunities to Improve Performance

The contribution to regional board financing from fines on plants for permit violations raises the issue of incentives vs. penalties and which costs should be borne by the consumer. At present, while the administrative emphasis appears to focus on violations rather than on achievement, incentives are provided through treatment facility award schemes. Professional associations offer competitive awards and the State has developed an exhaustive competition-based recognition system for both individual operators and plants as a whole.[13] These competitions are intended to recognize and reward excellence in individual and system operation.

Some operators, however, have reported that they cannot justify the time taken to enter their plant into competition even when the same operators feel their facility deserves recognition for standards achieved. Violations receive attention automatically, while rewards for improvements do not. It could be advantageous for both regional administration and plant operations to shift their focus from simply decreasing violations and to permanently improved performance that is aligned with statewide water resource policies and plans. The following two areas are suggested as starting points:

1) Redirection of fines toward more source control
Sanitary districts are typically fined for permit violations (25). Plants can request to apply a portion of a fine assessed for an administrative civil liability (ACL) complaint to a Supplemental Environmental Project (SEP) or a Regional Water Quality Improvement Project (RWQIP) as included on a SWRCB list. SEPs are designed to reverse "the negative impacts on the environment caused by illicit discharges, legacy pollutants or other factors." RWQIPs "address problems requiring cleanup and abatement actions and other significant unforeseen water pollution problems that may not be undertaken in the absence of financial assistance (e.g., wastewater treatment facility projects in disadvantaged communities)" (26). Given the issues of CECs, greater emphasis on projects centered on pollution prevention or reduction, i.e., source control (preventing

with other plants in the State.

13 See Wastewater Treatment Awards: Table under Additional Online Resources (Additional References, Summaries, & Sources section).

contaminants from entering the waste stream), including public education toward this end, could prove worthwhile as part of a long term strategy to decrease the pollutant load in the waste stream.

2) Finding new significance for treatment plant awards
Wastewater treatment plants in California participate quite extensively in award programs that offer titles such as "Regional Plant of the Year." This reflects the pride taken in performance by plant managers and may improve the chances of success in applications for funding. But in addition to standards of permit compliance as well as operations and maintenance, awards could and should focus on new categories relative to current needs. For example, achievements relating to wastewater reclamation and the recycling of water could be one such focus. The State's water recycling policy involves extensive consultation with regional water board representatives to agree on targets, but the mandate has not yet extended to the treatment plant itself in the form of new standards, reporting requirements or award categories.

A number of awards that provide official vehicles for evaluation of wastewater treatment plants are considered prestigious within the wastewater industry. The National Association of Clean Water Agencies (NACWA's) Peak Performance Awards are an example of recognition based on individual plant performance. This invites a line of inquiry about the sources used for compliance data and the procedures applied by awarding organizations to ensure consistency.

NACWA also runs the Excellence in Management Program to honor "member agencies that have implemented and sustained, for a continuous three-year period, successful programs that address the range of management challenges faced by public clean water utilities in today's competitive environment" (27). The EPA has run the Clean Water Act Awards program from 1985 to 2009, when it suspended the awards for a year to consider a significant redesign in order to "align the program more closely with its Sustainable Infrastructure goals and to the water industry through broader applicability' (28). Integrating objectives regarding water reuse and control of CECs with operational performance measures in awards would align new monitoring and policy directions with the desire of plant managers to improve their facility and to win recognition for doing so.

The awards reviewed appear to involve stringent criteria, and engage wastewater treatment plants in reporting extensive information about their operations. Since plant participation in awards is widespread, it may be useful to model changes to the official reporting systems on entry formats used for the awards, which could in turn assist in improving records and the tracking of operational and compliance performance. Alternatively, it may also prove effective and time saving to offer more recognition based on mandatory State and regional reporting rather than requiring separate and formal entry into a competition. This would offer opportunities and incentives as well as potentially improved reporting and related systems.

3) Assessment of NPDES permit fees based on actual effluent instead of design capacity
The SWRCB assesses permit fees based on the 'Permitted Flow' or 'Designed Flow' specified in each waste discharge permit" (29). In this case, two facilities, each rated at a capacity of 10 MGD for ocean discharge, will be charged the same fee. This occurs even if the community that owns one of them also builds a companion water reclamation facility to process water for beneficial use. In addition, the regional board also levies a second permit fee on the recycled water facility. In this way, the community taking effective action to conserve water and decrease pollution pays more in permit fees than the facility that simply discharges all of its wastewater to the ocean. As suggested by plant operators, a sliding scale based instead on millions of gallons actually discharged would provide an incentive to improve efficiency and increase the amount of water reclaimed by plants.

Suggestions for Improving Treatment Plant Reporting Protocol

Assessment of wastewater treatment plants in California would improve with full implementation of a standardized system of reporting. Improvements in reporting should shed clearer light on the treatment plant operations behind the reports and where changes could be made. To make the work of wastewater plants easier to comprehend, compare, and research, such a reporting system needs to include basic information related to plant technology, performance, and monitoring. Suggested improvements in reporting to increase the ease and value of evaluation are as follows:

- *Improved categorization of the size of treament plants:*
  This could be accomplished by using several more degrees of variation than the EPA classification of a plant as "major" or "minor," which is based on the number of gallons treated per day–over or under one million gallons respectively.

  The amount of treated wastewater discharged into the ocean by an individual sewage plant ranges from 0.01 million gallons daily (MGD) (Ragged Point Inn and Anchor Bay, Mendocino County) to 332.25

MGD (Hyperion). Out of a total of 43 wastewater facilities,[14] in 2005, 10 discharged under one; 18 facilities discharged between one and ten MGD; 11 discharged between 10 and 100 MDG; four plants discharged over 100 MGD (see Table 3.1). Basic information about a wastewater treatment plant needs to include: 1) its relative size based on how much it discharges; 2) its relative size also in terms of intake volume; and what proportion of influent wastewater ends up discharged. These figures would make it easier to compare treatment plant size, efficiency, and potential to reclaim water.

- *Characterization of community served:*
  A summary of community demographics and description of customer service classes would allow identification of source reduction opportunities and potential for water reuse.

- *Categorization by influent quantity and type, and by treatment processes used:*
  This would help to provide a quick reference for strategic assessment, for example, for the siting of pilot pre-treatment projects.

- *Standardization of monthly and annual reporting formats:*
  While the CIWQS remains under revision, an opportunity exists for improvements to reporting formats in order to bring greater consistency and provide more information about treatment plant operation and performance.

- *Standardized inclusion of performance goal reporting:*
  Besides plant regulatory standards, NPDES permits can also contain official performance goals that recognize the constraints on a particular plant in achieving certain water quality objectives. The 2008 NPDES permit for the new tertiary plant at Marine Corps Base Camp Pendleton provides an example and shows that individual plant reporting can provide more general information about effluent quality:

  The [reasonable potential analysis (RPA) procedure] results for [the Southern Region Tertiary Treatment Plant] discharge indicated that the effluent only has reasonable potential to cause exceedances of water quality objectives for chronic toxicity, copper, and total chlorine residual; therefore, water quality-based effluent limitations are included in the tentative order for these parameters. Performance goals, rather than effluent limitations, are included in the tentative order for all other toxic pollutant parameters of Table B of the Ocean Plan. Performance goals are not enforceable effluent discharge specifications or standards for the regulation of the discharge; however, inclusion of performance goals supports State and federal antidegradation policies and provides all interested parties with information regarding the expected levels of pollutants in the discharge that should not be exceeded to maintain the water quality objectives established in the Ocean Plan (30).

  Performance goals of this kind show the extent to which the official system of assessment can be tailored and how it can be extended without entailing enforcement per se. Creation of a standard method to report on performance goals would simplify the gathering of related information from different treatment plants. Pilot projects designed to test methods of monitoring prioritized CECs could include performance goals in WDRs as a formal measure that encompasses, ensures, and tests reporting before the monitoring of CECs becomes mandatory.

- *Differentiation in regulatory reporting and recording between one incident or several as the cause of recurring ACLs:*
  This would avoid the mistake of over-counting violations.

- *Clearer distinction between violations linked to discharges vs. those related to sanitary sewer overflows (SSOs):*
  Treatment plant water quality violations are recorded as NPDES permit violations. These are separate from SSOs, which occur before wastewater reaches the treatment plant. However, a review of the record of these incidents requires knowledge of the specific terms and an understanding of the difference between the direct implications for water quality of NPDES violations and the typically indirect consequences for water quality of SSOs. The use of simple categories for different types of violations would make assessment of water quality violations easier.

- *Clear distinction between administrative/technical violations and violations affecting water quality:*
  Assessment of regulatory compliance affecting water quality could occur more easily if the water quality violations were listed separately from violations of a technical or administrative nature.

- *Clear and consistent identification and pairing of ACL complaints and orders:*

14 Individual facility figures include those collected for 1) the Aliso Creek Outfall as the permitted facility discharging treated effluent from SOCWA Regional, SOCWA Coastal, Los Alisos, and El Toro wastewater treatment plants; and 2) the San Juan Creek Outfall as the permitted facility for the JB Latham, 3A, Chiquita, and San Clemente wastewater treatment plants.

In some regions, the ACL order and complaint are assigned the same identification number. However, other regions use different numbers, and reference the complaint number deep in the body of the text of the order rather than in the heading. Consistent use of the same number for both a complaint and its related order, and inclusion of the number at the head of both documents would make it easier to research and evaluate compliance.

PART TWO

Reclaimed water is water that, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. In this way, reclaimed water (also referred to as recycled water) is considered a valuable resource. "The degree of treatment provided for recycled water depends on the quality of water needed for the specific beneficial use and for public health protection." Such water may include effluent from primary, secondary, or tertiary wastewater treatment, or "advanced treatment" (1, p.F-8).

In 2003, when the Department of Water Resources (DWR) published Water Recycling 2030: Recommendations of California's Recycled Water Task Force, (WR 2030), the DWR task force estimated that by year 2030, "California has the potential to recycle up to 1.5 million acre feet (AF) [~1.3 billion gallons[15]] per year. This could free up freshwater supplies to meet approximately 30% of the household water needs associated with projected population growth" (1, p. xi). These figures may be modest given that California's ocean discharging plants alone release about 1.35 billion gallons daily. California's DWR task force calculated that $11 billion would be needed to build the infrastructure for the production and delivery of recycled water. This extrapolates to a unit cost of about $600 per AF (325,851 gallons) (1, p.48).

According to the *WR 2030* report, many of the recommendations made by the task force can be, "... implemented by State or local agencies without further legislative authorization or mandate and provide advice that can be used as a toolbox for communities to improve their planning for recycled water projects" (1, Letter of Transmittal).

In California, the State Water Code, together with the Health and Safety Code (in particular Title 22 on facilities and hazardous waste management), are the current statutes governing water reuse (2). The State Department of Public Health website summarizes these regulations and provides draft groundwater recharge reuse regulations, other related regulations, guidance documents and other reports.

The *WR 2030* report points out that, "...in terms of making the greatest impact on augmenting the State's water supply, emphasis should be placed on reusing recycled water that has no opportunity to be reused downstream" (1, p.10), and gives ocean discharges as an example of water that should be captured and recycled. In other words, ocean discharging wastewater treatment plants should be given priority over inland plants for water recycling.

Benefits of Reclaimed Water

In Florida, Seminole County has instituted advanced wastewater operations and has published a list of six advantages of reclaiming wastewater (3). As modified below, these advantages can provide the State of California with a cogent framework for a public education program as more reclaimed water projects are considered statewide.

1) **Environmental benefits**
   Environmental incentives are a strong motivation for recycling wastewater and should be a major basis for policy. In addition to avoiding the problems of salinity caused by over-pumping of groundwater, the diversion of wastewater discharges away from the ocean or freshwater bodies inhibits pollution by contaminants in effluent.

   Reclaimed water can also help to maintain the balance of natural water flows (the water budget) in a watershed, for example, by reducing the need to divert water for human use from trout streams. Many stream flows are now reliant on wastewater flow to maintain their function as habitat, and care is needed to avoid depleting such flows by ending the discharge of wastewater into them. Good examples of habitat protection by reclaimed water augmentation include saltwater marsh preservation around San Francisco Bay and around the South Bay close to the U.S./Mexico border (4).

2) **Financial advantages**
   As an August 2009 *Newsweek* online article states, "Climate models by the U.S. Global Change

15 1 million gallons per day = 1,120 acre feet per year. (Irvine Ranch Water District website: Water Equivalents http://www.irwd.com/MediaInfo/water_equivalents.php accessed October 2009.)

Research Program, the [California] state's water resources agency, and researchers at the University of California, Davis, all point to the same trend: the Sierra snowcaps that supply the state's water are disappearing" (5). If this forecast is accurate, the cost to import water from this source will increase and the available supply may not be capable of meeting established uses. The need to augment, or in some cases replace, this source (and others) may make reclaimed water a more attractive option.

3) **High-quality water**
Reclaimed water quality may be better for irrigation uses when the water contains nutrients such as nitrogen and phosphorus, as these elements are beneficial for agriculture, gardening, etc. As examples from Northern Virginia, Belgium, and the U.K. show, advanced secondary treatment alone can yield reclaimed water of a higher quality than that of standard water supplies (6). Tertiary treatment using reverse osmosis, as in Singapore, can produce very high quality water suitable even for specialized high-technology industrial processes (6, p.3). In California, the Orange County Groundwater Replenishment System was built on the premise that it would "produce water that is very similar to or better than bottled water quality" (6, p.3).

4) **Water conservation**
Conservation of potable water for human consumption occurs automatically when reclaimed water is used instead of potable water for irrigation and landscape watering, cooling or sanitary purposes (toilet flushing).

5) **Increased availability**
In times of drought, reclaimed water supplies will be steadier and more reliable than potable water and may be subject to fewer restrictions. This makes it possible for uses, particularly irrigation, to continue longer than when only potable supplies are available. Usage extended in this way forms the premise of the California Recycled Water Task Force's expectation that by 2030 recycled water could meet about 30% of the State's household water needs associated with projected population growth (7, p. xi). However, regional projections vary. The City of San Diego Water Department, which imports nearly 90% of its water from northern California and the Colorado River, concludes that, "...even the most optimistic projections" are that reclaimed water can meet only 20 to 25 percent of total demand (8).[16]

6) **Security of supply**
In September, 2008, this benefit of reclaimed water was summed up by David Nahai, CEO and General Manager of the Los Angeles Department of Water and Power, when he stated, "Moving forward with groundwater replenishment just makes sense. It provides a locally controlled source of water that is not at the mercy of drought, or court decisions, or politics" (9).

Two Key Water Reclamation Issues: Salinity and CECs

The degree to which reclaimed wastewater can be reused depends on a number of factors, including market demand, public acceptance, funding, local regulation, delivery and storage capacity, existing plant infrastructure, site size and location, background levels of pollutants, and the quality of the reclaimed water. But two key water quality issues, salinity and contaminants of emerging concern (CECs), must be addressed in any proposal to produce reclaimed water.

Before a wastewater treatment plant can begin to reclaim water, it has to ensure the final product will meet health criteria and not be so saline that it rules out many agricultural applications and/or causes salt stress in landscape plants or on golf courses and sports fields. The U.S. Environmental Protection Agency's (EPA) 2004 *Guidelines for Water Reuse* examine opportunities for, "substituting reclaimed water for potable water supplies where potable water quality is not required." Even this limited expectation for water reuse as a mechanism to conserve potable water supplies may need an improvement in reclaimed water quality. Water for indirect potable reuse in particular must meet health standards that increasingly need to take into account CECs. According to the *WR 2030* report, "...groundwater aquifers have been recharged with recycled water in California since the 1960s." For this long record to continue safely, the issues of salinity and CECs must be subject to careful scrutiny. Future regulation of CECs and the need to reduce salinity could require significant treatment improvements in order that recycled water will meet local beneficial use needs.

Water Reclamation Issue One: Salinity

Measured as total dissolved solids (TDS), salinity is the concentration of dissolved mineral salts in water. Typical salts include calcium, magnesium, sodium, sulfate and chloride (10).

16 North City Plant treatment capacity: 30 million gallons per day; South Bay Plant: 15 million gallons a day. San Diego's 2010 objectives include: a. Groundwater treatment program 10,000 acre-feet per year; b. Recycled water program 15,000 acre-feet per year; c. Groundwater storage program 20,000 acre-feet per year. d. Conservation program 32,000 acre-feet per year; e. Water transfer program 5,000 acre-feet per year. Also, by 2012: Develop and implement a desalination program (brackish groundwater and/or ocean water) (Source: City of San Diego Water Department web pages http://www.sandiego.gov/water/pdf/stratplan.pdf accessed December 2009).

The Southern California Salinity Coalition (SCSC), a ten-member coalition of water and wastewater agencies, lists the following consequences of excessive salinity:

- Detrimental effects on plant growth and crop yield
- Damage to wastewater and conveyance infrastructure
- Reduction of water quality
- Sedimentation problems
- Soil erosion

As pointed out on the City of Paso Robles website, "Water with salinity levels above 1,000 mg/l is of questionable use for irrigation and industrial customers" (11). Irrigation or watering with reclaimed water that is too saline can cause leaf burn, leaf drop, and plant death, which limits or rules out the use of such water for landscaping, agricultural, and sports field applications. Salt build-up negatively affects pipes and other infrastructure, thus limiting municipal, domestic, and industrial reuse. Without sufficient salt removal, reclaimed water used to recharge groundwater basins can cause a build-up of salt in the basins (12). The long list of negative effects of salt as a contaminant has led to the inclusion of TDS limits in wastewater.

Southwest Hydrology, a journal for consultants, regulators, researchers, water managers, lawyers, and policymakers working with water issues in semi-arid regions, has investigated the serious difficulties for wastewater treatment plants caused by brine discharges from industry and desalination plants in addition to the normal residential load. A March/April 2008 report in this journal states that, along with the loss of reclaimed water, other impacts of the combined saline influent "...can be significant, and include loss of hydraulic capacity of sewerage systems, infrastructure degradation of WWTPs from corrosion... lowering of the value of and ability to reuse biosolids, and mineral salt pollutants that adversely affect downstream reuse of the watershed supplies." The report quotes Walt Pettit, former executive director of the State Water Resources Control Board (SWRCB): "Salinity in Southern California is probably the biggest water problem that isn't being adequately addressed" (13).

Highly saline influent causes a serious obstacle to wastewater recycling because standard treatment processes remove very little salt. At present, reclaimed water is primarily used for irrigation, for example, spraying or drip feeding freeway plantings, parks, flower nurseries, agricultural fields, cemeteries, and golf courses. Reuse of this kind is highly desirable because irrigation and agriculture are the leading uses of water. Using recycled water for these purposes significantly reduces the demand for potable water and conserves its use for drinking. In some locations, however, reclaimed water must be mixed with equal volumes of potable water to reduce salinity to non-harmful levels.[17] Removing TDS from reclaimed water could greatly increase the amount of potable water available for drinking.

The financial cost of wastewater desalination is high. Nevertheless, a recent evaluation by the Rancho California Water District, in conjunction with Eastern and Western Municipal Water Districts of Riverside County, proposes that "...partially desalinated wastewater would be a cost-effective means to replace potable water currently used for irrigation" (14).

Salinity in wastewater has several causes: natural minerals dissolved in water flows; natural salt spring or seawater infiltration into freshwater flows; fertilizer runoff; byproducts of wastewater treatment chemicals such as chlorine, foods, and cleaning chemicals (15). A large influx of salt to the wastewater plant also comes from home water softeners.

Salt-based water softeners[18]

Water softeners offer real benefits to consumers. Hard water is abrasive to clothes, towels, etc., and can shorten the life of appliances such as washing machines and dishwashers. Hard water can also lead to mineral buildup and blockage in plumbing. The amount of energy needed to operate a water heater using hard water can increase by up to 30 percent (16). Where water softeners can be justified, the use of less salt is advised if an alternative is unavailable. The choice of alternatives to sodium salts is limited, however, particularly because the use of potassium chloride leads to the expensive problem of chloride removal (11).

Cutting the amount of salt entering the waste stream keeps salt removal costs down. In California, water softeners have come to be addressed as a major source of salinity in wastewater. In the Santa Clarita Valley Sanitation District, for example, water softeners are reported to be responsible for 20 per cent of chloride (17). Such sizeable contributions to the salinity problem have led local governments and water districts, such as Paso Robles, to emphasize the problems posed by water softeners in their public education programs.

In July 2008, California Governor Arnold Schwarzenegger vetoed AB 2270, a bill that would have made it easier for water districts to impose water softener bans.
The Governor's veto was predictably praised by the $500-million a year softener industry (18). But in October 2009, AB 1366 was signed into law, allowing the regional

17 Communication with plant operators revealed, however, that fifty-fifty mixing of overly saline water with potable water can be avoided by flushing fields that receive overly saline water at intervals typically of one month.

18 See basic description of water softener process: Wight, Chuck, How do water softeners work? Scientific American (2001) online, September 24, http://www.scientificamerican.com/article.cfm?id=how-do-water-softeners-wo.

water boards in certain hydrologic regions[19] to pass ordinances that would result in a reduction of the amount of sodium chloride released by water softeners, but only if those regional boards can prove such actions will "contribute to the achievement of water quality objectives" (17). According to the LA Times, the AB 1366 regulations allow the substitution of potassium chloride for sodium chloride (17), which proves just as problematic for water treatment plants because potassium chloride adds to the TDS load for chloride (11). The environmental problems associated with chloride are outlined on the website of the Madison (Wisconsin) Metropolitan Sewerage District, which states, "...high concentrations of chloride are harmful to aquatic plants and animals...Although it consists of potassium instead of sodium, [potassium chloride] still contains chloride...The technology to remove chloride is available, but it is very costly. It would involve microfiltration and reverse osmosis...One community determined that it would cost about twenty cents to add a pound of chloride at the water softener, and $5.00 to remove it at the treatment plant. Households can use up to 100 lbs of salt a month in their water softeners."

