State of California | California Natural Resources Agency

Memorandum

Date: September 21, 2017

To: Laura Peters, Supervising Engineer

From: Ruey-wen Wang, Engineer
Salton Sea Management Program
Environmental Restoration and Enhancement Branch
IRWM
Department of Water Resources

Subject: Salton Sea Management Program Water Demand and Supply Study

Introduction

The California Natural Resources Agency, the California Department of Water Resources (DWR), and the California Department of Fish and Wildlife released the Salton Sea Management Program (SSMP), Phase I: 10-Year Plan in March 2017 (10-Year Plan). The 10-Year Plan illustrates a continuous effort to manage the Salton Sea's natural, agricultural, and municipal water inflows to maximize bird and fish habitat and minimize fine-particle air pollution that will allow California to protect regional health and ecological wealth.

Species Conservation Habit Project (SCH) is specifically designed as fish and avian habitat and will have areas of water depth that are up to 6 feet deep to accommodate a sustainable fishery. SCHs concepts were developed in 2012 and the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) was approved in 2013. In the 10-Year Plan, five similar projects are demonstrated: New River West (NRW), New River East (NRE), Alamo River South (ARS), Alamo River North (ARN), and Whitewater River (WR).

This technical memorandum presents the estimated water demand for each project and examines the reliability of river water supply from the New River, Alamo River, and Whitewater River. The results provide critical information for implementation of the SSMP.

SSMP Projects

All five SSMP projects consist of water management ponds, pump stations, conveyance facilities, mixing and sedimentation basins, and habitat and dust mitigation components that will be constructed adjacent to the three main rivers that flow into the Sea and on playa that will be exposed between 2018 and 2028.

Broad scale dimensions of the components are shown in Figure *1* and listed in Table *1*.