As residents face increased water rates to pay for augmented treatment to remove salt from wastewater, more bans on salt-based water softeners may succeed. Residents of the Santa Clarita Valley Sanitation District made their choice clear when they voted in 2008 to outlaw salt-discharging water softeners by 2009, with a six-month grace period (18). A comprehensive approach to reduce salinity by incorporating source control and treatment can be found in the 2004 recommendations of a Western Australia treatment plant. Recognizing a level of approximately 550 mg/l TDS as appropriate for sustainable use (with higher levels possibly acceptable for some uses), Melbourne Water and City West Water investigated the feasibility of: a) a reduction at source of influent salt loading by industry through cleaner practices; b) an education program with consumers and manufacturers to encourage a change to lower salinity domestic laundry detergents; and c) introduction of a desalination process to make up the shortfall in achieving the targeted salinity level (19). A similar set of measures could be effective for ocean discharging wastewater treatment plants in California.

Alternative water-softening devices are marketed, including some that use magnetic and electromagnetic softening methods, which reportedly alter the electrostatic properties of the ions instead of removing them from pipes and incoming water. But the effectiveness of these devices, especially on a small scale, is subject to debate (20). Other advertised softeners claim to use a "non-sacrificial catalytic alloy," but the process appears to be chemically impossible and one to be avoided. Some domestic systems based on reverse osmosis are available, but at a high price. In addition, energy use with reverse osmosis is high, and the process itself wastes water. A small Arizona community, the White Cliffs Mutual Domestic Water Users Association, decided the advantages of reverse osmosis outweigh its disadvantages and moved ahead with the installation of a reverse osmosis desalination system. Their action may serve as an example of a shared cost solution, which can be initiated inappropriate sites to achieve both source control and softened water, and to lessen the amount of salt reaching the wastewater treatment plant (21).

Brine Waste

Brine waste, which is wastewater high in salts, from industrial and wastewater treatment can contain a concentrated residual of CECs and poses a serious disposal problem. In the absence of CEC regulation, brine waste discharge to the ocean is included in long-term salinity management proposals. Water recycling that mixes brine waste in effluent possibly increases ocean pollution and cannot be considered a sensible solution, especially since future, revised standards could rule out ocean discharges of brine waste altogether.

The Water and Wastewater Salinity Management Project of the Eastern Municipal Water District of San Diego County is an example of salinity management that ultimately results in ocean discharge. The district serves an inland area and proposes to build as many as four brine-disposal pipelines to transfer non-recyclable brine waste from industry and the District's desalination program to existing brine management facilities. Waste from the Eastern Municipal Water District's brine management facilities is carried by the Santa Ana Regional Interceptor (SARI), to specially-equipped treatment plants operated by the Orange County Sanitation District (23), and from there to the Pacific Ocean (24). The stated aim of the project is to "...help protect existing groundwater supplies...and reduce the salinity of recycled water, both of which will reduce the need for additional imported water into Southern California" (22). Such discharge may meet current water quality standards, but the wastewater discharged to the ocean from the Salinity Management Pipeline (SMP) and San Diego County's SARI is highly treated and likely to contain CECs. The project fact sheets lists as a benefit that the SMP, "safely removes salts to the ocean where they cause no harm," but the issues surrounding CECs throw real doubt on this claim.

In Ventura County, the Calleguas Municipal Water District (CMWD) is bringing online a new Hueneme outfall and also an SMP (25). Like the Eastern Municipal District project in San Diego, Calleguas has a dual focus on

19 The regions stipulated in Assembly Bill 1366 are: South Coast, Central Coast, San Joaquin Valley, Tulare Lake and the lower half of the Sacramento Valley.

wastewater desalination and recycling, and any ultimate discharge of unused treated wastewater to the ocean must also contain the chemical residue of desalination. The CMWD project fact sheet states that, "By providing a discharge mechanism, the SMP will enable local brackish groundwater resources to be demineralized and utilized for potable purposes, reducing dependence on imported water and improving local water supply reliability. The SMP will also deliver recycled water to areas where it can be used and export salts out of the watershed to help achieve compliance with total maximum daily loads (TMDLs) for salts." The questions around CECs, however, could bring the stated benefits only at the cost of environmental pollution caused by the ocean discharge of brine wastes.

On another front, the Calleguas project illustrates the need for storage infrastructure to ensure capacity and delivery to as many users as feasible, along with reuse regulations that can make way for dual plumbing–the installation of secondary piping to convey reclaimed water. These measures would have the potential to increase demand. Without the right balance of such measures in place, districts like the CMWD will continue to discharge usable reclaimed water to the ocean when demand is low. Increases in water reclamation need to be accompanied by expansion of markets and usages to ensure full reuse and prevention of the waste of recyclable water.

Wastewater Treatment Plant Desalination Processes

In areas around the world where fresh water is scarce, desalination of ocean water is increasing despite its expense. The market analyst company BCC Research issued an industry report in 2008 on the membrane and separation technology used in desalination processes. The company predicted an annual global growth rate for desalination plants of 13.7% by 2012. The technology used in desalination plants is also employed by wastewater treatment plants to remove salts for the production of high quality reclaimed water, maximizing its potential for reuse. Using 2005 data gathered from the largest water reusers in Florida, California, Texas, and Arizona, the BCC Research report includes a survey showing the 13 most prevalent water recycling and reuse technologies in the U.S. (26). For those treatment plants using demineralization technologies, approximately 82.4% used ion exchange, approximately 11.8% used electrodialysis reversal (EDR),[20] and approximately 5.9% used deionization. No plants surveyed used electrodialysis or electrodeionization. For treatment plants using membrane-based filtration technologies, 22.4% used microfiltration, 32.7% used ultrafiltration, 4.1% used nanofiltration, and 40.8% used reverse osmosis.

Membrane Separation of Salts

The following methods that use membranes of different types and in different ways are currently employed to remove salinity from wastewater:

Reverse Osmosis (RO)

This is a process by which a solvent such as water is purified of solutes by being forced through a semi-permeable membrane through which the solvent, but not the solutes, may pass (27). (See also Nanofiltration.) Reverse osmosis uses a membrane to separate water from dissolved salts. No heating is required, but energy is needed to power a pump that pressurizes the seawater fed into the treatment plant. As the salt water squeezes against the membrane, some water molecules are pushed through minute pores, with a diameter roughly 100,000 times smaller than a human hair. This creates a stream of fresh water on the opposite side of the membrane (28).
If enough pressure is applied to the solution with the higher concentration of dissolved solids (such as saline water), the natural osmotic pressure can be overcome (reversed), forcing the solution through the membrane towards the solution with less dissolved solids and removing the dissolved solids in the solution of higher concentration (29).

Microfiltration (MF)

Microfiltration is the physical retention of particles behind a filter medium while the liquid in which they were suspended passes through the filter. Particles are retained because they are larger than the pores in the filter. Other factors affecting retention are fluid viscosity and chemical interactions between the membrane and the particles in the solution. Microfiltration removes particles with a pore size of .05 and 5.0 μm, including bacteria and some viruses (13).

Ultrafiltration (UF)

Processes using ultrafiltration work in basically the same way as microfiltration, except that the pore sizes are considerably smaller. Solutes are retained behind the filter on the basis of molecular size while the bulk of the liquid and dissolved salts pass through. A pressure gradient across the membrane, known as transmembrane pressure, drives the filtration process. Ultrafiltration membranes are designed for the concentration and separation of complex protein mixtures (13).

Ion Exchange

Ion exchange is a reversible interchange of one kind of ion present in an insoluble solid with another of like charge present in a solution surrounding the solid with the reaction being used especially for softening or demineralizing water,

20 Electrodialysis reversal was investigated by the authors of a report to the Food & Agriculture Organization (FAO) of the UN that includes an overview of plants in southeast mainland Spain and the Canary Islands and Balearic Islands, including some using desalination processes in wastewater treatment and providing water for irrigation. The authors found that "the process is particularly suitable for brackish water with total dissolved solids (TDS) up to 3,000 mg/litre because the amount of energy required is directly proportional to the amount of salts to be removed" (ftp://ftp.fao.org/agl/aglw/docs/lwdp5_e.pdf).

or for purifying chemicals, or separating substances.[21] The process relies on "the selective permeability of ionized inorganic and ionized organic exchange membranes" (26). During ion exchange, the scale-forming ions of calcium and magnesium are replaced with an equivalent amount of sodium ions from a synthetic resin or a naturally occurring resin, typically from zeolite clays. This method is effective with only moderate levels of hardness because the exchange capacity of the resin is limited.

Water Reclamation Issue Two: Contaminants of Emerging Concern

Several variations of description and definition relate to the concept of CECs. The European Commission Network of Reference Laboratories for Monitoring of Emerging Pollutants (NORMAN), established in 2005, distinguishes between "emerging substances" versus "emerging pollutants" and does not appear to use the term CEC (1). While the topics under study through NORMAN are being reviewed by the U.S. EPA, the EPA's official definition of CEC has still to be finalized and different definitions are used by the U.S. Geological Survey, the California Department of Toxicology, and the EPA Office of Water (2).[22] The U.S. EPA's official definition of CEC has still to be finalized, but the following is under official consideration by the EPA Office of Water: "The term 'contaminant of emerging concern' is being used within the Office of Water to replace 'emerging contaminant,' a term that has been used loosely since the mid-1990s by EPA and others to identify chemicals and other substances that have no regulatory standard, have been recently 'discovered' in natural streams...and potentially cause deleterious effects in aquatic life at environmentally relevant concentrations" (3). While the EPA has not made its official designation, the term "CEC" appears to have become increasingly used in related literature.

CECs can be summarized as chemicals whose behavior, fate, and effects are uncertain but thought possibly to be harmful in the following ways: 1) they are toxic to aquatic life, persist in the environment, and accumulate in tissues (including human tissues); and/or 2) they interfere with hormone systems governing reproduction and growth. As chemicals become suspected of causing these kinds of harm, they raise concern about their possible impacts in the coastal and marine environment. Wastewater monitoring programs focus only on a small list of priority contaminants that were identified decades ago. Production of new contaminants and contaminants of emerging concern, however, is continuing and could increase in the future, making the update of monitoring programs a matter of urgency.[23]

Treatment plants began to battle significantly with CECs following the discovery in 1974 of trihalomethanes as a byproduct of chlorine disinfection (4), particularly when used to treat influent containing high levels of organic matter (5). The potential threat of these compounds to human health led to regular monitoring of their concentration in municipal water and treatment systems (6). Over three decades later, N-Nitrosodimethylamine (NDMA), also a chlorine disinfection byproduct, remains a subject of concern, and is a current example of a CEC that needs tertiary treatment for removal, adding to the costs of reclaiming water for potable use and of avoiding unintentional NDMA contamination through indirect potable reuse (7). NDMA is a "classic" CEC, like perchlorate, 1, 4-Dioxane (a manufacturing solvent), MTBE (methyl tertiary-butyl ether; a solvent and gasoline additive),[24] and TBA (tertiary-butyl alcohol; a paint remover ingredient and gasoline additive), and has long been considered a risk to environmental and human health. NMDA is in fact an example of a CEC under local discharge regulation (under public health legislation), where its removal is required for direct aquifer injection (subsurface application) under several water recycling permits issued to reclamation plants by the Los Angeles Regional Water Quality Control Board RWQCB.

Work is underway at national and state levels to ensure that guidelines and legislation address CECs. Meanwhile, wastewater contains increasing amounts of these substances, and not enough is known about their individual and combined fate. Wastewater engineers are finding that they have to tackle both the greater quantity and the increased complexity of CECs and their interaction. In 1998, a U.S. EPA study of chemical hazard data revealed the scale of the problem in its finding that of the 3,000 chemicals imported or produced by the U.S. at the rate of more than one million pounds per year, "...43% of these high production volume chemicals [had] no testing data on basic toxicity and only seven percent [had] a full set of basic test data" (8). In the years since this chemical hazard study, research has increased and policy has begun to shift. However, the *WR 2030* report states that lack of funding for research on CECs is a critical issue, as is the lack of funding for infrastructure and public health concerns. The U.S. EPA Office of Water guidelines for deriving ambient water quality criteria (AWQC) (established in 1985 pursuant to the Clean Water Act (CWA)) are now being revised to take account of the need "to help assess and manage the potential risk of some CECs in the aquatic environment" (3).

In the meantime, the 2008 report on "Green Chemistry" by the University of California's Centers for Occupational and

21 Source: Merriam-Webster.com
22 The U.S. Geological Survey and the California Department of Toxicology refer to "emerging contaminants" and "emerging chemicals of concern" ("ECC") respectively (2).
23 Adapted from Southern California Coastal Waters Research Project: http://www.sccwrp.org/view.php?id=53 (accessed January 2010).
24 MTBE is monitored by Point Loma WTP.

Environmental Health (CCOEH) finds that the amount of chemicals produced or imported in the U.S. has increased since the 1998 EPA tally of one million pounds per year.

The quantity has increased to, "42 billion pounds of chemical substances ... produced or imported in the U.S. for commercial and industrial uses." The CCOEH report also points out that, "An additional 1,000 new chemicals are introduced into commerce each year" (9). EPA's recently appointed Administrator Lisa Jackson stated in September 2009 that, "Over the years, not only has [the Toxic Substances Control Act (TSCA) of 1976] fallen behind the industry it's supposed to regulate, it's been proven an inadequate tool for providing the protection against chemical risks that the public rightfully expects" (10). The EPA anticipates new legislation to strengthen TSCA and proposes six "Essential Principles for Reform of Chemicals Management Legislation" (11). These include a call for manufacturers and the EPA "to assess and act on priority chemicals, both existing and new, in a timely manner," for "green chemistry" to be encouraged, and for strengthened provisions assuring transparency and public access to information. Wastewater treatment is certain to be affected by new legislation and regulations that address CECs.

CEC Categories and Definitions

Several CECs are included in the EPA's 2009 Contaminant Candidate List 3 (CCL3),[25] which consists of 104 chemicals designated as "contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations that are known or anticipated to occur in public water systems." The list also includes 12 microbial contaminants, four of which cause mild gastrointestinal illness and two of which cause respiratory illness, as well as *Helicobacter pylori* (an uncommon bacterium that can colonize the human intestine and cause ulcers and cancer), hepatitis A (causing liver disease), *Escherichia coli* (a bacterium that can cause gastrointestinal illness and kidney failure), *Legionella pneumophila* (causing lung disease), *Mycobacterium avium* (causing lung disease in the severely immuno-compromised) and a parasite that can cause primary amoebic meningoencephalitis. The CCL3- listed microbes may become subject to regulation.

The field of CECs is becoming better defined due to research such as that of the U.S. EPA's 2005-2008 *Nine Publicly Owned Treatment Works* study, which investigated, "...the occurrence of Contaminants of Emerging Concern (CECs) in untreated and fully treated wastewater at POTWs [publicly owned treatment works]." The study lists five categories of CECs, with definitions, descriptions, and short summaries relating to each category (12). These categories are used below with some adapted and mainly additional content. The class of perfluorinated compounds (PFCs) is also summarized below, since the two CCL3-listed compounds perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) have recently received international attention and are being researched in relation to wastewater treatment (13). Additional chemicals being studied in relation to wastewater treatment include: the chlorinated organic compounds Dioxane (a manufacturing solvent) and the herbicides Acetochlor and diuron; and benzenes such as Dinitrobenzene and n-Propylbenzene (e.g., (14) (15)).

Pesticides

These are chemicals used to inhibit, repel, or kill pests that include compositions ranging from insecticidal soaps to formulations such as alachlor, malathion, carbaryl, and chlorhexidine. Many pesticides are persistent organic pollutants (POPs) and as such are "characterized by their long lifetime in the environment (persistence), their potential for long range transport and their capacity to build up to dangerous levels in predatory species"(16). Atrazine, DDT, lindane, and Carbofuran are among the most common pesticides found in water (17).

Between 1992 and 2001, an average of almost one billion pounds of conventional pesticides was used each year in the United States (18). Limits are already in place for many pesticide compounds, including organo-halides, but research continues into their individual, variant, and combined effects and their treatment in the wastewater process.

The U.S. EPA CCL3 list includes several pesticides such as Acrolein and Ethoprop. The older and well-known pesticide DDT presents a case of once-emerging and now ongoing concern at some ocean sites off California. Research on CECs should help to prevent a reoccurrence of the DDT story–an unsuspected, widely-used chemical that becomes a banned substance, but which continues to pollute.[26] DDT was banned in 1972 for most uses (19), but still contaminates the coastal waters of the Southern California Bight. Several harbor locations, including the Long Beach Outer Harbor, are listed as impaired due to contamination by DDT among other toxic chemicals (20). The Los Angeles RWQCB describes how, "The highest concentrations of DDT and PCB are in a layer of low density sewage-derived sediments around the main sewer outfalls at Whites Point on the Palos Verdes Shelf" (21). The DDT/PCB-contaminated area has been declared a

25 The US EPA's Contaminant Candidate List 3 is published every five years. The list is published on the U.S. EPA: website: http://www.epa.gov/ogwdw/ccl/ccl3.html

26 Chemicals that continue to pollute following an end to their use are known as "legacy" contaminants. Other CECs of this nature include the organochlorine (OCL) compounds dieldrin, chlordane, toxaphene, PCBs and dioxins (http://www.axysanalytical.com/services/organochlorine_legacy_compounds/)

Superfund Site by the U.S. EPA, which is investigating capping and other methods to remediate the sediments. The WDRs of most of the ocean-discharging wastewater treatment plants in the Southern California Bight (most of which provide secondary treatment) include monitoring for DDT. Methods including membrane filtration, solvent sublation, and activated carbon absorption remove DDT from wastewater by changing its chemical composition (18). To destroy DDT, a method known as the "Fenton Process" is used, but does not yield potable water. Research is ongoing into methods to improve the photodegradation of DDT (22).

Alkylphenols and Alkylphenol Ethoxylates (APEs)
These synthetic surfactants are used in some detergents, cleaning products, and paper. APEs can affect the reproductive systems of aquatic organisms. Nonylphenol ethoxylates (NPEs) are the most common form and are said to be removed at rates of 92% to 99% by wastewater treatment methods (23). However, new research presented at a SCCWRP/SWRCB 2010 meeting[27] suggests detrimental effects of nonylphenol buildup in marine life, with a wide range of sea animals exhibiting cancerous symptoms (tumors) over a wide area associated with septic system and wastewater discharge. As is the case with steroids, hormones and polybrominated diphenyl ethers (PBDEs)–which include flame retardants and plastics–APEs are hydrophobic, facilitating their removal through secondary treatment, but there is concern about the possibility of their buildup in the biosolids that are a byproduct of wastewater treatment (24).

Bisphenol A (BPA)
This is an organic, estrogenic compound used in the manufacture of polycarbonate plastic items such as eyeglass lenses, medical equipment, water bottles, CDs, DVDs, and many other consumer products, including paper. At least one study has shown that toilet paper is contaminated with BPA (and APEs) and is a source of this compound in wastewater (25).

The treatment of BPAs is the same as for APEs and PBDEs where the use of certain types of bacteria in secondary treatment has been found to biodegrade and remove BPA from wastewater (25).

Polybrominated Diphenyl Ethers (PBDEs)
These constituents of flame retardants are found in furniture foam, plastics for TV cabinets, consumer electronics, wire insulation, personal computers, small appliances, and clothes. PBDEs are related to PCBs and are a subcategory of brominated fire retardants (BFRs). Bromophenyl phenyl ether, manufactured as DecaPBDE, PentaPBDE, OctaPBDE, etc., is on the U.S. EPA's Priority Chemicals list (26).

The U.S. EPA's 2006 PBDE Project Plan notes that PBDEs are "...widely distributed in the environment and are present at increasing levels in people." The Project Plan also states that, "In recent years, scientists have measured PBDEs in human adipose tissues, serum and breast milk, fish, birds, marine mammals, sediments, sludge, house dust, indoor and outdoor air, and supermarket foods" and includes an account of the discovery of these compounds in San Francisco Bay area sewage effluent and sludge (27). A "Review of Available Scientific Research" by the Illinois EPA Toxicity Assessment Unit cites a study that found decaBDE "in glaucous gulls and polar bears from the Arctic" (28).[28] A 2008 study published in *Environmental Science & Technology* reports that, since the discovery of PBDEs in the environment in 1979, levels have soared, with the highest levels in the country of these chemicals now found in California residents (29) (30).

Two of the commercial forms of PBDEs, PentaBDE and OctaBDE, were withdrawn from the European market in 1998 (31). After the discovery of PBDEs in breast milk, the U.S. followed suit in 2004 (32). California became, in 2003, the first state to ban the two forms of PBDEs by 2008 (33). Production was scheduled to halt because PBDE has "...increased fortyfold in human breast milk since the 1970s" and holds the potential to contribute to low intelligence and learning disabilities (34). In 2008, the European Union restored Deca-BDE to its Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) list[29] to be phased out, although it can be used without restriction in the meantime (31) (35). California began to phase out DecaPBDE in December 2009, with the use of DecaPBDE scheduled to end by 2013. Steve Owens, an assistant administrator at the U.S. EPA said that "studies have shown that DecaBDE persists in the environment, potentially causes cancer and may impact brain function...[and that] DecaBDE also can degrade to more toxic chemicals that are frequently found in the environment and are hazardous to wildlife" (36).

Studies reviewed by the EPA Unit in Illinois show that diet is the major route for human exposure to PBDEs, although a 2004 report by the Environmental Working Group, a non-profit research organization based in Washington, D.C., calculates that dust is a more potent route for children (37). Research reviewed by the Illinois Unit also found "high concentrations of decaBDE in municipal sewage sludge and [that] workers in sludge-related activities are potentially

27 Constituents of Emerging Concern Coastal & Marine Ecosystems Science Advisory Panel Meeting, January 12, 2010, Costa Mesa, California (www.sccwrp.org/view.php?id=574).

28 The Review also notes that PBDE levels have been found to be much higher in farm-raised salmon than in wild salmon. The difference is thought to stem from the diet of farmed salmon, which consists of concentrated feed high in fish oil and fishmeal from small open-ocean fish.

29 The EU REACH list was brought into law in 2007.

exposed to very high concentrations, primarily through inhalation" (28). Research at treatment plants in Tucson, Arizona, and Palo Alto, California, for example, shows that the resistance of PBDEs to wastewater treatment can lead to their accumulation in sediments where wastewater is discharged and in soils where biosolids are added (38) (39).

Steroids and Hormones

Steroids and hormones are naturally occurring and related synthetic copies of chemicals that serve as messengers between cells. "Many of the responses to hormone signals can be described as serving to regulate metabolic activity of an organ or tissue. Hormones also control the reproductive cycle of virtually all multicellular organisms" (40). Many hormones, body constituents, and drugs are steroids. Cholesterol is an example, the word "steroid" being derived from "sterol" (41). The category of steroids and hormones is included by many sources as a subset of Pharmaceuticals and Personal Care Products (PPCPs) since some originate in pharmaceutical products. Phthalates belong to this category and are included on the EPA's list of chemicals for priority review.

Several steroids and hormones come from sources such as dairy wastewater, aquaculture, and spawning fish (42). Endocrine disrupting compounds (EDCs) are substances that interfere with the normal functions of steroids and hormones. Steroids and hormones can themselves be EDCs. Studies have found that tiny amounts of biologically active natural and synthetic steroid estrogen hormones that survive sewage treatment, including the active ingredient of the contraceptive pill and naturally occurring female hormones, can disrupt the physiology of wild fish (43). The Office of Environmental Health Hazard Assessment of the California EPA has included butyl benzyl phthalate (BBP), di-n-butyl phthalate (DBP), and di-n-hexyl phthalate (DnHP) on the Proposition 65 list of chemicals known to cause reproductive toxicity (44). This listing, in compliance with the Safe Drinking Water and Toxic Enforcement Act of 1986, shows that phthalates fall into the category of endocrine disrupting compounds.

A British 2004-2005 study shows that conventional wastewater treatment does not completely remove EDCs; as a result these compounds can seep through river sediments and from there potentially into groundwater. This finding raises concern because, as pointed out by the authors of the study, it is less likely for these compounds to be neutralized by attaching to suspended solids (45).

Scientists from SCCWRP are investigating whether wastewater effluent or natural factors are the cause of unusual hormone levels in certain species of fish off the coast of California. A 2009 *Environmental Science & Technology* article summarizes: "With very few differences between the contaminated sites and the control site, [the] widespread pattern of odd endocrine levels could mean that the contamination is much more pervasive than scientists thought, or it could mean that these hormone levels are normal" (46). While the answer to this question is being determined, it is unknown whether regulatory changes affecting water reclamation will take a precautionary approach on suspect pollutants in order to avoid potential risk.

More research from the United Kingdom reviews how advanced technologies, such as activated carbon adsorption, ozonation, advanced oxidation processes, and nanofiltration/reverse osmosis, remove potential EDCs. However, the cost of these wastewater treatment methods and the scale of infrastructure and manpower needed to operate them, have led research engineers to experiment with supported biofilms in aeration tanks, taking note of by-product and additive issues (47). This alternative technology echoes the same approach of applying extended secondary treatment (longer holding times) to PBDEs and APEs for higher levels of removal, with the same cautions relating to byproducts and contaminant buildup in biosolids.

Pharmaceuticals and Personal Care Products (PPCPs)

PPCPs are a range of prescribed and over-the counter pharmaceuticals, and personal care products used for health or cosmetic purposes. The U.S. EPA considers "any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock" to be a PPCP (48). Other examples include blood pressure, cholesterol and antidepressant medications, over-the-counter drugs, caffeine, detergents and soaps, lotions and cosmetics.

Excretion of medications from the body, the rinsing of cosmetics and soaps, and the disposal of prescription drugs through domestic plumbing are ways in which PPCPs enter sewage systems where a possibility may exist of onward transport to water bodies if they are not removed by treatment. Varying levels of PPCPs from point and non-point sources alike have been detected in measurable quantities in water bodies, both in the saline waters of oceans and the fresh waters of rivers, lakes, and groundwater aquifers (49) (50). It is unclear, though, at what levels these contaminants lead to manifested toxic events (51).

Among PPCPs, triclosan is a widely used nonprescription antibacterial/antimicrobial compound that illustrates how a single compound in the wastewater stream can have many sources. Triclosan is found in anti-gum disease toothpaste, deodorant soaps, deodorants, antiperspirants, body washes, detergents, dishwashing liquids, cosmetics, antimicrobial creams, lotions, and hand soaps, and is also used as an additive in plastics, polymers, and textiles to give these materials antibacterial properties (53). It also serves as an example of a PPCP coming under increasing scrutiny and monitoring by the EPA (54). The call in August 2009 by the Canadian Medical Association to the Canadian Government to ban all antibacterial household products (55) reflects the growing concern over the potential of such products to cause bacterial resistance.

Triclosan also serves as an example of a chemical of potential risk with many and varied fates. In 2002, a Swedish study published in *Chemosphere* found, "High levels of...Triclosan...in three out of five randomly selected human milk samples. It was also found in the bile of fish exposed to municipal wastewater and in wild living fish [exposed to] the receiving waters of the three wastewater treatment plants" (56). A 2003-2004 study for the U.S. Centers for Disease Control and Prevention detected triclosan in 74.6% of 2,517 urine samples. Exposure was thought to stem from use of consumer products that contain triclosan. The same study cites research showing that the chemical affects hormonal processes in frogs and rats but does not cause acute toxicity in humans (57). A risk assessment published in 2007 in Food and Chemical Toxicology concluded that, "... there is no evidence to indicate that the presence of a miniscule amount of triclosan in breast milk presents a risk to babies" (58). This range of findings shows the prevalence of triclosan in the environment, with known and unknown effects and risks for different species, but demonstrates the difficulty of determining if the substance should be regulated. The same problem applies to other PPCPs.

A study published in 2008 by the Washington Department of Ecology is an example of research into the fate and transport of PPCPs in relation to wastewater treatment. The researchers investigated "the potential for and status of PPCP contamination of area waters from application of tertiary treated wastewater via reuse programs and conventional land application" (50). The scientists conducted a screening analysis for 24 PPCPs in tertiary wastewater treatment plant effluents and nearby wells and creeks in the Sequim-Dungeness area of northwest Washington State. Sixteen compounds were detected in effluent: acetaminophen, caffeine, carbamazepine, cimetidine, codeine, cotinine, diltiazem, hydrocodone, ketoprofen, metformin, nicotine, paraxanthine, salbutamol, sulfamethoxazole, trimethoprim, and estrone. The study found that, "Only Caffeine, Nicotine, and the diabetes drug Metformin (tentatively identified) were consistently detected in the well and creek samples; concentrations were less than 25 ug/L."

The researchers concluded that, "These limited results give no indication that PPCPs represent a significant concern in the wells or creeks sampled." While the scientists considered additional monitoring for PPCPs to be a low priority for the two treatment plants involved, these results nevertheless show that tertiary-treated effluent can contain some PPCPs. However, the fact that most of the same PPCPs became undetectable in the downstream samples may provide evidence for the effectiveness of tertiary treatment in preventing PPCPs from reaching harmful levels in discharges.

The results of a national pilot study in the U.S. published in 2009 by the Society of Environmental Toxicology and Chemistry assessed "the accumulation of PPCPs in fish sampled from five effluent-dominated rivers that receive direct discharge from wastewater treatment facilities." The results show that better CEC-removal efficiency is achieved by advanced treatment. "Fish tissue analyses from the two sampling sites receiving more advanced treatment...showed lower overall concentrations of PPCPs, fewer compounds detected, and lower frequency of detection compared to the other three sampling sites... which employed less advanced treatment" (59). Modeling produced for the 2006 U.S. EPA's *Final Report on Occurrence and Fate in Drinking Water, Sewage Treatment Facilities, and Coastal Waters* by the National Center for Environmental Research (NCER) led to the conclusion that longer solids retention times should increase the removal of pharmaceuticals and antiseptics–a finding similar to those of studies investigating APEs as cited above (60).

The NCER findings on pharmaceuticals and antiseptics add to research that shows that removal and neutralization of PPCPs in influent is accomplished by biodegradation and biotransformation. A 2003-2004 British study of the removal specifically of triclosan by three different types of wastewater treatment works found that removal ranged from 58 to 96% using rotating biological contactors, 86 to 97% using trickling filters, and 95 to 98% through longer retention times in activated sludge (52). These results align with the U.S. EPA's review of studies of the fate and transport of triclosan, and its finding that, "the majority of published studies on the occurrence of triclosan in wastewater treatment plants, treatment plant efficiency, and open water measurements of triclosan suggest that aerobic biodegradation is one of the major and most efficient biodegradation pathways" (54). In 2009, the international journal *Environmental Pollution* published an assessment of removal efficiency indicating activated sludge with nitrogen treatment and membrane bioreactor achieves the most effective removal. Longer retention times during the activated sludge and membrane bioreactor phases of wastewater treatment allow for increased breakdown of PPCP organic compounds, resulting in large reductions in

PPCP concentrations in plant effluent (61) (62). Results of a Welsh study of the fate of PPCPs published in 2009 found that, "the [wastewater treatment plant] utilizing trickling filter beds resulted in, on average, less than 70% removal of all 55 PPCPs studied, while the WWTP utilizing activated sludge treatment gave a much higher removal efficiency of over 85%" (63).

Perfluorinated Compounds (PFCs)
A group of chemicals containing fluorine, PFCs are used to make household products and industrial materials stain resistant and non-stick. A 2009 review of PFCs by the Global Health & Safety Initiative (GH&SI), a collaboration of U.S. health care insurance providers, hospitals and non-governmental organizations, notes that PFCs are also used in food packaging, paints and lubricants. Products such as Teflon®, Stainmaster®, Scotchgard™, and NanoTex™ contain PFCs (13).

The GH&SI review summarizes how PFCs are highly persistent compounds that accumulate in the tissues of living organisms, including humans. The review found that PFC exposure is "nearly ubiquitous" and that PFCs can cross the placenta, "...directly exposing the developing fetus." According to the GH&SI, the existing data on toxicity of PFCs so far relates mainly to animal studies and tends to focus on two common PFC compounds–perfluorooctane sulfonate (PFOS), which is still used in fire-fighting foams and various surfactants because no alternatives are available, and perfluorooctanoic acid (PFOA), which is used in the manufacture of substances that provide non-stick surfaces on cookware as well as waterproof and breathable membranes for clothing. PFOS was added in May 2009 to the list of contaminants identified by the Stockholm Convention on Persistent Organic Pollutants (POPS) (16), and PFOS and PFOA are included on the U.S. EPA's CCL3 list.

A 2007 study by Stanford University researchers and the Santa Clara Valley Water District investigates perfluorochemicals in water reuse. The study focuses on PFOS and PFOA and their presence in wastewater effluent, particularly of three California treatment plants employing tertiary treatment, as well as their presence in ground and surface waters where the effluents are discharged (64). The study outlines the tertiary processes as follows: 1) dual media filtration and chlorination, followed by polymer treatment and repeated filtration for reclaimed wastewater; 2) dual media filtration and chloramination, followed by additional chloramination for reclaimed wastewater; 3) dual media filtration and chlorination; and 4) fixed growth reactor (ammonia removal), flocculation, dual media filtration, and chlorination, followed by additional flocculation, dual media filtration, and chlorination for reclaimed wastewater. PFCs were found "...to persist beyond the tertiary treatment steps...at concentrations [that] are consistent with reports for other municipal wastewaters which vary between plants."

Despite the persistence of these compounds beyond wastewater treatment, the researchers conclude, "Compared to the global perfluorochemical burden from sources such as wastewater discharge and rain, water recycling plays only a limited role." The authors indicate that nanofiltration and reverse osmosis tertiary treatment remove PFCs, although the filtered contaminants still remain intact in a post-treatment brine stream. To stop the flow of PFCs to the environment through the wastewater stream, the only apparent method is incorporation of disposal methods that completely avoid discharge into waters, including the ocean. Because, as the GH&SI review states, "Studies of the persistence of PFOS, for example, show that under *no conditions* does the chemical show any evidence of breaking down in the environment" (13), the logical precautionary approach would be a ban on the manufacture of PFOS.

Wastewater Treatment to Control CECs

Given the research available, improvements that optimize secondary biodegradation processes may prove to be the most cost-efficient and accessible way for wastewater treatment plants to increase the removal and neutralization of many CECs. Although research needs to continue on the subject of safe reuse of recycled water for agricultural irrigation, park facility application, public facility sanitation, industrial and commercial uses, several researchers find that extending secondary treatment can make a significant step towards this goal. The 2009 survey published in Environmental Pollution points out "activated sludge with nitrogen treatment and membrane bioreactors" as the most efficient process (61). Improvements to secondary treatment remove a high percentage of CECs, but thorough biological processing over long retention times is necessary to ensure that CECs do not accumulate in the resulting biosolids. Ternes et al find that many wastewater treatment plants in the U.S. and the EU do not operate with solid retention times long enough to achieve the necessary biological decomposition. Their report recommends that medium-sized and larger sewage plants upgrade to "a sludge age of 12–15 days by nitrification combined with denitrification" (62). Activated sludge operations and membrane bioreactors are relatively easy to incorporate and are compatible with the retrofitting of existing infrastructure. These methods do not create additional treatment side streams, and allow for the neutralization of many bioactive compounds without requiring including separate holding tanks and diversion infrastructure.

Advanced secondary treatment methods, optimized to treat influent content, also help to ensure the efficiency of tertiary treatment that follows, since the breakdown of CECs decreases the toxic load that goes on to more advanced processing (62). Higher levels of secondary treatment add the benefit also of a lesser amount of toxic residue after tertiary filtration.

However, these kinds of assessments of the effectiveness of treatment contrast with the findings of a wide-ranging review of treatment methods for pharmaceuticals. The review, published in 2009 in the Journal of Environmental Management, describes how advanced technologies all have shortcomings, which include: the effect on efficiency of the type of compound; undesirable changes to compounds caused by treatment; minimal improvement in elimination rates as a result of increased retention time; possible increase in antibiotic resistance as a result of treatment with bio-membrane reactors; high carbon dioxide emissions as a result of increased energy demands to operate advanced technologies; and unsustainability because they do not tackle the origin of the chemicals and are too expensive for many countries (65). The review describes how a life cycle assessment of three treatment processes to discover when the removal of micro-pollutants and reduction in toxicity would outweigh the increased resource- and energy consumption. The research found advanced treatment can induce more environmental impact than it removes. Unlike ozonization and membrane bioreactors, sand filtration was the only method found to have net benefits.

As a 2009 review for the journal Clean states, PPCPs and endocrine disrupting compounds, "are not completely removed in treatment plants" (66). The point that removal efficiencies depend on the chemistry of the compound being treated is also echoed. Nevertheless, the Clean review finds that, "Advanced posttreatment units (ozone, AOPs, activated carbon, membranes) may constitute reliable options for the removal of EDCs/PPCPs" However, techniques that are filtration-based *also generate a high-concentration pollution residual that is discarded in treated effluent if the pollutants are unregulated.* Such pollutants can remain in their raw form, and ideally should be subject to further biodeactivation treatment and careful disposal. Advanced treatment may maximize CEC removal, providing high-quality reclaimed water for agricultural irrigation, urban and industrial use, and even groundwater recharge, but its financial and energy costs are high. Many passes may be needed through the treatment process,[30] and typical disposal methods following treatment do not remove CECs from the waste stream.

30 Information from correspondence with treatment plant operators.

CECs and the Call for Analytical Methods, Research, and Water Quality Criteria

Wastewater treatment professionals face continual funding demands that only increase with new regulatory requirements and water recycling targets. These professionals will surely be the first to echo the U.S. EPA's Essential Principles for Reform of Chemicals Management Legislation. The U.S. EPA provides the principles in order to "help inform efforts underway in this Congress to reauthorize and significantly strengthen the effectiveness of the [Toxic Substances Control Act]. These Principles present Administration goals for updated legislation that will give U.S. EPA the mechanisms and authorities to expeditiously target chemicals of concern and promptly assess and regulate new and existing chemicals" (11). Action on the U.S. EPA's principles is needed to manage, or eliminate, the chemicals that flow daily into wastewater treatment plants and from there, into surface waters or the ocean. But action must be based on sound scientific research on substances whose rate of increase has so far greatly outstripped our understanding of their fate, transport, and consequences.

The need for the authors of the U.S. EPA's *Treatment Works* study to develop three analytical methods to detect the occurrence of CECs in wastewater illustrates the inadequacy of CEC analysis tools (12). The lack of CEC-analysis technologies as discussed in the study could alone justify a new U.S. EPA essential principle to set in place sustained funding for research to guide reform of chemicals management legislation. Changing environmental conditions, including ocean acidification, combined with an ever increasing chemical load, have raised the level of urgency for action on EPA's first new principle as set out under its pollution prevention strategy: "Chemicals should be reviewed against safety standards that are based on sound science and reflect risk-based criteria protective of human health and the environment" (11).

Hepatitis A is an example of a microbial CEC for which reliable and financially feasible monitoring methods are needed. A study published in 2006 in Water Science and Technology revealed that reclaimed water used to irrigate two golf courses in Spain and Portugal included somatic *E. coli* bacteriophages, enteric viruses (*entero-, hepatitis A* and *rota-*) and *Legionella pneumophila*. The study concluded that the wastewater treatment processes produced an adequate reduction in the number of indicator microorganisms. However, "...a significant correlation between pathogenic and indicator microorganisms tested was not found" (67). This lack of correlation between indicator and pathogenic microbes provides more evidence of the need for research to improve monitoring and testing protocols to ensure that wastewater treatment removes pathogens that may presently survive undetected through a range of processes.[31]

In July 2007, a Special Project of the State/EPA Water Quality Standards Workgroup began a survey on the issue of "emerging contaminants" (68). The survey was distributed to the Ambient Water Quality Standard (AWQS) contacts in all 52 states within the U.S. The results of the survey were published in 2008 and include a summary of responses elicited from 37 states as well as from interstate organizations in 27 states. Asked whether their state/organization defined "emerging chemicals," 13.5% responded "yes," 10.8% responded, "don't know, and 75.7% of the states answered, "no." Contacts were also asked about the level of interest of their state or organization in emerging chemicals, regulatory activities concerning these chemicals, and also about for near-term (1-year) and longer term (5-year) priorities to further develop a coherent "emerging chemicals program" in water quality regulation. Out of 37 responses, "only six indicated that their agencies already factored emerging chemicals into their programs." The proportion of agencies "interested enough to investigate ways to incorporate emerging chemicals into their agencies' programs" came to 62%. Another six agencies were "very interested, but not ready to implement" for the following reasons: "[1] Lack of national ambient water quality criteria; [2] Lack of state resources to develop and adopt standards; [3] Analytical methodologies are still in development; [4] [State] laboratories do not have necessary analytical capability; [5] Funds are insufficient to contract outside laboratories; [6] Toxicological research is still inadequate; [7] Acute and/or chronic aquatic life database still in development." Clearly, the need for research, new standards and for funding and administrative support regarding CECs and wastewater extends nationally.

The Water Quality Standards Workgroup survey also shows that considerable CEC research occurs in California and involves much collaboration, for instance, by the SWRCB with SCCWRP, and the Central Valley regional board with the University of California, Davis, and the U.S. EPA. Taking a lead role on the CEC issue, SCCWRP has convened two information-gathering panels at its headquarters in Costa Mesa, California: the SWRCB Advisory Panel on CECs in Recycled Water and the Advisory Panel for CECs in Coastal and Marine Ecosystems (69). The goal of these public sessions is to share and examine information about CECs for the purpose of developing a State policy for identifying the contaminants that should be monitored.

Increased monitoring and specialized treatment to remove CECs could help ensure reclaimed water quality reaches standards needed for safe reuse. However, present water shortages as seen, for instance, in Los Angeles and the San Joaquin Valley, combined with California's increasing population (70), could push water reclamation and recycling ahead of science, technology, and the establishment of new standards. Maximizing the potential to reclaim water from wastewater treatment plants is fast becoming a necessity. More action on the call made by the State's Recycled Water Task Force in 2003 for funding of research on recycled water issues has become urgent.

Four Advanced Treatment Offset Approaches

The cost of producing recycled or reclaimed water has in many cases inhibited wastewater treatment plants from moving forward with new technologies. One of the biggest problems in meeting technology improvement costs has been the resistance of ratepayers to rate increases, even though wastewater treatment rates are very low relative to fees for other household utilities (e.g., gas, electricity, cable). Researchers continue to investigate ways to reduce the cost of treatment plant processes both for desalination and the removal of CECs, processes that are expensive in terms of both equipment and energy costs. Related research on desalination covers topics such as membrane types, energy efficiency, and pretreatment, including methods such as enzyme enhancement (1). Factors affecting the cost of treatment to reduce or eliminate salinity include the type of technology used, the salinity level of feed water, the salinity level of product water, available energy sources, and the short and medium term demand for recycled water (2).[32] Whichever technology is used, desalination is a costly process.

Cogeneration

Many wastewater treatment plants use processes that allow for cogeneration–the simultaneous production of power/electricity, hot water, and/or steam from one fuel (3). Methane, a "biogas," is a typical plant biomass fuel, one produced in wastewater treatment facilities with anaerobic digesters. Bacteria in the digesters break down biosolids in sewage. Combustion of the resulting methane creates energy and also cuts emissions of this powerful greenhouse gas, which some plants flare off (4). Combined cycle power plants can be energy self-sufficient, as demonstrated by

31 Studies, however, such as Occupational Medicine's 2009 short report, "*Wastewater workers and hepatitis A virus infection*," provide some reassurance, for the research contributing to the report found that "...working in a wastewater treatment plant does not seem to be related to a greater prevalence of antibodies to hepatitis A. Moreover, the relative risk of HAV infection among (wastewater workers) seems to be correlated with low anti-HAV(+) prevalence in the general population" (16).