SURNAME DWR 155 (Rev 7/11)	RW Wang Ruey-wen Wang 9/21/2017	Laura Peters 9/21/17

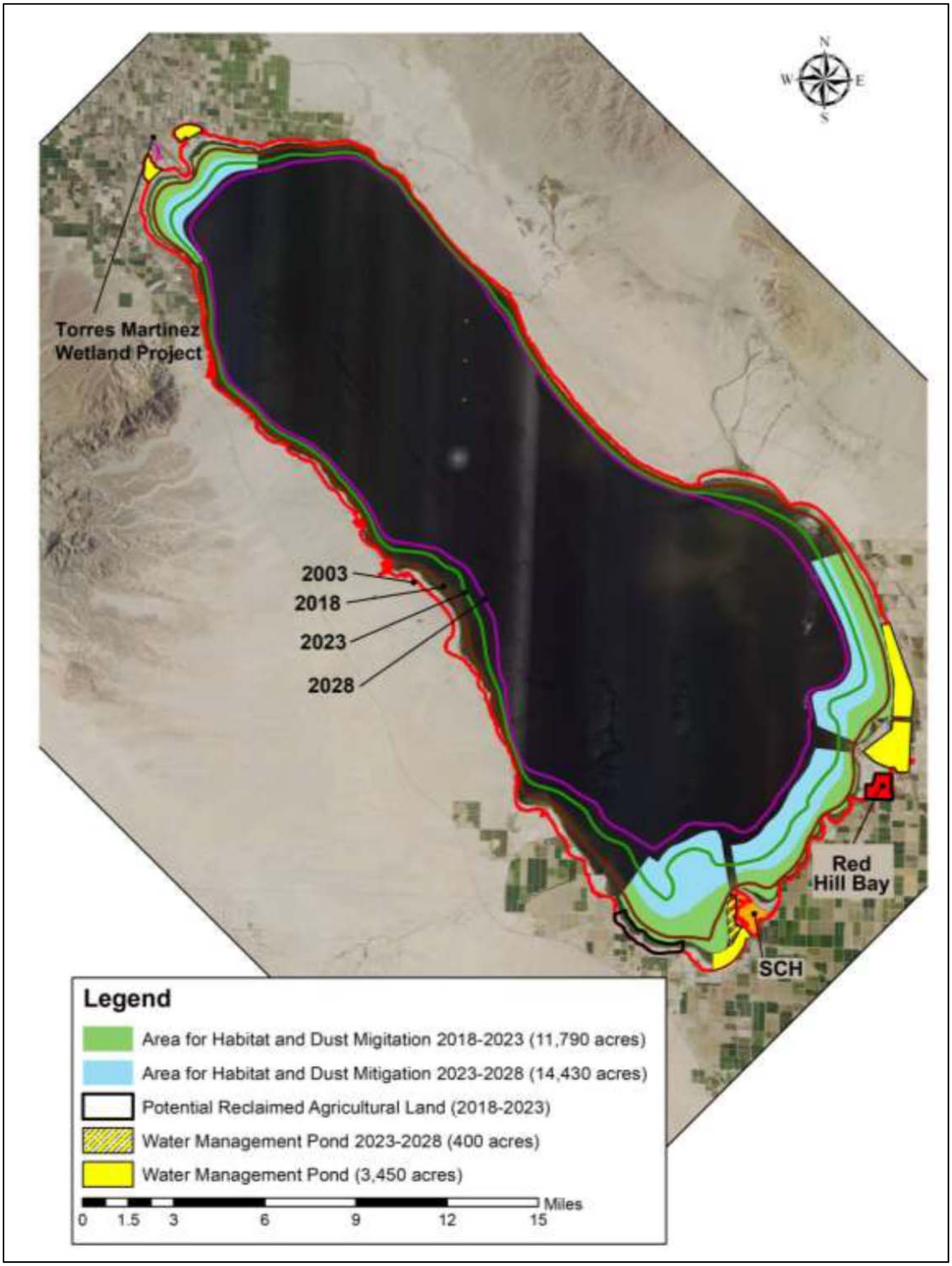

Figure 1. Salton Sea and Locations of SSMP Projects

Source: SSMP 10-Year Plan

Table 1. SSMP 10-Year Plan Habitat Projects

Region	Parameter	Dimension
New River West		
Water management pond	Surface area, 2018 - 2028	900 ac
	Average water depth	4 ft
Mitigation area	Green area, 2018 - 2023	3,460 ac
	Green area playa coverage	50%
	Green area water depth	0.5 ft
	Blue area, 2023 - 2028	4,500 ac
	Blue area playa coverage	50%
	Blue area water depth	0.5 ft
	Assumed outlet discharge	10% - 20%
New River East		
Water management pond	Surface area, 2018 - 2028	640 ac
	Average water depth	4 ft
Mitigation area	Green area, 2018 - 2023	1,340 ac
	Green area playa coverage	50%
	Green area water depth	0.5 ft
	Blue area, 2023 - 2028	2,000 ac
	Blue area playa coverage	50%
	Blue area water depth	0.5 ft
	Assumed outlet discharge	10% - 120%
Alamo River South		
Water management pond	Surface area, 2018 - 2028	1,300 ac
	Average water depth	4 ft
Mitigation area	Green area, 2018 - 2023	1,440 ac
	Green area playa coverage	50%
	Green area water depth	0.5 ft
	Blue area, 2023 - 2028	2,270 ac
	Blue area playa coverage	50%
	Blue area water depth	0.5 ft
	Assumed outlet discharge	10% - 300%
Alamo River North		
Water management pond	Surface area, 2018 - 2028	1,200 ac
	Average water depth	4 ft
Mitigation area	Green area, 2018 - 2023	3,580 ac
	Green area playa coverage	50 %
	Green area water depth	0.5 ft
	Blue area, 2023 - 2028	3,640 ac
	Blue area playa coverage	50%
	Blue area water depth	0.5 ft
	Assumed outlet discharge	10% - 60%
Whitewater River		
Water management pond	Surface area, 2018 - 2028	450 ac
	Average water depth	4 ft
Mitigation area	Green area, 2018 - 2023	1,970 ac
	Green area playa coverage	50%
	Green area water depth	0.5 ft
	Blue area, 2023 - 2028	2,020 ac
	Blue area playa coverage	50%
	Blue area water depth	0.5 ft
	Assumed outlet discharge	10%

Note: 1) The period 2018 – 2023 is for January 1, 2018 to January 1, 2023; the period 2023 - 2028 is for January 1, 2023 - January 1, 2028; 2) See *Figure 1* for locations of green and blue areas.