32 According to the above mentioned experts' report to the FAO, various recovery devices "can reduce energy requirements by as much as 50%." In addition, "Larger plant size... contributes to the economy of scale that is significant between a plant producing 1,000 m3/d and that producing 40,000 m3/d, where the capital cost per cubic metre of water can decrease by a factor of 2.5. However, RO plant sizes larger than 40 000 m3/d will not have any further considerable effect on cost reduction" (ftp://ftp.fao.org/agl/aglw/docs/lwdp5_e.pdf)

the Joint Water Pollution Control Plant in Los Angeles (JWPCP). JWPCP uses digester gas (mainly methane), to generate electricity and produce surplus energy that is sold back to a utility company. Installation of co-generation systems that are simultaneous with upgrades to achieve desalination may help, over time, to offset the costs of the upgrades.

Alternative Energy Generation
New site construction and, potentially, upgrades and improvements can provide opportunities not only for cogeneration, but also for use of plant facilities and/or space for the installation of energy-generating technologies such as solar power. Two wastewater treatment plants in California have installed solar photovoltaic (PV) systems: the Las Gallinas Valley wastewater treatment facility in the San Rafael, California area, and the San Joaquin water treatment plant, inland from Monterey, California (6).

The San Joaquin wastewater treatment plant formed an electricity-producing facility in 2005. With electricity costing about $400,000 annually, the District installed a solar project on property adjacent to the plant, in order to generate electricity for itself and to sell the excess into the Pacific Gas and Electric (PG&E) system. With incentives worth $6 million from the California Solar Initiative Program, it has been estimated that it will take 15 years for the long-term payback on the capital expenditure for the solar project.

The California Solar Initiative Program also contributed incentives in relation to the installation at the Las Gallinas Valley wastewater treatment plant. Near the shores of San Pablo Bay, the Las Gallinas plant sited a solar PV system in 2006 on a foundation of manmade bay-fill. The wastewater plant reports power production of over 1 GWh annually, "...meeting and exceeding the contract's levels" and saving $156,000 in its first year of operation. By November 2008, this wastewater treatment plant was meeting 100% of the facility's power needs.

Energy Efficiency
Both the San Joaquin and Las Gallinas districts contracted expert energy usage analysis with the aim of designing "... the smallest [PV] system with the largest rate of return." Several proposals were submitted to the districts for systems that would have supplied 100% of both plants' power needs. The Las Gallinas energy audit revealed, however, that the plants' energy use could be reduced by applying certain efficiency measures. A proposal was accepted that incorporated these measures and, as a result, required a smaller PV system than specified in proposals based on the plant's original energy needs. Following installation, the plants achieved a fifty percent cut in electricity use and a net savings on the project of $175,000. Energy audits of treatment plants throughout California would show where savings could be achieved, savings that could be applied to plant improvements and upgrades.

Public-Private Partnerships
In some cases, public-private partnerships can make plant improvements feasible. Since 1994 the privately-owned Pebble Beach Company (PBC) in California's Central Coast region has been the fiscal sponsor of modifications to the Carmel Area Wastewater Treatment Plant, working in partnership with the Carmel Area Wastewater District (CAWD), Pebble Beach Community Services District (PBCSD), and the Monterey Peninsula Water Management District (7). CAWD and the PBCSD own and operate the wastewater plant while PBC guarantees repayment of "certificates of participation" and pays annual operating expenses over and above the revenues derived from reclaimed water sales.

The Carmel plant produces about 800 AF of reclaimed wastewater annually [0.7 million gallons daily], "...which is used to irrigate the Pebble Beach golf courses and other recreational areas. This supply is replacing an equivalent quantity of potable water that was previously applied to these grassy areas." The other important result of using the high-quality effluent in this way is that "about 700,000 gallons of secondary effluent does not get discharged to Carmel Bay every day."
The Pebble Beach model may be applicable at other locations in California and serves as an example of a financial means to reduce CEC pollution in California as well as help realize the State's reclaimed water potential. The *Sacramento Bee* newspaper reported on a more recent example of a successful public-private partnership, with the March 2009 adoption by the Sacramento Regional County Sanitation District of, "a strategy to partner with buyers to recycle wastewater from the State Capitol's 1.4 million residents into a new municipal water source" (8). Similar opportunities may exist elsewhere in the State of California.

Water Reclamation: Conclusion

While the Water Recycling 2030 report summarizes key issues identified by the California Recycled Water Task Force and makes recommendations to increase water recycling (9), environmental and scientific findings in the years since the Task Force's report have led the National Water Research Institute (NWRI) to call in June 2009 for a re-prioritization of the report's recommendations. NWRI recommends an emphasis on communication with the public, followed by state leadership and advocacy, regulatory consistency, funding, and public support (10).

Heal the Ocean concurs based on its research for the *Report and Inventory,* and makes specific recommendations that fall under the following

- Public education and promotion of water reuse
- Research and technology development
- Updated and streamlined regulations
- Improved water quality treatment
- Financing

A concerted, concentrated effort is needed to address the problems of salinity and CECs in reclaimed water. Both issues present serious challenges to water reclamation and its benefits. While work is underway to find solutions, and while the health and environmental effects of CECs remain uncertain, the most cost-effective and immediately accessible wastewater treatment processes should be applied as soon as possible in order to reclaim water for basic uses such as irrigation and habitat preservation. New plans for treatment to remove salt and other contaminants for water reuse must include plans for the disposal of residual contaminants and should not include the method of ocean discharge. Contaminants that cannot be removed at reasonable cost by wastewater treatment need to be eliminated at source to prevent them entering the wastewater stream. Bans should be considered for CECs that are found to pose high risks.

Given that efforts to reclaim treated wastewater are increasing worldwide, opportunities exist for international exchange of both research and information emerging from cutting edge pilot projects that use potentially cheaper technologies and engineering. Ongoing collaborative efforts to examine and improve the control of toxic pollutants in California waters include those of the Bay Delta Conservation Plan, the Recycled Water Policy Science Advisory Panel, and the Advisory Panel for CECs in Coastal and Marine Ecosystems (11). In addition, many integrated regional water management plans now in process around the State are already proving to be effective in promoting pilot projects, research partnerships, and stakeholder involvement.

The reclamation of wastewater necessitates the building of appropriate infrastructure, including dual plumbing, to maximize wastewater capture, storage, and delivery. While implementation costs may be high, public-private partnerships, and energy efficiency, co-generation, and generation schemes can offer solutions for overcoming financial difficulties.

Source control needs to take priority as the most effective and economic method of preventing water pollution. Funding should be provided for sustained public education and pre-treatment. Wastewater treatment plants are nder siege from an ever-growing list of chemicals that plants are not typically designed to treat. Strong pre-treatment measures would help to combat the high costs of wastewater treatment by lessening the contaminant load in influent.

Publicly owned treatment works are designed mainly to process domestic wastewater. However, many facilities also receive wastewater from industrial or commercial sources. Regulations, and monitoring and inspection regimes for industrial wastewater are implemented by the local sanitary districts. Industrial wastewater is defined by the sanitation districts of Los Angeles County as, "all wastewater from any manufacturing, processing, institutional, commercial, or agricultural operation, or any operation where the wastewater discharged includes significant quantities of waste of non-human origin."[33] Sources employing particular industrial processes and/or discharging high volumes of wastewater are required to obtain a permit to discharge to the municipal sewer system, but local limits on discharge constituents apply to all industrial discharges. Recognizing the positive effects of source control, some districts such as the Montecito Sanitary District in Santa Barbara County, already provide pre-treatment assistance beyond any official program. Greatly expanded funding for source control programs could help districts and treatment plants significantly reduce the pollutant load reaching wastewater facilities and therefore increase the potential to reclaim water.

Water reclamation is currently undermined by outdated water quality standards, lack of demand, and outdated regulations for reuse. Public education is crucial to increase conservation, demand for reclaimed water, and to support relevant government action. All public education programs should focus on:

- the crucial role of the wastewater treatment plant in maintaining public and environmental health
- the urgent need for water conservation and the potential for safe water reclamation by wastewater treatment plants
- the need to support regulatory changes to facilitate reclamation
- the need for funding from sources, such as environmentally sustainable State bond measures and ratepayer increases, to pay for the increasingly demanding tasks of the wastewater treatment plant

Coordinated public education statewide would support the work of individual authorities to increase water

33 See 1) U.S. EPA web page: Pretreatment of Wastowater (Industrial Users) Compliance Monitoring http://www.epa.gov/compliance/monitoring/programs/cwa/wastewater.html
2) SWRCB NPDES Pretreatment Program: http://www.waterboards.ca.gov/water_issues/programs/npdes/pretreat.shtml
3) Sanitation Districts of Los Angeles County website: About the Industrial Waste Section http://www.lacsd.org/info/industrial_waste/default.asp

reclamation, enabling the replication of effective local campaigns such as the citywide program begun in 2008 by the Los Angeles Department of Water and Power (LADWP) that presents a dialogue with the public through its website. The LADWP cites this program as the start "of a multi-year outreach campaign to inform the public and raise awareness about the need for recycled water and groundwater replenishment to create a locally sustainable water supply in Los Angeles." A statewide campaign tailored to local needs and circumstances could ensure consistency of information and presentation, and add greater weight and urgency to local public education efforts.

A concerted effort should be made to bring consistency to the State regulations for reuse of reclaimed water. The State's Recycled Water Policy, effective from May 2009, and the proposal for a statewide dual plumbing code, indicate that California is beginning to move in the direction of achieving a more unified policy for water reclamation.

The case for reclaimed water in California is clear. The U.S. Geological Survey figures for water use in the year 2000 revealed that California accounted for "almost 11 percent of all freshwater used in the United States." California also consumes 22% of all the water used for irrigation in the U.S., making it the largest user in this category.(see Table 2.1) Replacement of potable flows with reclaimed water for irrigation alone could provide a considerable boost to the public drinking water supply in California.

Irrigation	Thermo-electric power	Public supply	Industry	Domestic (self-supplied)	Mining	Livestock, aquaculture
40 %	39 %	13 %	5 %	1 %	1%	less than 1 %

Table 2.1. Water uses in California in 2000 by percentage. Source: U.S. Geological Survey

It may not be long before the environmental stresses on California's water supply make reclaimed water an unquestioned, everyday reality for the general population, but an effective, coordinated communications campaign is needed. Meanwhile, it is a hopeful sign that the State has begun to invest in policy, research, and public funding of infrastructure and treatment upgrades to tackle the challenges of salinity and CECs. Contaminant removal and desalination, along with more storage capacity and delivery infrastructure, will increase water reclamation in California. Together with comprehensive new water quality standards, updated reuse regulation, and consistent, statewide public education, the statewide investment in wastewater treatment and water reclamation will help California combat its present and predicted water shortage. The most welcome side benefit of a concerted drive for reclaimed water in California will be a significantly reduced pollutant load on the Pacific Ocean.

Summary of Heal the Ocean Recommendations on Water Reclamation and Reuse

Public education and promotion of water reuse: The public should be engaged in an active dialogue in developing new regulations and planning water recycling projects. Curricula need to be developed for public schools and institutions of higher education addressing water reuse issues. Public service announcements and relevant agency media bulletins and websites should highlight water recycling.

Research and technology development: The State should expand funding sources to include increased and sustained funding for research on the full range of recycled water issues.
Updated and streamlined regulations: State government should take a leadership role in improving consistency of policy within branches of State government. This should extend to regulations for indirect potable reuse to ensure adequate health and safety assurance for California residents. Regulation must be able to accommodate revised ambient water quality standards as research findings on CECs become clearer. A framework is also necessary for uniform regulations and revisions to be made to building and plumbing codes at local levels. Additionally, less burdensome regulatory mechanisms affecting incidental runoff of recycled water from use sites need to be implemented.

Improved water quality treatment and pollution prevention: Source control programs should be expanded and implemented in a wide-reaching campaign targeting and quickly engaging industrial wastewater dischargers and the general public for the long term. Local governments should have the ability to impose bans on, or require more stringent standards for, residential water softeners. Wastewater treatment plant improvements and upgrades should be at the most advanced level feasible and designed to efficiently accommodate enhanced treatment and increased water reuse in the future.

Financing: State funding for water reuse/recycling facilities and infrastructure should be increased beyond Propositions 50 and 84, and other current sources. A reliable and predictable funding procedure should be developed to provide local agencies with assistance through State and federal funding opportunities. State funding agencies should make better use of existing regional planning studies to determine the funding priority of projects. Funding sources should be expanded to include sustainable State funding for technical assistance and research, including flexibility to work on local and regional planning, emerging issues, and new technology.

Reclaimed Water – a Worldwide Effort

The need for increased water supplies worldwide has spurred a global campaign for recycled water, a campaign that is motivating improved wastewater treatment in many countries. A Queensland (Australia) Water Commission publication, *Fact Sheet* on *Purified Recycled Water*, states that the Commission's process for indirect re-use "...will be the world's best practice, underpinned by state-of-the-art technology, similar to that used in Singapore and Orange County." The *Fact Sheet* provides a useful guide to many technologies and operations in use by various wastewater plants around the world. The examples also show that California boasts at least one treatment plant known internationally for its water reclamation achievements (12).

Groundwater Reclamation Plant (GWR), Orange County (California). This facility is one of three U.S. examples of six summarized in the Queensland *Fact Sheet*. Treatment involves a dual membrane microfiltration process, reverse osmosis and advanced oxidation, yielding 70 million gallons daily of reclaimed, "near-distilled quality" water. The GWR website explains how the system received approval in 2008 "...to inject about half of the purified sewer water from the GWR System into OCWD's [Orange County Water District's] seawater intrusion barrier." On January 18, 2008, OCWD won final approval to allow for the release of the other half of the water to OCWD's groundwater spreading basins in Anaheim, and from there to be conveyed for indirect potable re-use.

Upper Occoquan, Northern Virginia. This treatment plant uses no membrane processes, but instead, incorporates aerobic treatment using activated sludge, high pH lime treatment, recarbonation, sand filtration, upflow carbon adsorption and chlorination. In 1998, this Northern Virginia plant reclaimed 87 million liters/23 million gallons of water, which was used to augment the Occoquan Reservoir. Monitoring results show the reclaimed water is "far cleaner" than other surface inflows.

Montebello Forebay Groundwater Recharge Project, Los Angeles County. The facility in this project uses sedimentation and activated sludge treatment, sand filtration and disinfection with chlorine before recharge of the aquifer. Influent is mainly domestic. Reclamation began in 1969 and contributes up to 38% of drinking water supplies, meeting "...drinking water standards for pesticides, heavy metals, minerals, trace organic compounds, microorganisms and radionuclides." The Queensland *Fact Sheet* states that, "studies examining health have found no negative impacts from drinking recycled water in this community." Further information from a technical bulletin of the Water Replenishment District of Southern California provides details of the of the recharge sources: "Since 1962/63, over 5.6 million acre feet (AF) of water has been recharged at the spreading grounds, including 2.23 million AF (40%) of storm water, 1.45 million AF (26%) of recycled water, and 1.92 million AF (34%) of imported water. Over time, recycled water amounts increased while imported water amounts decreased as the safety and reliability of the recycled water was proven through intensive sampling, monitoring, and research efforts. Currently, about 40% of the replenishment water is storm water, 40% is recycled water, and 20% is imported water" (13).

Torreele Reclamation Plant, Veurne-Ambacht, Flemish Coast, Belgium. In this tourist region, the local water supply comes from groundwater, which is under threat of seawater intrusion due to over-pumping of the groundwater. The Torreele plant treats wastewater from a nearby sewage plant to produce 660 million gallons annually of recycled water. Treatment consists of ultrafiltration, reverse osmosis, and ultraviolet disinfection. Following discharge into an infiltration basin, the water filters through sand dunes into the groundwater. A study published in January 2008 in the international (Elsevier) journal *Desalination* looked at the effectiveness of this case of indirect potable reuse. The study states that, "...due to the sensitive environmental nature of the dune area, the quality of the infiltration water is subject to stringent standards. The combination of membrane filtration techniques proved capable of producing this quality and enabled a sustainable groundwater management of both dune water catchments owned by the IWVA [Intermunicipal Water Company of the Veurne region]" (14).

Essex & Suffolk Water. Water reclamation in the County of Essex (United Kingdom) began in 1997. Using wastewater from a local sewage treatment plant, 128 million liters/134 million gallons per day of treated and UV-disinfected wastewater was mixed with river water and then sent into a reservoir. Extracted reservoir water was then treated with pre-ozonation, coagulation, settling, lime softening, rapid sand filtration, ozonation, granular activated carbon filtration and chlorination. Since 2003, a permanent system using these technologies now processes 40 million liters/40.5 million gallons per day. Wastewater receives advanced treatment at a reclamation plant before release to the river, which actually improves the river water quality. Downstream, all the water receives drinking water treatment before distribution to consumers, all of which augments the local drinking water supply by about 10 percent. The utility website states that the area served is one of the driest regions in the UK, "...with less water available for use than in many parts of Spain, Portugal and Italy (15).

Singapore. According to a *U.S. Water* news article, Singapore has been pumping reclaimed water into its water system since 2003. Today, with its new Changi plant producing up to 50 million gallons of per day, the government of Singapore has branded reclaimed water as "NEWater." Official promotion of NEWater by the State included the Prime Minister and his cabinet ministers drinking NEWater in public, along with the distribution of free, brightly labeled bottles of the reclaimed water at public functions. Although most of the reclaimed water supplies industrial uses, the quality achieved is so high that, "The water fabrication plant operators who require water quality more stringent than for drinking have reported savings of some 20 to 30%." The aim in Singapore is to produce 250 million liters per day for industry and 2.5% of drinking water by 2011. Treatment involves "membrane pre-treatment, reverse osmosis, UV disinfection and chlorination for control of bio-fouling and residual chlorine in NEWater. Unlike Water Factory 21 [Orange County's original 1976 reclamation plant], advanced oxidation is not required, (because) the level of n-nitrosodimethylamine (NDMA) in NEWater is low, at less than 10 parts per trillion. This could be attributed to wastewater mainly from domestic sources and to full secondary wastewater treatment" (12).

The Changi plant came on line in June 2009 and has a treatment capacity of 176 million gallons daily. The latest component of the country's deep tunnel sewage system, which was designed to treat and reclaim wastewater for 100 years, the system was named "Water Project of the Year" at the 2009 Global Water Awards held in Zurich (16) (17).

Moving beyond its long-established water conservation policy, the Singapore government plans to use nonconventional sources, including water reclamation and seawater desalination, to meet one third of the country's total water demand. Unused effluent is discharged through a five-mile ocean outfall (18).

Hong Kong. In 2001, the collection of sewage from five major areas around Victoria Harbour in Hong Kong received only chemically-enhanced primary treatment, and in 2005, disinfection was added (19). Improvements have accelerated since 2005 under the Hong Kong Government's Total Water Management program. Two pilot schemes promote the use of reclaimed water. Ngong Ping Sewage Treatment Works on Lantau Island has been operational since 2006 and is the first tertiary treatment works in Hong Kong to produce reclaimed water. The plant uses a sequencing batch reactor, dual media filter, and disinfection process to reduce organic pollutants, suspended solids, nutrients, and pathogens. The reclaimed water is used for local toilets, the Ngong Ping Cable Car Terminal, to raise aquarium fish, and for use in controlled irrigation within the sewage treatment works. The Shek Wu Hui Sewage Treatment Works also opened in 2006 and supplies reclaimed water to select nearby users, such as schools, senior citizen housing, decorative streams and fountains. The water is also used for domestic toilet flushing and unrestricted irrigation.

The Kingdom of Saudi. Reclaimed water is big business in Saudi Arabia. The Queensland Commission information states that, in 2009, "...the National Water Company described plans to set up joint-venture reclaimed water marketing companies in Riyadh and Jeddah that will be in charge of promotion and distribution of the TSE [treated sewage effluent], with the reclaimed water to be supplied by the new generation of advanced wastewater treatment plants being built in the Kingdom."

For California, like many of the above locations, leadership in wastewater treatment has become a necessity rather than a choice. The present push for more research and strong trend toward wide collaboration are signs of the progress toward new water quality standards and improved monitoring and reporting. The resulting new requirements will necessitate improvements in wastewater administration, infrastructure, and technology. But these improvements are already badly needed. The technology to remove or reduce CECs and salinity already exists. Water supplies are already growing scarce. Meanwhile, huge quantities of water that could be reclaimed are being wasted in ocean discharges that pollute the ocean. Support for improved wastewater treatment from State and federal funds, energy schemes, and public-private partnerships directed first to plants on the coast would represent a wise and overdue investment. In present times of uncertain supply and risk, investment now would help secure more than future water supplies. By acting together to reclaim high quality water, we would take a sensible and necessary step toward a sustainable, future for both the environment and the people of California.

The City of **SAN DIEGO** *Development Services Department*

Public Scoping Meeting Sign In Sheet // August 23, 2016, 6:00PM – 7:30PM
Scripps Miramar Ranch Public Library // 10301 Scripps Lake Dr., San Diego, CA 92131

Pure Water San Diego Program, North City Project EIR/EIS, PTS No. 499621

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CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

Pure Water San Diego Program // AUGUST 23, 2016

This meeting is being held pursuant to the *California Public Resources Code Section 21083.9 et seq.*, and is provided to give the public and interested parties an opportunity to submit comments regarding the potential environmental impacts of the proposed project. This information will be used to develop the scope and content of the proposed Environmental Impact Report (EIR) for the project to be described at this meeting. Please record your comments in the space provided below and submit this form to City staff at the conclusion of the meeting, or you can mail to the address noted on the back of this form. Thank you.

Comment: ① why was this not on the ballot for the public to vote on? Why do you call it "Pure water" instead of what it is "Recycled Sewer water" or "toilet to tap"? It is not pure water.

② The potential for harm to ~~health~~ health is tremendous given industrial waste, dangerous diseases thru hospital waste, medications, etc being put down toilets. You have not proven that you can eliminate chemical pollutants.

③ What is the plan for testing in the homes when sewer water is piped into my home? What happens when a problem arises?

④ Tremendous potential to loss of property values if this proves to cause health or environmental impacts

⑤ why was this meeting not publicized in SKCA calling it "Toilet to tap" or "sewer water" so homeowners would be aware & have opportunity to object to your plan to impact Miramar Lake?

Name: RUTH FEATHER Signature: Ruth Feather

Address: 9899 Camenito Rogelio, San Diego CA 92131

email: drfeather@sbcglobal.net

Use back of sheet if additional space is needed.

CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

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Comment:

alternatives to be considered in the EIR should include expanding the "Purple pipe" program to underserved areas

The DEIR should address the negative consequences of reducing support for ~~recycled~~ reclaimed water for (purple pipe) agricultural, landscape recycled use and effects on fire danger

Please disclose impact of curtailing the purple pipe program

Name: Wallace Wulfeck Signature: [signature]

Address: 12517 FAIRBROOK Rd. 92131

Use back of sheet if additional space is needed.

CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

Pure Water San Diego Program // AUGUST 23, 2016

This meeting is being held pursuant to the *California Public Resources Code Section 21083.9 et seq.*, and is provided to give the public and interested parties an opportunity to submit comments regarding the potential environmental impacts of the proposed project. This information will be used to develop the scope and content of the proposed Environmental Impact Report (EIR) for the project to be described at this meeting. Please record your comments in the space provided below and submit this form to City staff at the conclusion of the meeting, or you can mail to the address noted on the back of this form. Thank you.

Comment:

Please consider an alternative Route for the pipeline from the Treatment plant to Miramar Reservoir,
- instead of under Miramar Rd, please consider ~~[illegible]~~ routing thru Carroll Canyon under the new Carroll Canyon Rd.

Name: Wallace Wulfeck Signature: [signature]

Address: 12517 Fairbrook Rd 92131

Use back of sheet if additional space is needed.

The City of
SAN DIEGO
Development Services Department

Public Scoping Meeting Sign In Sheet // August 25, 2016, 6:30PM – 8:000PM
City of San Diego Public Utilities Department // 9192 Topaz Way, San Diego, CA 91923

Pure Water San Diego Program, North City Project EIR/EIS, PTS No. 499621

NAME	ORGANIZATION	EMAIL	MAILING ADDRESS
Al Lau	PDMWD	alau@padre.org	9300 Fanita Pkwy Santee, CA 92071
James Peasley	Metro Comm	jpeasley@padre.org	"
John Stump		jwstump@cox.net	2413 Shamrock City Heights 92105
Brian Aquino			10872 Hijos Way
Alex Aquino	BSA	aaquino012@gmail.com	10872 Hijos Way
Ray Paulson		Raymond.Paulson@gmail.com	6362 Caminito Marcial SD CA 92111
Deborah Knight	Friends of Rose Canyon	rosecanyon@san.rr.com	~~[illegible]~~ PO Box 221051 S.D. 92192-1051
Doug McPherson	USBR	dmcpherson@usbr.gov	27708 Jefferson, Ste 202 Temecula 92590
Scot Andrews	SEA	scott300@earthlink.net	4245 Del Mar SD CA 92107
Summer Adleberg	City of SD	Sadleberg@sandiego.gov	9192 Topaz Way

The City of SAN DIEGO Development Services Department

Public Scoping Meeting Sign In Sheet // August 25, 2016, 6:30PM – 8:000PM
City of San Diego Public Utilities Department // 9192 Topaz Way, San Diego, CA 91923

Pure Water San Diego Program, North City Project EIR/EIS, PTS No. 499621

NAME	ORGANIZATION	EMAIL	MAILING ADDRESS
Jim Peugh	S.D. Audubon Soc.	peugh@cox.net	2776 Nipoma St San Diego 92106
Shelli Craig		shelli.craig7@gmail	7728 Laramie Ct. S.D. CA 92120
Mark Stephens	City of San Diego Storm Water Div.	mgstephens@sandiego.gov	9370 Chesapeake Dr. Suite 100 S.D. CA 92123 MS1900

The City of SAN DIEGO Development Services Department

Public Scoping Meeting Sign In Sheet // August 25, 2016, 6:30PM – 8:000PM
City of San Diego Public Utilities Department // 9192 Topaz Way, San Diego, CA 91923

Pure Water San Diego Program, North City Project EIR/EIS, PTS No. 499621

NAME	ORGANIZATION	EMAIL	MAILING ADDRESS
Robert Chait	Vex Property	RLEIF@RLEIF.com	3345 Hopi Place San Diego, CA 92117

CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

Pure Water San Diego Program // AUGUST 25, 2016

This meeting is being held pursuant to the *California Public Resources Code Section 21083.9 et seq.*, and is provided to give the public and interested parties an opportunity to submit comments regarding the potential environmental impacts of the proposed project. This information will be used to develop the scope and content of the proposed Environmental Impact Report (EIR) for the project to be described at this meeting. Please record your comments in the space provided below and submit this form to City staff at the conclusion of the meeting, or you can mail to the address noted on the back of this form. Thank you.

Comment:

1. feasibility of another desalination plant.
2. Cost of each option
3. analysis of impacts on marine ecosystems from continued discharges from Pt. Loma.

Name: Shelli Craig Signature: Shelli Craig

Address: 7728 Laramie Court

Use back of sheet if additional space is needed.

Comment continued:

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Development Services Department
ATTN: Mark Brunette
1222 First Ave., MS 501
San Diego, CA 92101

CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

Pure Water San Diego Program // AUGUST 25, 2016

This meeting is being held pursuant to the *California Public Resources Code Section 21083.9 et seq.*, and is provided to give the public and interested parties an opportunity to submit comments regarding the potential environmental impacts of the proposed project. This information will be used to develop the scope and content of the proposed Environmental Impact Report (EIR) for the project to be described at this meeting. Please record your comments in the space provided below and submit this form to City staff at the conclusion of the meeting, or you can mail to the address noted on the back of this form. Thank you.

Comment:
(1) Potable water traditional supply shrinking with global warming - this will continue
(2) Reuse water sewage to tap 250% losses due to evaporation, leaks, treatment etc.
(3) Therefore this will not solve drinking water shortage and is waste of public funds this can be litigated for a win for the public!
(4) The oceans are rising and can provide water until CO_2 < 350ppm to stabilize global warming -- w/ new graphene low energy RO filters OAK RIDGE NATIONAL LAB is developed.

Name: Ray Paulson Signature: Ray Paulson

Address: 6369 Caminito Marcial SD CA 92111

Use back of sheet if additional space is needed.

OVER ⤵

Comment continued: (5) Sewage to tap closed loop toilets not controlled - water can be sabotaged.

~~(6) UCSD medical labs cannot ensure range of bacteria, they evolve, diameter in size for treatment e.g. < nano in size etc.. and higher resiliency to treatment.~~

(7) Therefore P.E. engineers cannot guarantee drinkingwater Standards - - -

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Sustainability = (quality of water for community and quantity of supply) securing for water, ecological impact, economic

this respect not good ...

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(8) Sewage to Irrigation mitigates (reduces) Potable water use - by installing gray water lines P!!! this a real solution for water reuse!!!
→ yet a shrinking supply of water!!!

(9) "www.magnegas.com" is lowest cost one step sewage treatment to irrigation water + a gas mixable w/ natural gas to feed the electrical grid backup to Solar replaces natural gas/ fracking brings in income or cost avoidance!
monies saved - earned help pay for saltwater to fresh!

JOHN W. STUMP
2413 SHAMROCK STREET
CITY HEIGHTS, CALIFORNIA 92105
VOICE: 619-281-4663 EMAIL: mrjohnstump@cox.net

City of San Diego via First Class USPS and Email to cityclerk@sandiego.gov purewatersd@sandiego.gov
Development Services; & Storm Water Departments kbalo@sandiego.gov; HMDeisher@sandiego.gov;
202 C Street cityattorney@sandiego.gov; planningcommission@sandiego.gov
San Diego, California 92101

California Regional Water Quality Control Board, San Diego Region
San Diego Storm Water Permit, Implementation, Monitoring and Enforcement
2375 Northside Drive, Suite 100 via USPS & Email: sandiego@waterboards.ca.gov; Rebecca.Stewart@waterboards.ca.gov
San Diego, CA 92108 Main Phone Number: 619-516-1990

RE: PURE Toilet to Tap Water project and Scoping for Pending Studies (Projects: 438188 SCH No. 2014111068 & City Number 21003699) and related, including any request for any California Federal Drinking Water or Sewage Permits

Dear City of San Diego and Regional Water Board,

The City of San Diego appears to be engaged in a program to foster uncontrolled and unsustainable growth by providing an artificial water supply based on new technologies and the expenditure of significant public resources without adequate notice; inadequate consideration of alternatives; and failure to consider the known and cumulative impacts of entering into this project and its components. My testimony and letter of November 17, 2014 (**RE: ITEM-330: Point Loma Wastewater Treatment Plant - National Pollutant Discharge Elimination System (NPDES) Permit Application, (Citywide.) for MEETING OF TUESDAY, NOVEMBER 18, 2014, AT 2:00 PM,**) on file with the San Diego City Clerk and incorporated herein by reference, raised many of the points I present and highlight again.

These proposals are for an expanded approach and direction for regional water production and waste water processing. It assumes a Billion dollar construction program and significant new energy demands for combined sewer water processing and redelivery systems. I am requesting a California environmental review before this proposal becomes the permanent policy of the City. "If CEQA is scrupulously followed, the public will know the basis on which its responsible officials either approve or reject environmentally significant action, and the public, being duly informed, can respond accordingly to action with which it disagrees. The EIR process protects not only the environment but also informed self-government." *Sierra Club* at 13-14 (citing *Laurel Heights Improvement Assn. v. Regents of the University of California.*

The City's Web page states: "Water System Improvement Projects are funded by the rate increases." (SEE: http://tinyurl.com/jrt2n6y). The Notice of the plans and projects under consideration or in progress are inadequate, as they fail to give the public and potential ratepayers any reasonable notice of the plans of the government. These notices should be included in the Water and Sewer bill for the persons currently served by the system. The Notice should be in the languages used in the City of San Diego, under Election Law. These notices should give a reasonable range of the money spent to date and the treasure required in the future. Ratepayers should know that if these plans continue Water, Sewer, and Storm water will increase significantly and the cost of housing will become proportionally less affordable. Please Notice these plans in regular billings. A "...notice must be "reasonably calculated" to inform known parties..." ***Mullane v. Central Hanover Bank & Trust Co.***, 339 U.S. 306 (1950),

The City now has a legally enforceable Climate Action Plan , incorporated by reference herein, which is presented in an article in the May 18, 2016 San Diego Union Tribune newspaper (See: http://tinyurl.com/je49vx6) and a City Attorney Memorandum on Climate Action Plan (See: http://tinyurl.com/zbposv2). These projects and proposals must be evaluated and analyzed against the goals, standards and features of the referenced Climate Action Plan to determine if any project or proposal, including, but not limited to, its energy usages and growth inducing effects are consistent with the Plan. The Climate Action Plan requires change and one of the alternatives that must be considered to obtain Plan compliance must be alternatives that limit growth to sustainable levels, within existing resources.

The City is under a Municipal Storm Water permit and there have several been several enforcement actions imposed or pending concerning the City's lack of compliance with the permit and regulations, particularly on projects it has built for its own purposes or operation, the Municipal Storm Water Permit and Compliance matters are incorporated into these comments by reference (See: http://tinyurl.com/zsktyul). The proposed project and programs must specifically be analyzed for how these programs and projects foster the goals and objects of the Municipal permit. The Municipal Storm Water Permit requires change and one of the alternatives that must be considered to obtain Permit compliance must be alternatives that limit growth to sustainable levels, within existing resources. Please analyze and present reasonable information on how continued growth will contribute to obtainment of the standards required of the permit and settlement agreements. It is inconceivable that the City could continue to provide processed toilet to tap water to foster growth and yet not increase the amount of polluted storm water run-off to the water sheds and ocean. Analysis must include the conjoined effects and induced growth, waste generation, water and sewer demands that result from continued growth of San Diego and its larger sister City Tijuana. San Diego is a linked city like Budapest. We need to think San Dejuana not just North of the wall. Demand is generated together.

In addition to my demands for reasonable Notice and analysis to determine how the proposed projects will foster obtainment and timely compliance with regulatory permits, plans, and regulations, illustrated above without exclusion of other permits and regulations that the City is subject to, I have some specific matters for consideration. These are listed below:

1. Is the system or systems being proposed going to require rate increases and in what range(s);
2. Is the system or systems being proposed based on specific proprietary vendors or suppliers rather than generic methods? If proprietary systems are being proposed what are they and why are they being locked in or chosen?
3. What waste materials and volumes are likely to result from this program and projects operation? Specifically, address what filters and chemicals are going to be used? How will these filters be disposed of? How will used filters and the materials filtered out by the PURE toilet to tap operations be stored and disposed of? What volumes of materials are anticipated? Will this waste increase over the reasonably foreseeable life of the program and project? Are any of these materials classified as Hazardous or radioactive, by California or Federal standards?
4. What, if any, Homeland Security, Police, Fire or related costs will be required to build and operate the facilities proposed by this project or program? Would alternative approaches reduce these costs?;
5. Will all instructions and warnings for this program and project be posted in multiple local languages?
6. Has an emergency procedure manual and procedures been developed for the safety of operational and emergency personnel?
7. On the first day of operation will the proposed program or project fully conform to California and Federal permits? Will any continuing or new waivers of California or Federal law or regulations be required? Please additionally discuss whether the program or project will continue to use chloramine (SEE: http://tinyurl.com/h6cjtw2) and will regardless of the program or project selected will the City be in compliance with current orders to improve the disinfect ion of potable water? Is there any compliance to current orders or standards being held captive to this new approach? ;
8. Will the program or project, by the time of initial operation, have removed all water pipes and facilities containing asbestos. Where and how will any asbestos decommission by this program or project be disposed of? ;
9. The proposed project or program appears to require a new electrical transmission line. How much new power is required and how is it being generated? What is the resultant carbon load from this new project an? Are any carbon offsets being proposed? If the project was not operated how much carbon monoxide and related global warming pollutants would be avoided? Is this project scalable to mitigate and minimize impacts? ;
10. Has the City explored the reuse of the natural gas Rainbow pipeline 1600 to deliver recycled water South of the I-8 Freeway , In Council Districts 3, 4, 8, and 9 where the City has major parks, public facilities and landscaping; so as to reduce water demands? Specifically address the impacts on water demands if recycled water was used at the SD Airport, Balboa Park, SD Zoological, KELCO, Cholas Lake, and other Southern area major water using facilities , to reduce demand and thus the need for the project or a program at this scale. Would more purple pipe supply reduce demand? ;
11. Please analyze whether the rate increases, employment outcomes, and availability of recycled water, in the Southern area, adversely effects persons of color or low income ; so as not to advance Environmental Justice? ;
12. Please discuss and analyze whether the cost of filtering and/or processing of the waters from this program or project will increase the costs of health care, at dialysis or surgical centers, dental or other human care facilities; high technology manufacturing or research facilities; Specifically address how environmental justice is promoted if costs increase or economic costs limit health care, housing affordability, and employment opportunities? ; and
13. Please analyze the externalities that are generated by this program and project. This program and projects should not result in a transfer of costs to the general taxpayers. For example, a filter provider should not be able to provide us a filter that causes extra costs to dispose of it. They should be required to recycle all of that waste. In economics, an **externality** is the cost or benefit that affects a party who did not choose to incur that cost or benefit.[1] Economists often urge governments to adopt policies that "internalize" an externality, so that costs and benefits will affect mainly parties who choose to incur them.[2] [See: https://en.wikipedia.org/wiki/Externality]. I urge the staff planners to be more conscious of the trend towards externalities and suggest consideration of the SEEA Environmental Accounting document standards http://tinyurl.com/hdp6y94 .

I request written responses to my comments and inquiries. I request that my comments be published in the same size font as the response document is presented. I request timely notice of all future opportunities to comment and participate in any public hearings on these matters. These studies should be re-noticed by using both the annual Safe Drinking Water Report and the regular billings for Water, Storm Water, and Sewer. Please prevent even the appearance of ex parte communications consistent with local, State and Federal Law, as expressed in City Attorney Legal Opinion LO 90-2 (See: http://tinyurl.com/hyw7d76.) .

All the best,

/s/ John W. Stump, San Diego resident, ratepayer, and taxpayer

CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

Pure Water San Diego Program // AUGUST 25, 2016

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A. Comment: Please observe the prohibition on exparte communications to "decision makers" who foreseeably could serve ~~as~~ a quasi judicial manner See City Attorney Legal Opinion 90-2 Please assure public that there have been NO contacts with planning commissioners or City Council outside of public hearings

B. How much water is lost in the delivery system Before meter and other side of meter.

Name: John Stump Signature: [signature]

Address: 2413 Shamrock City Heights CA 92105

Use back of sheet if additional space is needed.

C *Comment continued:* What provisions have you made to PRESERVE & RESTORE Habitat. Will project increase Habitat?

D. Please describe how current water supply is not "pure" Is our current water neither pure or safe?

E. Your slide on 5 steps indicates that water will be disinfected by "ozonization" are you representing that the project will eliminate all chloramine treatment. Is chloramine elimination of chloramine going to happen regardless of project alternative selected?

F. You stated there is going to be a "Cogeneration plant" what is the market value of this Cogeneration? Is this cogeneration going to be sold at market rate from one enterprise fund to another enterprise fund?

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CITY OF SAN DIEGO

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Comment: G. Why do you need to "Blend" water? Is it not pure when it is put in the reservior? How long must the the water mix before its pure?
H. How much ~~water~~ treasurer has been sunk into this scheme?
I. What will this cost the to ratepayers?
J. What are your estimates of Methane loss or venting from the Co generation? What vented volumes?

Name:

Signature:

Address:

Use back of sheet if additional space is needed.

Comment continued: K. What is the smallest chemical that will be pulled out of water than now.

L. Will over time and long operation, there be increased concentration in the rest reservoir or pured water?

M. Your presentation misrepresents your support from the environmental community. Please do not present that the environmental community supports this proposal. I have been an environmentalist

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for more than 50 years and I do not yet ~~suggest~~ support this project

N. What waivers are you asking for? What waivers are in place now? ~~to~~. How long have these waivers been in places. What sewer and water volumes have been waived?

PRA Request below in "Q"! Page 5 of 6

CITY OF SAN DIEGO

DEVELOPMENT SERVICES DEPARTMENT

PUBLIC SCOPING MEETING

Pure Water San Diego Program // AUGUST 25, 2016

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Comment: Q. Your presentation refers to "aquifers" what are there ~~your~~ aquifers and what are there volumes and refresh rates?
P. Why are you not recharging aquifers as an alternative?
* Q Public Records Request for minutes agendas, and all documents concerning the consultations and formation of the listed environmental groups please respond in writing

Name: Signature:

Address:

Use back of sheet if additional space is needed.

Comment continued:

My letter of 8/25/16 is herein incorporated by reference

[signature]

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The City of
SAN DIEGO
Development Services Department
ATTN: Mark Brunette
1222 First Ave., MS 501
San Diego, CA 92101

Why not substitute this water Now for all the bottled water purchased by city departments like Mayor, Council and Fire

Pure Water Comments

Robert C. Leif, Ph.D., (619)582-0437. Rleif@rleif.com

August 25, 2016

1) Each member of a reverse osmosis array needs to have its own conductance detector.
2) A Ph.D. biomedical engineer, microbiologist, and/or molecular geneticist with perhaps postdoctoral training should be in charge of the management of the quality of the purified water. This person should have the right to report to the Mayor and Council on questions of water quality.
3) The results of purification of the following water samples need to be reported:
    a) Present Raw input (Colorado River) water
    b) Existing Method Purified Present Raw input
    c) Present Raw input after new purification method
    d) Recycled water starting material
    e) Recycled water after new purification method.
    f) Poseidon Water

PURE WATER SAN DIEGO PROGRAM NORTH CITY PROJECT

PUBLIC ENVIRONMENTAL SCOPING MEETING

AUGUST 23, 2016 - 6:00 P.M.

SCRIPPS MIRAMAR RANCH PUBLIC LIBRARY

10301 SCRIPPS LAKE DRIVE

SAN DIEGO, CALIFORNIA

REPORTED BY JULIA LENNAN, RPR, CSR, NO. 12843

AUGUST 23, 2016 - 6:05 P.M.

SAN DIEGO, CALIFORNIA

MARK BRUNETTE: Good evening, everyone. We're going to go ahead and get the scoping meeting started.

Thank you for coming for the environmental impact report public meeting for the Pure Water Program North City Project. My name is Mark Brunette. I am the senior environmental planner in the City of San Diego's Development Services Department. These meetings are referred to as EIR scoping meetings and are for the purpose of helping to define the scope of work for the EIR. The City's environmental review staff scheduled this meeting to gather public input prior to the preparation of the project's environmental documents.

Environmental review staff are required by the City's municipal code to provide the public and design makers with independently prepared environmental documents which disclose impacts to the physical environment. This information is used by decision makers as part of the deliberative process in approving or denying a project. The environmental document does not recommend approval of her denial but is provided as information on the environmental impacts of the project.

I'm going to go through a few comments about how we'll be conducting the meeting this evening. First, I'm going to provide a brief description of the project, followed by a short presentation by the Applicant.

This meeting is designed to get as much public input on areas that need to be addressed in the EIR in the time allotted; therefore, each speaker is asked to introduce themselves, state their address, and complete their comments within three minutes.

This entire meeting, if we have a lot of people -- if we get more people, would last approximately an hour and a half and would end at 7:30 p.m. If after the people who are here who comment have no more comments and there is no one else left, we will end the meeting early.

In addition to verbal comments, which are being recorded, there are forms available on the table over here from the City upon which you can provide written comments. We will need to have these comment forms submitted to City staff by the close of the meeting, or you can mail the completed form with your comments to the address listed on the back page. It is a three-fold sheet of paper, two-sided, so all you have to do is put a stamp on it, and you can mail it directly to me.

Please remember to put your name and address on the sign-in sheet before you leave the meeting if you would like to receive the notice of availability for the draft EIR, and if you have an email address, go ahead and put that on in place of your street address because we can mail a public notice which will have a link to the EIR at a later date.

Please refrain from conducting a debate on the merits of the project at this meeting as this is not the purpose for tonight's gathering. Rather, please focus your comments on those environmental impacts you would like thoroughly analyzed in the project's environmental document.

Lastly, I will be acting as the moderator and timekeeper for the duration of the meeting and, therefore, would respectfully request that you yield when notified that your three minutes are up.

Thank you for your patience, and we'll begin with the project description and then a brief presentation by the Applicant.

Oh, also we have a Spanish interpreter here. If anyone needs an interpreter, just let me know.

This meeting is being conducted in accordance with CEQA for the Pure Water Program's North City Project. Today is Tuesday, August 23rd, 2016. It's a little after 6:00 p.m.

The Bureau of Reclamation and the City of San Diego will prepare a joint Environmental Impact Report/Environmental Impact Statement to evaluate the effects of the North City Project, the first phase of the Pure Water San Diego Program or the Pure Water Program.

The Pure Water Program is a water and wastewater facilities plan to produce potable water from recycled water. The Pure Water Program consists of the design and construction of new advanced water treatment facilities, wastewater treatment facilities, pump stations, and pipelines.

The proposed project will expand the existing North City Reclamation Plant and construct an adjacent North City Pure Water facility with a purified water pipeline to Miramar Reservoir. A project alternative would install a longer pipeline to deliver product water to the larger San Vicente Reservoir.

Other project components include a new pump station and force main to deliver additional wastewater to the North City Water Reclamation Plant, a brine discharge pipeline, and upgrades to the existing Metropolitan Biosolids Center to accommodate additional biosolids from the increased treatment capacity at the North City Water Reclamation Plant.

A new electrical transmission line is proposed connecting the North City Water Reclamation Plant to the future cogeneration facility at the Metropolitan Biosolids Center to deliver power for North City Project components. The electrical transmission line will cross Marine Corps Air Station Miramar and will require approval of the United States Marine Corps.

With that I'm going to turn over the microphone to the Public Utilities Department staff, and they'll give a brief presentation.

BRENT EIDSON: Good evening. My name is Brent Eidson. I'm with the Public Utilities Department, and I'm here to provide you an overview of the Pure Water Program and then also to get into more of the specifics about what is included in the reason we're here today, the Phase 1 project of the Pure Water Program.

So first, a little bit about Public Utilities Department. We are both your wastewater and water service providers. We serve about 2.5 million wastewater customers versus 1.3 million water customers. Why the difference? We also have contractual obligations with 12 other agencies here in the region to treat their wastewater, and so we are a regional wastewater provider, not just the City of San Diego wastewater provider. As you can see from some of these other numbers, we're a fairly large department with a lot of activity that's happening.

First, I want to talk a little bit about our current water supply. We import between 85 to 90 percent of our water from outside of the region between the Colorado River and the Sacramento Bay Delta, and what's important to note on this screen as it's relative to the Pure Water Program is all of these dots that you see located here along these two watersheds. Those are different discharge permit holders upstream from us.

This gentleman asked me a question earlier how many upstream discharges are there from our water supply, and there's already over 400 that discharge into our water system or our water supply and conveyance systems. Because of this imported water challenge, we face a number of obstacles. First, as you can see from the graph on the right, the cost to buy that same drop of water has increased by three times since 2000, and now it costs us $1200 to buy an acre-foot of water versus $400 in 2000.

We also have to be mindful of recurring drought, which we've all witnessed over the last few years, and then also culminating with some State-mandated reductions. We have to be cognizant and prepared for population growth, as well as other factors that might impede our imported water supply, such as natural disasters along those two water supply lines.

So as we mentioned, we're in a pretty severe drought, and before the drought really took hold, we had already started talking about how can we become more independent for our water supply, and that's where Pure Water was born. And so in addition to Pure Water, though, we do have other activities underway. First and foremost is conservation, of course. We all have learned to get better and to use less water, and we appreciate that.

Recently the region has a new desalination plant providing about 7 percent of our treated water every day. The City is also working on some groundwater development. Admittedly, our groundwater basins are pretty small, and they're not connected, so the yield from those groundwater basins aren't as great as some you might see up in Orange county, LA, or in the Central Valley.

As you probably know, in this community we do have recycled water, which is tertiary treated water, and that water is eligible to be used for irrigation purposes, as well as some industrial purposes, and you'll notice it by the purple color of the piping. And then what we're here to talk about today is Pure Water, and this is our program that will convert recycled water into drinking water.

So we have done a lot of work on proving the technology, and this is definitely a safe, reliable, and it would be a cost-effective approach to providing new water supply for our city.

A little bit about our existing system: This graph, as you can see, starting here at the lower level, started with the reservoir. And whether that's from local runoff or imported water, our water goes to the reservoir, goes to a drinking water treatment plant, and then it's delivered to all of our customers in their homes and businesses.

Right now we have a little bit of water that goes to a water reclamation plant, but the majority of it is treated and discharged to the ocean. Pure Water will help close this water cycle by taking more of this water, treating it, and taking it to the reclamation plant, which, I'm going to talk about in a moment, is being expanded, and from there it will go to a Pure Water facility where it's treated to a very high standard, nearly purified water, before being reintroduced to the reservoir and continues the cycle again.

So we use at -- now, what I'm going to talk about here is after recycled water. So we're starting -- consider this starting at the purple pipe. We've already treated it to purple pipe standards, very high-quality standards.

From there we have five additional treatment processes before we transfer it to a reservoir. I don't know if they mean a whole lot to you, but I'll tell you what they are. They're ozonation -- you add ozone, actually, to the water. That helps clean it a bit -- biologically activated carbon -- that helps with further filtration -- and then also membrane filtration, which is like hollow straws that water molecules can pass through but many other elements in the water cannot. And then reverse osmosis is really the workhorse of this train, and this is where water is pressed through membranes at high pressure, and, essentially, the only thing that can pass through that is water molecules. But just to be safe, we also add UV light and advanced oxidation, which is a chemical reaction which, if anything was left in the water after reverse osmosis, would kill anything in the water.

We've been running this demonstration facility over at the North City Plant since 2011. In the last couple years, we added the first two elements of that treatment process. We ran it for the majority of the time with three treatment trains, which proved after 28,000 lab tests that we met or exceeded all state and federal drinking water standards for that demonstration water. The water quality is absolutely exceptional. In fact, if you come take a tour, you can taste it yourself, and tours are free to the public.

And then one of the major considerations is how much energy are you going to use. Well, think about how far we bring water from out of our community. We have to pump that water over several mountain passes, and so our energy use is going to be comparable to imported water, maybe even less, and I'll tell you why in a moment.

At the end of the program in 2035, we will be producing a third of our city's water right here in the county. The first phase would produce 30 million gallons per day, and that's what we're here to talk about tonight, and that will be at the North City, location, and it will transfer the water to the Miramar Reservoir.

Phases 2 and 3, as you can see, would be new facilities in the central area, and that water would either go to Lake Murray or San Vicente and, if needed, a new facility down in South Bay, which would then put the water to the Lower Otay Reservoir.

So Miramar, Murray, and Lower Otay is where the City has their already existing three drinking water treatment plants, which is, of course, an important component of this process, is to be able to push the water back through a drinking water treatment plant.

Today, though, what we're talking about is Phase 1, North City, and Phase 1, North City, is comprised of a new pump station essentially at the base of the University of San Diego down there along Morena Boulevard, and that will convey new wastewater because we need to expand our water -- North City Water Reclamation Plant, and then we'll build a new Pure Water facility and then pump station and pipeline. I have more slides on those. I'm not going to try to go over it quickly. I'll talk about them in a little more detail.

What's not part of the scoping, but it's important to know, is that because more solids will be created, we're working to expand our Metro Biosolid Center, working with a landfill to capture landfill gases and create new generation of electricity.

Remember, I told you it would be comparable to imported water? With this cogen facility, we'd be able to be using renewable energy right here in San Diego and not having -- we'll be able to reduce our need from SDG&E.

AUDIENCE MEMBER: Will you be capturing methane also from these plants and using that as an energy source or not?

BRENT EIDSON: Yeah, that's part of the cogen.

AUDIENCE MEMBER: Okay.

BRENT EIDSON: So this is a little bit about the schedule. I know these are hard to read, but just to give you a little sense, we've broken it down into, you know, different facets that we need to do, from outreach, to doing the environmental impact report, regulatory approval, and then, of course, construction of Phase 1. And so as you see, we're here in 2016, and we're out doing design and here starting the environmental documents and talking with you tonight about the scope of the plan.

First, let me give a little more detail about the Morena Pump Station and Pipeline. This will be a brand new facility down along Morena Boulevard, and from there we will have to construct two pipelines, one to move wastewater up to North City Water Reclamation Plant, which will be expanded, and then also a second pipeline that will bring brine -- which is, you know, a more concentrated byproduct of the treatment process --

back down to Point Loma for further treatment.

As you can see from the slide here, that we will also -- are cognizant of some very interested and impactful areas, including environmentally sensitive areas and high-traffic areas that we may be doing trenches, construction, to avoid those.

That Morena Pump Station and Pipeline will transfer that water to the existing North City Water Reclamation Plant, which, as we mentioned earlier, is where we treat our water to purple pipe standards, and then that will be expanded to allow for the expansion of -- to allow for the continued distribution of recycled water to our existing customers, as well as accounting for the new Pure Water Facility that's going to need product -- or source water, I should say.

So if you've been to the North City Plant -- hopefully, you have -- you've seen that -- this might mean something to you, but right now we have our Pure Water demonstration facility right here. Just to orient you, this is Interstate 805 northbound, and then this is eastbound Miramar Road.

So we have our existing demonstration facility, which, again, I really encourage you to come take a tour of, but this is the new type of outline of where the new structures will be in order to expand the plant to allow for the new amount of water we're going to need for Pure Water.

Across the street on property that the City already owns is where the new Pure Water Facility will be located. This is the facility that will have that five-step advanced treatment process we spoke about earlier.

Once that water has been purified, then, at this facility, we will be constructing a pump station -- again, those are the steps, sorry. You've already seen that -- we'll be constructing a pump station right on-site that will then help to convey the water through a new pipeline the eight miles out to Miramar Reservoir.

Again, as we mentioned, on Morena Boulevard Pump Station, we will be doing some mitigation of high-impact areas through either microtunneling or trenchless construction.

At the Miramar Reservoir, then, we will have to build a small dechlorination facility, and that is so that we have dechlorinated water going in at the pump station at the new purifying facility. We will add chlorine to make sure that nothing -- that the water is safe as it travels those eight miles, and then you dechlorinate it. And then it will be entered into the lake through an underwater pipeline, and that is necessary for us to be able to have the water enter at the point of the lake where we need it to enter.

So we're also committed to sustainability. I mentioned a bit about the cogeneration where we'll be able to have renewable energy that will be providing the power for this facility, but we're also going to meet silver certification for our facilities, and we'll be doing waste aversion and recycling of our construction materials. And at the end, this will provide us with, as we said, safe, reliable, and sustainable water supply.

To give you -- I didn't tell you earlier, but the first phase is 30 million gallons per day. The total all in both phases will be 83 million gallons per day, and that will get you to your third. So the 30 is about a 15 percent water supply for our city.

Over the years we've been working hard with our stakeholders and our community to get support. As you can see here, we've been able to get a lot of organizations, both from the environmental community as well as from business groups and education and other water agencies, to support the Pure Water Program.

So with that, that concludes my portion of the presentation, and I'll turn it back over to Mark, who will talk about --

AUDIENCE MEMBER: Will you take any questions at this point?

MARK BRUNETTE: Actually, what we'd like to do is get into the public comment, and possibly at the end of that, at the end of the meeting, we might be able to answer some questions, or put some questions on your comment form, but we'd like to get into public comment right now, so I'd say hold your questions until afterwards.

Well, thank you for the presentation and overview of the project. I will now open up the meeting to public comment. Please remember that all comments are limited to three minutes.

So, I guess, if you want to come up to the microphone here, anyone who wants to speak.

AUDIENCE MEMBER: Yeah, my name is David Feather. I live in Scripps Ranch.

You want my address?

MARK BRUNETTE: Please.

AUDIENCE MEMBER: 9899 Caminito Rogelio, San Diego, 92131.

And I have a question for Brent, and it's basically -- the full process starts with the purple pipe process, followed by a Pure Water process, and my question is: Is that identical process and the steps in it being followed by any other community, and if, what communities?

BRENT EIDSON: Sure. Orange County has a large hundred-million-gallon-per-day facility that uses the three treatment steps. So they start with recycled water, as we would, and then they go with microfiltration, reverse osmosis, and then UV with advanced oxidation. So Orange county uses the three treatment steps, and then they go and deliver it in -- with their product water in a groundwater basin.

AUDIENCE MEMBER: An aquifer.

BRENT EIDSON: In the aquifer, which we don't have, as I mentioned earlier, and so we are going through a reservoir.

So in working with the State regulators, we've come to a path forward where we're adding these two additional treatment steps at the front end, and that's why it's not exactly the same. We're actually giving more treatment than anybody else.

AUDIENCE MEMBER: But it hasn't been proven on an industrial scale. In other words, we're not replicating something that Orange County did.

BRENT EIDSON: It's --

MARK BRUNETTE: If I can interrupt, the purpose of the meeting is really to focus on comments, on issues you'd like the EIR to cover. So let's try to focus on those comments, and then possibly at the end of the -- again, at the end of the meeting, if we have time, maybe some questions can be answered, but let's focus on comments.

And I can give you the mike, but I don't know if it's --

AUDIENCE MEMBER: That's fine. Wes Danskin, 10387 Rue Finisterre, 92131. I'd like the EIR to address other places in the world where an identical system has been used, if any.

MARK BRUNETTE: Okay. Thank you.

And were there other comments?

AUDIENCE MEMBER: Have you all done a cost analysis as to whether it is cheaper purifying all of the water to a high degree or putting in separate pipelines for irrigation purposes versus potable water that you -- because most people -- more of the water is used for irrigation than it is for household tasks.

MARK BRUNETTE: That's certainly something that we're taking down in the record and we'll look at. We're not going to answer questions --

AUDIENCE MEMBER: I understand that.

MARK BRUNETTE: -- here today, but that comment is noted --

AUDIENCE MEMBER: Okay.

MARK BRUNETTE: -- and staff will look at that issue.

AUDIENCE MEMBER: Can I amplify on that? I'd like the EIR -- my name is Wally Wulfeck. I am the chair of the Scripps Ranch Planning Group. My address is 12517 Fairbrook Road, 92131.

I would like the EIR alternatives to consider expanding the purple pipe program and, alternatively, also analyzing the negative consequences of reducing support for the purple pipe program that has been the stated policy for the past several years of the water department.

Here in Scripps Ranch, we have -- a simple 1-mile extension down Miramar Road would open up the availability of recycled water to a large number of public City-owned parks, as well a bunch of HOA-maintained open space areas.

It makes no sense to purify water completely and then spray it on grass, so the EIR needs to analyze quite carefully the impacts on the purple pipe program as an alternative to this. It should be included as part of the program in order to expand it.

One other comment is, please consider an alternative route for the pipeline from -- instead of under Miramar Road. Instead, consider going through Carroll Canyon, the Corley area, that is expected over the next several years to become a major housing development. So it would be much smarter to put that new -- the new pipes under the to-be-constructed Carroll Canyon Road rather than digging up Miramar Road once again.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: Hi. My name is Ruth Feather. I live at 9899 Caminito Rogelio in San Diego, 9213l, in Scripps Ranch here.

What precautions have been taken in the event of a power outage like we had in 2011 when we had -- when all -- we had a terrible power outage. What precautions are taken at these various facilities?

So if the pumps go down for untreated water or water that isn't treated properly coming into homes, will all the water just stop, or is untreated water that's not purified totally coming into our homes and therefore polluting all of our pipes, our homes? What's the plan on that?

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: My name is Larry Peranich. I live at 11745 La Colina Road, San Diego, California, 92131.

My main concern is about this -- while I support the project, from an environmental standpoint, I'd like to make sure that electrical usage is minimized, if at all possible; therefore, I'm assuming the alternative out to San Vicente Reservoir would use more electricity for pumping than Miramar. If that's the case, I'd support the Miramar Reservoir plan. So that's my main concern.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: Hi, I'm Greg Lichtenstein, live at 12265 Rue Cheaumont, 92131.

And I don't see in the health and safety section here anybody addressing the issue of antibiotics in water. You mentioned that were downstream from 400 waste treatment sites. So as you know, people excrete antibiotics through urine and feces that they've been given. There's a concern about increasing antibiotic resistence in bacteria. I'm just wondering how effective, maybe, reverse osmosis is at removing the antibiotics so we don't keep recycling, recycling, recycling those contents.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: John Todd, 11122 Promesa Drive, San Diego, 92124.

And for years we've been reading about how the

City of San Diego has failed to meet water quality standards for the discharge into the ocean.

What assurances are we going to have that they are going to suddenly be able to meet the standards that are called for in this project?

MARK BRUNETTE: Thank you. Any other comments?

AUDIENCE MEMBER: Wes Danskin, 10387 Rue Finisterre, 92131.

I'd like a robust field trial with measurable tracers in Miramar Lake to document the mixing that is believed to occur.

MARK BRUNETTE: Thank you.

Is there anyone else who wanted to make a verbal comment?

AUDIENCE MEMBER: Dave Feather again, 9899 Caminito Rogelio, San Diego 92131.

I'm sure this is answered, but for my edification if it hasn't been, could you please compare the cost per acre-foot of this process, total, from -- beginning with purple -- or including purple pipe step, followed by the Pure Water step -- what's its total cost, fully loaded -- with the Poseidon cost up in Carlsbad.

MARK BRUNETTE: Okay.

AUDIENCE MEMBER: I don't have a clue how they stack up.

MARK BRUNETTE: Thank you for your comment. We've got that on record. Thank you.

AUDIENCE MEMBER: Thank you.

MARK BRUNETTE: Were there any other comments?

Doesn't look like it. You also have the -- you can do written comments over at the table there if you'd like.

Again, thank you very much for your comments, and, again, no one else wishes to speak or offer a comment?

Okay. Seeing that there's no other members of the public that want to speak to the item, I'm going to go ahead and close this meeting and make a few closing remarks.

This closes the public environmental scoping meeting for the Pure Water San Diego Program North City Project. Your input will be transcribed, considered by City staff for use in the scope of the EIR, and included as part of the official record for the document.

Speakers and commenters who provided their contact information will also be placed on the notification list for further environmental review actions related to the project. So if you haven't put your name on the sign-in sheet, please do so before you leave, and you'll receive future notices.

I would also like to remind everyone that this is just the start of the environmental review process and opportunities for public input. There will be other opportunities to provide comments on the project, such as during public review of the draft environmental document and in any further public hearings on the project.

Thank you for taking the time to participate in the meeting, and have a great evening. Thank you.

(The proceedings concluded at 6:38 p.m.)

* * *

STATE OF CALIFORNIA)
)
COUNTY OF SAN DIEGO)

I, Julia Lennan, a Certified Shorthand Reporter for the State of California, No. 12843, and Registered Professional Reporter, No. 8269, do hereby certify:

That the foregoing proceedings were reported stenographically by me and later transcribed through computer-aided transcription under my direction and that the foregoing is a true record of the proceedings taken at that time.

I do further certify that I am in no way interested in the outcome of this action or connected with or related to any of the parties in this action or to their respective counsel.

In witness whereof, I have hereunto set my hand this 2nd day of September, 2016.

____

JULIA LENNAN, RPR, CSR NO. 12843

PURE WATER SAN DIEGO PROGRAM NORTH CITY PROJECT

PUBLIC ENVIRONMENTAL SCOPING MEETING

AUGUST 25, 2016 - 6:30 P.M.

SAN DIEGO PUBLIC UTILITIES DEPARTMENT

9192 TOPAZ WAY

SAN DIEGO, CALIFORNIA

REPORTED BY JULIA LENNAN, RPR, CSR, NO. 12843

AUGUST 25, 2016 - 6:35 P.M.

SAN DIEGO, CALIFORNIA

MARK BRUNETTE: Good evening, everyone. I'm going to go ahead and get started.

Thank you all for coming to the environmental impact report public meeting for the Pure Water Program North City Project. My name is Mark Brunette. I'm a senior environmental planner in the City of San Diego's Development Services Department.

These meetings are referred to as EIR scoping meetings and are for the purpose of helping to define the scope of work for the EIR. The City's environmental review staff scheduled this meeting to gather public input prior to the preparation of the project's environmental documents.

Environmental review staff are required by the City's municipal code to provide the public and decision makers with independently prepared environmental documents which disclose impacts to the physical environment. This information is used by decision makers as part of the deliberative process in approving or denying a project. The environmental document does not recommend approval or denial but is provided as information on the environmental impacts of a project.

I'm going to go through a few comments about how we'll be conducting the meeting this evening. First I'm going to provide a brief description of the project, followed by a short presentation by the Applicant.

This meeting is designed to get as much public input on areas that need to be addressed in the EIR in the time allotted; therefore, each speaker is asked to introduce themselves, state their address, and complete their comments within three minutes.

This entire meeting, if we end up having a lot of people, would last approximately an hour and a half and would end at 8:00 p.m. If after the people who are here who comment have no more comments and there is no one left, we will end the meeting early.

In addition to verbal comments which are being recorded, there are forms available on the table over here from the City upon which you can provide written comments. We will need to have these comment forms submitted to City staff by the close of meeting, or you can mail the completed form with your comments to the address listed on the back page. It is a three-fold sheet of paper, two-sided, so all you have to do is put a stamp on it, and you can mail it directly to me

Please remember to put your name and address on the sign-in sheet before you leave the meeting if you would like to receive the notice of availability of the draft EIR, and if you have an email address, go ahead and put that on in place of your street address because we can email the public notice which will have a link to the EIR later on.

Please refrain from conducting a debate on the merits of the project at this meeting, as this is not the purpose of tonight's gathering. Rather, please focus your comments on those environmental impacts you would like thoroughly analyzed in the project's environmental document.

Lastly, I will be acting as a moderator and timekeeper for the duration of the meeting and, therefore, would respectfully request that you yield when notified that your three minutes are up.

Thank you for your patience, and we'll begin with a project description and then a brief description by the Applicant. And I also need to mention we have a Spanish interpreter here. Just let us know if you need the interpreter to help you out.

This meeting is being conducted in accordance with CEQA for the Pure Water Program's North City Project. Today is Thursday, August 25th, 2016. It's a little after 6:30 p.m.

The Bureau of Reclamation and the City of

San Diego will prepare a joint Environmental Impact Report/Environmental Impact Statement to evaluate the effects of the North City Project, the first phase of the Pure Water San Diego Program or Pure Water Program.

The Pure Water Program is a water and wastewater facilities plan to produce potable water from recycled water. The Pure Water Program consists of the design and construction of new advanced water treatment facilities, wastewater treatment facilities, pump stations, and pipelines.

The proposed project will expand the existing North City Water Reclamation Plant and construct an adjacent North City Pure Water facility with a purified water pipeline to Miramar Reservoir. A project alternative would install a longer pipeline to deliver product water to the larger San Vicente Reservoir

Other project components include a new pump station and force main to deliver additional wastewater to the North City Water Reclamation Plant, a brine discharge pipeline, and upgrades to the existing Metropolitan Biosolids Center to accommodate additional biosolids from the increased treatment capacity at the North City Water Reclamation Plant.

A new electrical transmission line is proposed connecting the North City Water Reclamation Plant to the future cogeneration facility at the Metropolitan Biosolids Center to deliver power for North City Project components. The electrical transmission line would cross Marine Corps Air Station Miramar and will require approval by the United States Marine Corps.

With that, I'm going to turn over the microphone to the Public Utilities Department staff, and they'll give a brief presentation.

AMY DORMAN: Thank you. Good evening. My name is Army Dorman, and I'm with Public Utilities, and I'll go through this quick presentation to give you an overview of our program. These first few slides give you some information about the systems that we operate, as well as the key drivers as to why we have embarked on this Pure Water Program.

So Public Utilities operates both a water and wastewater system. On the water side, we serve 1.3 million customers, primarily within the city of San Diego, and on the wastewater side, our service area is much larger. It not only serves the City, but also 12 other agencies in the region, where we collect their wastewater and treat it at Point Loma.

Operating and maintaining a system requires a large capital investment to keep them in proper working order. We spent over 800 million in the last five years to maintain and keep them in proper working function. On an annual basis, the single largest line item on our annual budget is the cost of imported water. In this past year, we spent over $200 million on imported water purchases.

We have historically relied heavily on imported water. About 85 percent of the water that we need is imported to San Diego, and we are at the far downstream end of the line, and so as a result of this, we are using water that has already been used and reused hundreds of times over by the communities who are upstream of us.

And so with that heavy dependence on imported water comes a variety of challenges. First, there are court-ordered restrictions that limit how much we can pump from the Bay Delta. The pumps have to be shut off a couple times a year, and that's in order to protect the environment in that region.

Also, earthquakes are a threat to the infrastructure that delivers our water. If one was large enough, it could interrupt the aqueduct supplies to our region. And also the cost of the water has tripled since the year 2000, and there aren't any signs of that rate of increase slowing.

And then, finally, we are in our fifth year of drought. Our drought cycles are seeming to last longer with shorter breaks in between. This last winter we did get normal rainfall; however, as early as May, the State reported that our snowpack levels were already far below normal levels, so we're still in the thick of a drought.

So San Diego's approach is to develop a variety of local supplies, and conservation is one that we've actively done for the last -- well, the City has had a program in place for the last 30 years, and San Diegans have really embraced some of those principles. So in 1990 our water consumption was actually higher than it is now, and so that's a result of people changing out their plumbing fixtures and replacing their turf for more drought-tolerant landscape.

And then moving to desal, last year the region's first desal plant began operating up in Carlsbad, and it's run by the County Water Authority, and at a 50 MGD capacity, it serves about 7 percent of the County's water needs. And we are studying the potential we have for groundwater supply; however, our basins are limited.

In the late '90s, we began recycling more water, providing it to mostly irrigation and industrial customers who use it for nondrinking purposes, and now we would like to implement Pure Water.

So what is Pure Water? It's a local supply concept that's safe. It's based on proven technology. The technology is capable of producing water --

AUDIENCE MEMBER: Are we not getting pure water now?

AMY DORMAN: No, we're not getting it now.

AUDIENCE MEMBER: So it's polluted water or what is it? What kind of water do we get?

MARK BRUNETTE: Actually, if she can finish her presentation, and then --

AUDIENCE MEMBER: I don't want her to -- I want a factual presentation, not a presentation --

MARK BRUNETTE: Okay. Well --

AUDIENCE MEMBER: -- that leans us one way or another.

MARK BRUNETTE: If we can just let her finish her presentation, and then you can make comments when she's done. Thank you.

AUDIENCE MEMBER: Okay.

AMY DORMAN: So in addition to being safe, Pure Water is reliable. It's something that would be available in both normal rainfall years, as well as drought years, and it's cost-effective.

So we currently operate a primarily single-use system where we treat the water, provide it to our customers, and then we take their wastewater and treat it at Point Loma, after which it's discharged to the ocean.

We are able to recycle a small portion of that water. About 8 percent of our total water need is recycled for those nondrinking purposes that I described earlier, but, again, that's only 8 percent of our total need. And with Pure Water, we will be able to purify that recycled water so that it's safe to put back in our water supply reservoirs, and then we can complete that cycle and be able to utilize all of our recycled water.

So Pure Water is based on proven technology. We would treat the water to a tertiary level and then subject it to this five-step treatment process: It starts with ozonation. It's followed by biological filtration, then membrane filtration, reverse osmosis, and UV. And the purpose of using these treatment steps one after another is to just make sure that no contaminants are able to get through.

And so we have a 1 million-gallon-a-day test facility. It's up at our North City Reclamation Plant. We've been testing the technology for the last five years. Through that extensive testing, we've done numerous lab tests. Samples have been analyzed at outside labs, and the results all show that the water has exceptional quality.

So Pure Water is a program that we're going to implement in phases from now to 2035, and by that time our plan is to produce 83 million gallons a day, and that will be a third of our need. In Phase 1, which is the subject of this EIR, we'll be delivering the first 30 MGD by 2021, and the focus is all at North City. The remaining 53 will come from a combination of facilities located in the central and southern parts of the city, and in those phases we'll be utilizing other City reservoirs, Lake Murray and Lower Otay, and their adjacent treatment plants.

And so this slide just gives you a closer view of the Phase 1 facilities. It will start with the Morena Pump Station, which will be located near Morena Boulevard and Friars Road. We'll be building a new wastewater pump station, as well as an 11-mile force main, to send additional wastewater to North City.

We have an existing 3 million-gallon a day reclamation plant. We're going to expand that so we can continue to serve our purple pipe customers, as well as to provide recycled water to the new purification facility across the street. And this will house that five-step purification process to purify the water, and then it will be conveyed to our Miramar Reservoir about

8 miles away.

In addition to our Phase 1 Pure Water facilities, we'll also be building a cogen facility next to our Metro Biosolids Center, and this facility will take landfill gas and generate about 16 megawatts of power, and a portion of that will be transmitted to North City to support our new purification plant.

And this gives you a high-level look at our schedule. We are currently in design. All of our projects completed preliminary design last calendar year. Design is scheduled to complete in mid-2018 and then construction to start in early 2019 and be completed it 2021.

So these next slides walk you through the individual projects. Again, Morena, our new pump station, would be located off of Friars Road. We'll build an 11-mile pipeline to convey the wastewater up to North City, and then we'll also be taking waste from the purification process and bringing it back down to bypass that pump station so that it doesn't just recirculate.

AUDIENCE MEMBER: Can I ask you something while you're on that slide?

So is that the same -- you're going to have two separate pipes next to each other, one will be pumping north -- everything north, and the other will be pumping south?

AMY DORMAN: Correct, two separate pipelines.

AUDIENCE MEMBER: And how far apart are they separated?

MARK BRUNETTE: Again, I want to try to wait on questions. This is really intended that she does her presentation, and then what I would suggest is that you can pose those questions in the comments when we have the comment period.

AUDIENCE MEMBER: But questions won't be part of the limitation on our comments, would it?

MARK BRUNETTE: No, no. I'm just saying --

AUDIENCE MEMBER: Okay. So we're going to have a comment -- or a question period and then a comment period.

AUDIENCE MEMBER: How are we going to know what to comment on if we can't --

MARK BRUNETTE: Well, actually, this isn't set up to be a dialogue and to be a question --

AUDIENCE MEMBER: It should be.

MARK BRUNETTE: -- and answer.

Well, I understand. That's the way it's set up, and we're here to take input from you. If there's time at the end of the meeting and if Public Utilities staff is available -- they may be available to answer questions, but, again, the intent is for you to provide input for things that should be analyzed in the EIR. So let's let her finish her --

AUDIENCE MEMBER: I mean, we've got to know what's going on if we're going to make a comment, and without -- you know, Ms. Knight asked how many -- you look at the diagram, there's only one pipe.

MARK BRUNETTE: Okay. Well, again, I want to stay focused on letting her finish her presentation, and then I'll open it up to comments.

AUDIENCE MEMBER: Questions.

AMY DORMAN: Okay. So on to our North City Reclamation Plant. We will be expanding it from its current capacity, again, to continue supporting purple pipe demand and to provide tertiary feed water to the purification plant.

This is a preliminary site layout of the expansion. We will be building new basins, new filters, a pump station, and purifier. So it's quite complex, and we'll be carefully planning the sequencing of the construction just to ensure that the plant maintains operations at all times.

Across the street the Department owns a vacant parcel of land, and this will be the site for our future purification plant. It will be equipped with that five-step purification process. Again, those are ozone, biological filtration, membrane filters, RO, and UV with advanced oxidation.

The purified water will be conveyed to our Miramar Reservoir through a 30 MGD pump station located adjacent to the purification plants, and it also entails an 8-mile pipeline through Miramar Road and makes its way up to Scripps Ranch to our Miramar Reservoir.

The last mile or so of the pipeline will actually be installed within the reservoir, and the intent is to release the water at the west end -- or, I'm sorry, the east end, and this is to maximize the time the water is in the reservoir, as well as maximize blending with other supplies to the reservoir. We actually take water out on the west end of the lake.

So Pure Water is sustainable. Our buildings will be LEED certified, and during construction we'll be recycling our construction waste.

Just one last thing: Pure Water has received broad support over the years. These are the logos of organizations that have come together in organized support of the program. There are about 30 organizations shown here. So we have environmental community -- so groups like the Audubon Society and Coastkeeper -- along with the building industry and the

Taxpayers Association and many others.

So if you would like more information, you can visit our Web site at purewatersd.org or follow us on social media. So that concludes the formal presentation.

MARK BRUNETTE: Thank you for the presentation and overview of the project. I'll now open up the meeting to public comment. Please remember that all comments are limited to three minutes.

And I'm going to stress again, you can ask questions, but we're not going to answer them at this time. They will be recorded, and you can also do written comments, which will be given to staff preparing the document.

And, again, this is the first step in the process. You'll have many more opportunities to -- you know, if you put yourself on the list, you will get a copy of the draft document, and you can comment on that as well. So, again, just focus on comments. You can put questions in there, but we're not going to answer those tonight.

So I can either bring the microphone to you, or if we could come up here. What would you prefer?

AUDIENCE MEMBER: (Robert C. Leif) I prefer to go up there.

MARK BRUNETTE: Okay.

AUDIENCE MEMBER: This is a typical PR, rather than scientific engineering, meeting. It's not been peer reviewed. It should have been given as a seminar over at our major universities, a quick chemistry department would be fine.

I will now go that each member of your reverse osmosis array needs to have its own conductance detector. You need a PhD biomedical engineer, microbiologist, and molecular geneticist, someone well trained, postdoctoral training, to actually run this thing and have direct reporting rights to the mayor and council because it's a quality issue.

Now, you've never -- you talked about data, but you don't show it. What we need to know is what's the chemistry of the present raw input, primarily from the Colorado River, the existing method being applied to the present raw input, the present raw input after the new purification method, recycled water starting material, recycled water after the new purification method, and the competing Poseidon water. Without that data no one can make any rational decision.

We have a problem with the farm industry. Presently, they're discharging, as they should, to the ocean. There are certain things you can get away with.

Now, if you take that water and put it into the recycled water, I don't know, and I don't think anyone knows either.

By the way, in your assays it will be interesting to see how you measure your coliforms, what DNA you had in there, and all sorts of wonderful things in molecular biology, which I don't think you have anyone -- any real knowledge to do.

And, also, the methane production is poor. I realize it's the only way you can do coproduction now, but that has to eventually stop because the methane is such a rotten stuff when it comes to absorbing infrared light. It's much worse than Co2.

Do you have any questions, sir? Or I would put it this way: This is not a good way to have a discussion.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: Hello. My name is Ray Paulson, and a few comments.

MARK BRUNETTE: Could you also do your address as well.

AUDIENCE MEMBER: Address?

MARK BRUNETTE: Yeah.

AUDIENCE MEMBER: My address is 6369 Caminito Marcial, San Diego, 92111.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: I'm a registered professional mechanical engineer and also environmental engineer.

Back in 2001 the City of San Diego did a study on sewage treatment to tap. The engineer told the medical team he needed a microbiologist and those type professionals to certify what was in the water before he could design the system to treat it.

And they got some folks from UCSD medical team and the research scientists up there, and they came back with a comment that they couldn't certify what was in the water. They knew what they could measure for and the micro bacteria-type and virus-type stuff. They knew what they could look for with their instrumentation, but they couldn't guarantee there wasn't other things in the water.

In other words, the instrument you're looking with is limited. In life we're discovering this every day, and so how -- what's the smallest diameter bug you could have could not be answered. What's the spectrum, you know, that we can measure for, it couldn't answered. What they did say was that for what we can measure, we can tell you what's in there based on our current knowledge. So with that information the PE said, "I can't PE stamp a water treatment system for treating things that are unknown to the medical community."

How has this changed? Things evolve all the time. Like antibiotics work, and then ten years later they don't work because bugs evolve around treatment systems, and they evolve in diameter size for treatment. That's one big concern, and I haven't seen any data speaking to this.

When Orange County came down -- they've done this for some time, sewage to tap -- we've asked the same questions, and the engineer stalled and would not answer the questions, and they would not provide us data.

I think the City of San Diego -- I worked there years ago as a student engineer. Often things get rubber stamped in one district, and we start to assume they'll work in another district, and so we start to then -- we just assume things, and we don't check things out in enough detail.

The other concern is, you have -- if you take a good toxicology class at UCSD, you'll find that the medical teams will tell you they're discovering the results of poisons -- there's a lot of neat poisons out there, and when you have toilet to tap, every household is an uncontrolled source of potential sabotage of your water system.

And so there's been instances where the KKK and other terrorist groups -- like I know we have ISIS today. They're not real happy people, and they do things, and in our classes what they discussed were plans that terrorists have had to disrupt water supplies in the past, and it's very clever what they do, and it's very micro. It's below nano size in delivery systems, sometimes encapsulated in something so it won't dissolve, or it'll stay in solution, but filters can't catch it. So it's an order of magnitude below nano to get through a water treatment system. So you face an issue there because you've closed the loop.

MARK BRUNETTE: Sir, if you can kind of wrap up your comments.

AUDIENCE MEMBER: Yeah. So those are two issues. The third issue is, when you have -- global warming is not going away. I work for the Navy today, and sea rise is an issue. It's not going to turn around overnight because of the carbon released from the ocean is delayed 20 years, and we haven't reduced our combustion to date, so drought is going to be a reality for a while.

So what's filling our aquifers now, if you count on treating it with any method, your treatment -- your reject water, your evaporation, your waterline leaks, you get about a 50 percent loss when you go to treat. So you can't make up a hundred percent, and you're using a diminishing supply.

MARK BRUNETTE: Thank you for your comments, sir. We're going to have to wrap this up.

AUDIENCE MEMBER: Well, I'm wrapping up.

So it looks to be a waste of taxpayer monies to recycle sewage water, even if you could do it successfully, because you have diminishing supply.

What's promising and what the Navy is looking at is saltwater to tap because of the new graphene. Graphene is a new super material. Oak Ridge National Lab now has new RO filters with significantly reduced energy --

MARK BRUNETTE: I ask you to put the rest of it in written comments and --

AUDIENCE MEMBER: -- for treating saltwater to tap --

MARK BRUNETTE: -- three minutes each.

AUDIENCE MEMBER: -- which would -- where the money would be well spent for ensuring we have water security; otherwise, we may not. So there -- you can face major litigation on this choice for sewage to tap in these different ways.

MARK BRUNETTE: Thank you, sir.

AUDIENCE MEMBER: Deborah Knight. I'm the executive director of Friends of Rose Canyon, and one of the reasons why I was interested in asking questions is that my concerns relate to the physical construction required for this since it's an area we work on, Rose Canyon and the Rose Creek Watershed.

And a lot of the facilities that you are building, the force main -- the two force mains, as it turns out, cross Rose Canyon, and I certainly have questions about where they're chosen to cross Rose Canyon, Genesee, as opposed to going underground at Miramar.

Also, I hadn't realized that they were going to construct -- I know they're going to construct more facilities adjacent to the current plant that actually drains directly into Penasquitos Lagoon. So that's a concern.

And for the other -- the new facility on the vacant property is a property that we've actually worked to get protected in the past. Now I see something is going to be built there, but that also -- that is in the Rose Creek Watershed.

So there's a lot of construction going through and adjacent to the Rose Creek Watershed, and if I can't find out specific details about that, it's pretty difficult to comment on anything. You know, as I said, I didn't even know there were two -- you know, there were two mains. Where exactly are they going? Now I see a map. What are the other alternatives?

But I need to have some kind of information in order to make intelligent comments, suggestions, alternatives around the physical construction of facilities that will be required for this. Is there anywhere to get those? Is there someone I can call and ask those -- an engineer or someone I can call and ask those questions of?

MARK BRUNETTE: We'll see at the end of the meeting if we can --

AUDIENCE MEMBER: That would be helpful.

MARK BRUNETTE: -- give you a contact. I think the other thing is, you will also have a chance to comment on the draft EIR, which will go into much more detail and --

AUDIENCE MEMBER: Right, but once you're in -- once they've spent hundreds of thousands of dollars doing the draft EIR, they're not likely to consider options the way they are at this point. And the whole purpose of this point is to be able to make intelligent recommendations or suggested alternatives, and my experience is once you get the draft EIR, you're -- the horse is, you know, out of the barn, and legitimately so. You've spent a huge amount of money, and this is obviously going to be hugely expensive, the draft EIR. So I don't want to end up having to, you know, do this at a point way further down the line. I'd much rather be able to get the actual information and make some -- have intelligent discussions at this point in the process.

MARK BRUNETTE: And I hear what you're saying, and as I said, we'll see if we can put you in touch with someone at the end of the meeting. All of your comments have been recorded and will be given to the preparers of the EIR, but I'll see you at the end of the meeting and see if we could put you in touch with someone.

AUDIENCE MEMBER: Thank you.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: Scott Andrews, 4745 Del Mar.

I've heard that we need to resubmit our comments. I object to that. I refuse to do that. They should be part of the record. It's the same project. It's just been phased, but in the interest of brotherhood, sisterhood, transgenderhood, I'm presenting our -- the large mass of our scientific documents to you in hard copies, but I want assurance that our prior comments by email and verbal testimony are still in the record. Shouldn't have to submit those twice.

Are you asking for a permanent Clean Water Act waiver? You're leaving basic facts out of your promotional material. We need to know that.

Is the EIR for Phase 1 only? You can answer that right now.

MARK BRUNETTE: It is.

AUDIENCE MEMBER: Okay. Then we -- contraindicated to phase an EIR on a massive project of this scale.

We want to know the ocean marine life impacts. We had the NRDC and Heal the Bay scientists comment on the 2009 waiver. They hold true today. And further, we want the cumulative impacts decade by decade, year by year.

And we want mitigation for the City of San Diego's failure to comply for over three waivers now. So we want to see what they're going -- what their offered mitigation is for that failure and that intentional noncompliance.

Ocean viruses as discharged by Point Loma killed a surfer, a famous surfer in '15, 2015. What are you doing to mitigate the danger of viruses from Mexico, a third of whose discharge is raw sewage, and the stuff coming out Point Loma that comes up the coast and is pushed onto the beach by wave action and wind?

What are your population projections? Are you accepting SANDAG's projections to 2035? the original date of 2050? We need to know what your baseline data is, and you're not supplying it.

What's the optimal reclaim potential for reclaim? What is the optimal conservation number? Understand it's averaged around 20 percent, City of San Diego. Public was very responsive. We want those numbers. We want those -- if you don't have the numbers, we want the projections.

What are the conditions of the -- well, I don't know of any aquifers. I've never seen an aquifer map provided by your department. Is there a Mission Valley aquifer? Is there a Downtown San Diego aquifer? What is their condition? What is their capacity? Why are they not being used for natural filtration, as is being done in your favorite model, Orange county?

MARK BRUNETTE: Could you wrap up your comments, please.

AUDIENCE MEMBER: Regarding desalination, we want to know the online in Southern California. We want to know the proposed in Southern California and northern Mexico, because all of these alternatives I've listed in my questions could render your project totally redundant. And we're going to watch to see if you break the law by promoting this project prior to adequate, complete study.

The last point I want to make is -- excuse me.

The last point I want to make is that your notice has been very deficit. You're not notifying ocean user groups, recreational user groups, environmental groups, taxpayers of potential hikes and spikes in their fees.

I've already complained about notice, and I've complained about the notice of your meetings: two days apart, fighting traffic up to get here. So those are some other concerns.

MARK BRUNETTE: Thank you.

AUDIENCE MEMBER: Shelli Craig. My address, 7728 Laramie Court, San Diego, 92120.

I'm happy to cede whatever time I have left to you, Scott, if you would like to finish whatever else you might like to say.

But I'm confused as to why there's not another desalination plant planned for the cost of $1 billion. That's what Carlsbad ended up being, and it's about the same project time when another plant would go live.

Also, this plan does not get us any closer to water independence. We are operating on the same ever-dwindling resource, water that's imported. So I just don't think the math comes out, spending three and a half billion dollars on something that is operating on water that takes so much effort to get it clean just to put into an open body of water.

This is not a recommended way to handle this kind of water according to the EPA guidance document. In fact, there's no -- there really isn't any good guidance on water reuse like this. Really it's reuse, not recycle. Recycle, for the most part, of water like this goes to recharge aquifers. That's not anything that you've addressed. There's a lot of local aquifers that really need help, especially the local farmers. So honestly, I think that study needs to be done as well.

We need to grow food. It's simple. So, you know, without air, one minute. Without water, one week. Without food, maybe three weeks. So I understand we're close, but this isn't the right plan.

MARK BRUNETTE: Thank you for your comment.

AUDIENCE MEMBER: Thanks for ceding your time.

So the environmental -- that's an extraordinary coalition you've formed. Wasn't that formed a year or two ago? So I want the records of the meetings that prompted all those groups to sign on to your project. I never heard about them. I want those official records and minutes because they were not -- they did not have the benefit of any environmental study.

Why would any environmental group sign in to a multi-billion dollar project that affects the health of the ocean, the people who use the ocean, and the people slated to drink your water, including hospital patients on dialysis? So I want to know -- I want -- I'm formally requesting the records of those minutes. That's pretty interesting.

Regarding the three phases, are we assured that they'll all be completed on time? In other words, you used to have a total project that's now being phased in, and I want to briefly speak, and I'll complete.

MARK BRUNETTE: Sir, that's the end of her ceded time. Thanks.

We have any speakers?

AUDIENCE MEMBER: Who wants my data?

MARK BRUNETTE: Yeah, why don't you bring it up here.

AUDIENCE MEMBER: It's from our last comment.

MARK BRUNETTE: Thank you.

Hi. I'm Jim Peugh. I'm the conservation chair of the San Diego Audubon Society. I live at 2776 Nipoma Street in San Diego, 92106, and the Audubon Society supports this project and has as it's been evolving.

As far as comments on -- scoping comments of -- we're really pleased to see that the Miramar alternative seems to be working. We hope that the process will do as much as it can to make sure that works to keep the energy use down for the project.

Greenhouse gas, to us, is really important. Climate change has a huge impact on the wildlife that we appreciate, and so we urge the process to do as much as possible to reduce the greenhouse, you know, particularly the carbon discharges, and while -- we understand that methane is going -- from landfills is going to be used for this project, so we urge that that be emphasized as much as possible, you know, One, to prevent the methane from escaping and then, Two, to displace the use of carbon.

San Diego has a lot of pipe breaks, and there are a lot of things that can go wrong with this system. So we hope that the EIR will actually look and analyze the failsafe provisions, you know, failsafe as far as water quality. As far as breaking sewer lines that could contaminate areas and in the sludge lines as well -- and something else I can't read -- oh, and the chemical handling that you're doing. We want to make -- you know, we hope that the EIR will look aggressively at making sure those are all as failsafe as possible.

And just in the design of the system for maintainability, you know, we have a hard time maintaining the infrastructure in San Diego. This is a lot of stuff, so just make sure that this is designed to be maintainable as well.

And we want to make sure -- we understand there's a lot of quality control for the drinking water, and we also urge that as much quality control go into the water that's going to be discharged back into the ocean.

That's all my comments. Thank you.

MARK BRUNETTE: Thank you. Any other speakers?

Do you want me to bring you the microphone or are you --

AUDIENCE MEMBER: No. I can come over there.

MARK BRUNETTE: Okay.

AUDIENCE MEMBER: If there's another speaker that wants to go while I work my way over, that would be good. Am I going to be the last one, then?

MARK BRUNETTE: Maybe. Take your time.

AUDIENCE MEMBER: Oh, thanks. I appreciate that.

AUDIENCE MEMBER: So I'll use -- can I use ten seconds for another question while he gets here?

MARK BRUNETTE: No. I actually would ask that you put it in writing.

AUDIENCE MEMBER: Could you put the slides back up, please.

MARK BRUNETTE: The slides back?

AUDIENCE MEMBER: Yeah, I'd like the slide of the five-step process.

Now, here's -- I'm submitting for the record some written comments, which I've also submitted by email earlier today. And I'll give one to the court reporter so that she's got my proper name and address on file. Here you go, ma'am.

Hello. I'm John Stump. My name and address is on file. I took great umbrage to several misrepresentations in this presentation. One misrepresentation was the environmental community was against that -- is supporting this.

I've been an environmentalist for 50 years. I don't know where I stand on this because I can't get the information I need, and your presentation denied the public the ability to ask questions. We can only give you comments.

On this five-step process, are you representing that the current chlorine introduction will be discontinued when this goes through?

You're not responding?

MARK BRUNETTE: This is not the forum to answer the questions, but that's something that will be --

AUDIENCE MEMBER: Okay. So --

MARK BRUNETTE: -- staff will have on record.

AUDIENCE MEMBER: Because this slide represents that.

How much money has been put into this project to date? What have we sunk into this?

The most important question is -- the first question in my comments is: What are the projected costs to the rate payer, how much is this going to cost me at home, and how much is this going to make housing unaffordable?

I've got some other written comments which I made during the meeting, and I'm making a public records request -- which I think Mr. Andrews made a good point concerning the minutes, agendas, and correspondence to these so-called environmentalists.

Did they fill out conflict of interest forms? Have they received any benefit from you?

On the cogeneration, is that going to be a cost to the program because it's one enterprise fund transferring to another? I think that's got to be made clear.

I really don't like the fact that you're supposed to be a neutral body telling us facts, and yet you use euphemisms and put your thumb on the scale.

You know, I asked the young woman, "Is our water not pure today? Is it not safe today?" You know, by using that term "pure," it's either not safe today and you're really catching up, or is it going to be as pure as the water we got today?

Oh, key point: You, sir, made a statement that you were going to provide information to decision makers. Well, in my letter -- it's the last paragraph, the last sentence -- I remind you of City Attorney Policy LO 90-2, which prohibits you or anyone else that's going to be involved in the CEQA process from having ex parte communications with the legislative body because --

MARK BRUNETTE: Sir, could you wrap up?

AUDIENCE MEMBER: I'm going to wrap it up.

MARK BRUNETTE: Okay. Thank you.

AUDIENCE MEMBER: Do you understand what I'm telling you? Don't communicate outside of public hearings with city council. Amongst yourselves at the executive branch and the mayor, that's okay, but we have a separation of powers now, and it is inappropriate, since they will be the quasi-judicial body, for you to have any communication outside the public hearing or a council meeting with that body.

Thank you very much. I've submitted written comments, and I've got some more that I'll submit at the end of the hearing.

MARK BRUNETTE: Thank you. We have anyone else who wanted to speak?

AUDIENCE MEMBER: May I -- I have a question, just simple.

Is the PowerPoint that you presented here today, is that on the Web site? And if not, would you put it on the Web site, please.

AMY DORMAN: I believe we can make it available. It's not currently.

AUDIENCE MEMBER: Okay. I mean, you can email it out to those of us here today, but you might want to just put it on the Web site, since you've gone to the effort to prepare it. One way or the other.

MARK BRUNETTE: Okay. Thank you very much for your comments. Seeing that there's no other members of the public that want to speak -- I don't think anyone else wants to speak who hasn't spoken yet -- I'm going to go ahead and close this meeting and make a few closing remarks.

This closes the public environmental scoping meeting for the Pure Water San Diego Program North City

Project. Your input will be transcribed, considered by City staff for use in the scope of the EIR, and included as part of the official record for the document.

Speakers and commenters who provide their contact information will also be placed on the notification list for further environmental review actions related to this project. So if you haven't put your name on the sign-in sheet over at the entrance on the table here, please do so.

I would also like to remind everyone that this is just the start of the environmental review process and opportunities for public input. There will be other opportunities to provide comments on the project, such as during public review of the draft environmental document and in any further public hearings on the project.

Thank you for taking the time to participate in the meeting, and have a great evening.

(The proceedings concluded at 7:25 p.m.)

* * *

STATE OF CALIFORNIA)
)
COUNTY OF SAN DIEGO)

I, Julia Lennan, a Certified Shorthand Reporter for the State of California, No. 12843, and Registered Professional Reporter, No. 8269, do hereby certify:

That the foregoing proceedings were reported stenographically by me and later transcribed through computer-aided transcription under my direction and that the foregoing is a true record of the proceedings taken at that time.

I do further certify that I am in no way interested in the outcome of this action or connected with or related to any of the parties in this action or to their respective counsel.

In witness whereof, I have hereunto set my hand this 3rd day of September, 2016.

____

JULIA LENNAN, RPR, CSR NO. 12843

From:	Brunette, Mark
To:	Balo, Keli; McPherson, Douglas; Megan Lawson; Shawn Shamlou
Cc:	Lavan, Tiffany
Subject:	FW: Pure Water San Diego Program North City Project EIR/EIS NOP / 499621
Date:	Tuesday, September 6, 2016 7:38:39 AM
Attachments:	NOP_PEIR_PureWater_MorenaPumpStation.pdf NOP_PEIR_PureWater_PublicUtilities_StormWaterDrainage.pdf

Please see the attached NOP comments from the City of San Diego Transportation and Storm Water Department.

From: Stephens, Mark
Sent: Thursday, September 01, 2016 5:44 PM
To: Brunette, Mark
Cc: Rom, Catherine; Fajardo, Jane-Marie; Rothman, Christine; Kalkirtz, Victoria; Thomsen, Douglas
Subject: Pure Water San Diego Program North City Project EIR/EIS NOP / 499621

Mark,

Hi! As briefly discussed, am sharing informal comments from the City Storm Water Division in response to the Notice of Preparation (NOP) issued for this EIR/EIS. A few general questions that I don't think were covered in the NOP or the scoping meeting attended: 1) Is a consultant assisting preparation of the EIR/EIS, and if so, what firm (mainly interested in who might be involved with hydrology and water quality)? 2) What role is the Bureau of Reclamation expected to play (perhaps potential federal funding assistance, or just a federal presence to serve as EIS lead agency for federal approvals required)? 3) For planning purposes, when should we expect to see a first screen check draft to review?

Page 19, Biology, Issue 6. The Morena Pump Station would be adjacent to Multi-Habitat Planning Area (MHPA) along the San Diego River. Both pipelines connecting to the pump station would cross through the MHPA at several different locations along the pipeline corridor. Existing Public Utilities Department mitigation sites are located upstream, and additional potential wetland mitigation opportunities may be of mutual interest.

Page 24, Hydrology and Water Quality. As pointed out through input to the Pure Water San Diego Program EIR completed, it's critical to recognize that water quality improvement plans (WQIPs) were prepared by watershed management area as directed by the Regional Water Quality Control Board, and watershed management area boundaries may not correspond directly with hydrologic units. The North City Project area includes portions of at least three WQIPs – those prepared for the San Diego River Watershed Management Area, Mission Bay Watershed Management Area, and Los Peñasquitos Watershed Management Area. Analysis of water quality impacts must recognize these diverse watershed management areas, and that highest priority water quality conditions vary in the respective WQIPs. For areas within City of San Diego jurisdiction, familiarity and compliance with the most current Jurisdictional Runoff Management Plan (JRMP) are also critical, as are familiarity and compliance with the most current Storm Water Standards and applicable provisions of the San Diego Municipal Code. The Draft EIR/EIS should address potential potable water discharges associated with testing or operation and maintenance. In Issue 2, correct the typo for "patterns."

Page 26, Public Utilities, Issue 1. The proposed wastewater force main and brine pipeline would start at the San Diego River, and cross Tecolote Creek and Rose Creek. All three streams are Clean Water Act Section 303(d) listed water bodies with associated storm water runoff and/or sedimentation issues. Address potential impacts during construction and/or location of the pipelines with existing infrastructure.

Page 27, Water Supply. One of our reviewers raised the question of whether opportunities for augmenting increased water supply through capturing storm water and/or dry weather runoff is under consideration, or might receive consideration as an alternative. Could the proposed Morena Pump Station facility accommodate collection of flows that would otherwise reach the San Diego River untreated.

Also, am attaching a couple of schematic graphics one of our reviewers (Catherine Rom) produced to help illustrate areas mentioned, including the streams potentially affected along the force main and brine line corridor, and existing infrastructure around the proposed Morena Pump Station.

Please let me know of any questions. Thank you!

Best regards,

- Mark Stephens

Mark G. Stephens, AICP
Associate Planner
City of San Diego
Transportation & Storm Water Department
Storm Water Division

T (858) 541-4361
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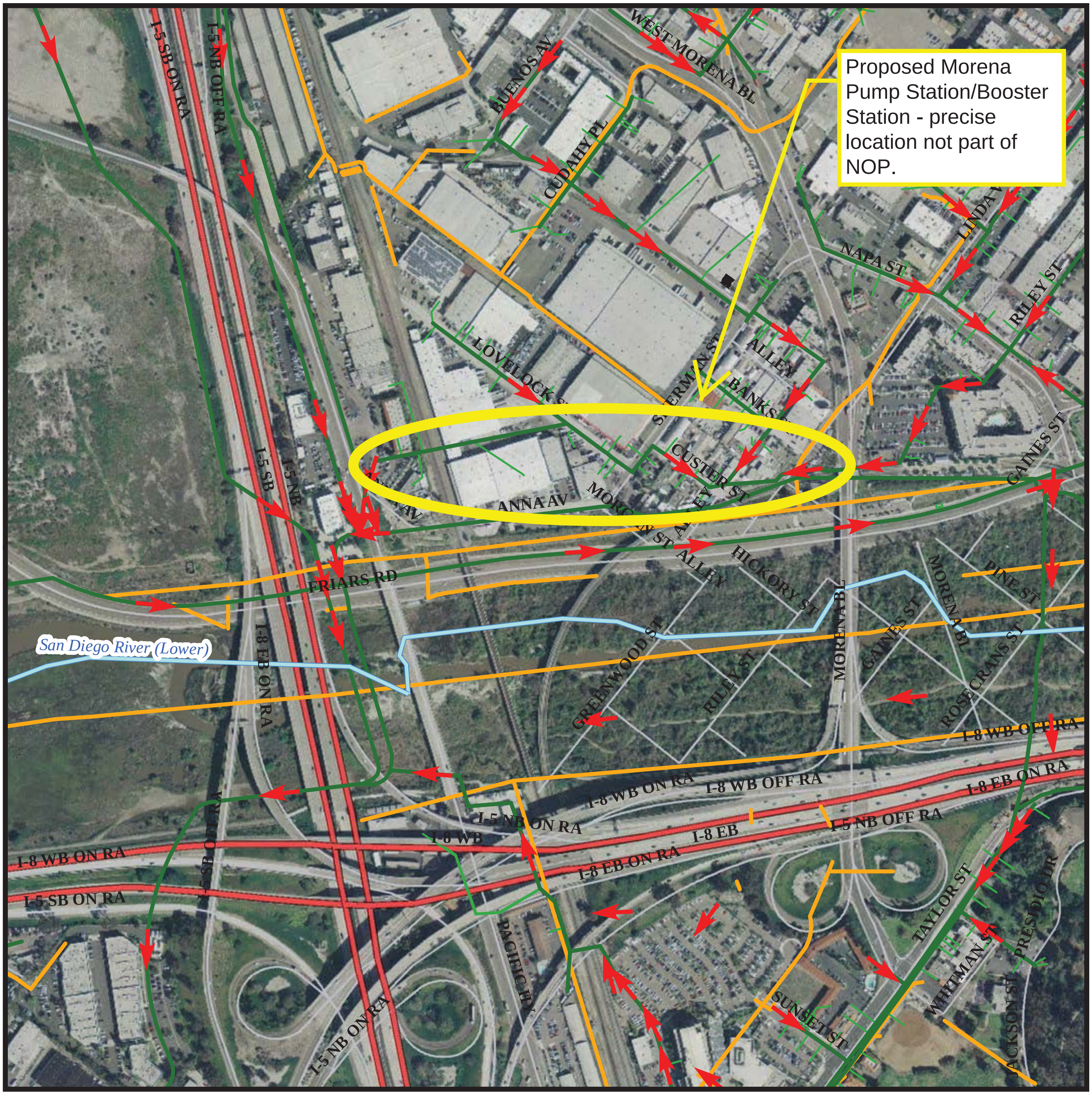
Pure Water San Diego Program
North City Project
Morena Pump Station

SENIOR PLANNER
Catherine Rom
(619) 527-7471



- Sewer Mains
- Storm Drain Pipe
- Flow Direction Arrows

N W E S
No Scale

COMMUNITY NAME:
Linda Vista, Mission Valley

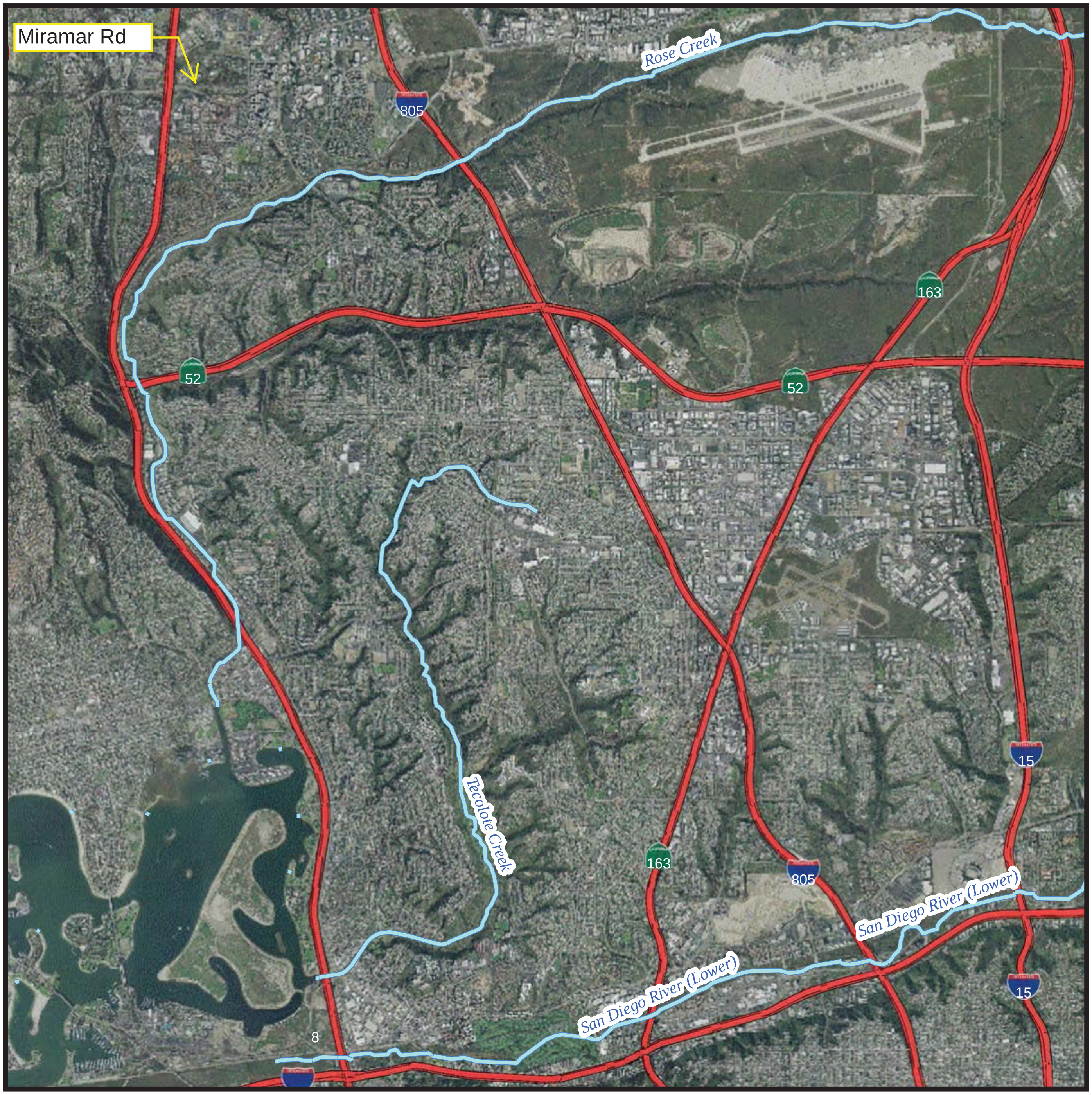
COUNCIL DISTRICT: 2, 7

SanGIS

Date: August 30, 2016

Pure Water San Diego Program
North City Project
Morena Pump Station

SENIOR PLANNER
Catherine Rom
(619) 527-7471



N
W E
S
No Scale

COMMUNITY NAME:
Linda Vista, Mission Valley

COUNCIL DISTRICT: 2, 7

SanGIS

Date: August 30, 2016