Methodology

Water from the New River, Alamo River, or Whitewater River will be diverted into the water management ponds and blended with saline water pumped from the Salton Sea to maintain designed water depths up to 6 feet and salinity levels in the ponds between 20 – 40 parts per thousand (ppt). The management ponds will provide areas of deep water habitat for fish and piscivorous birds, as well as supply water to areas down playa for habitat and dust mitigation. Figure *2* illustrates the water and salt balances in the two areas. To maintain a constant salinity of the blended water, both water and salt balances were considered in the water management ponds. The blended water will support coverage of 50% of the exposed playa for habitat and the remaining playa will receive dry dust mitigation measures, thus, only the water balance is considered for these playa areas.

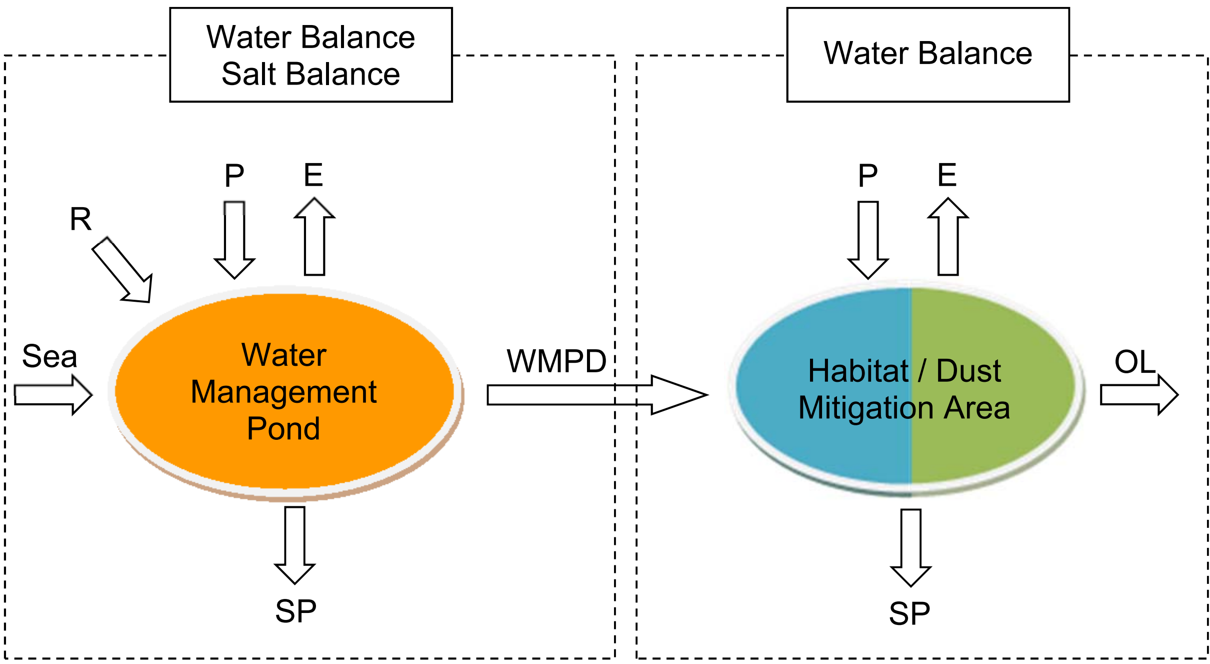

Figure 2. Water and Salt Balances in Water Management Ponds and Habitat / Dust Mitigation Areas

Where,

P:	Precipitation
E:	Evaporation (should consider ET in the future)
Sea:	Water pumped from Salton Sea to water management pond
R:	Water pumped from river to water management pond
SP:	Seepage
WMPD:	Blended water delivered from water management pond to the habitat and dust mitigation area
OL:	Outlet discharge from the habitat and dust mitigation areas

To calculate the amount of water needed from the rivers and the Sea, the first step is to resolve the water balance equation in the habitat/dust mitigation areas to obtain the diversion WMPD. The second step is to resolve the water balance and salt balance equations in the water management pond to obtain the river and Sea water demands.

The primary water demand is to compensate for the water losses due to evaporation and seepage; however, additional water is needed to flow through the ponds to reduce residence time and to maintain water quality.

Water and Salt Balance in Water Management Pond

Assuming storage change in water management pond is zero, inflows (*I*) are equal to outflows (*O*):

$$I_P + I_{Sea} + I_R = O_E + O_{SP} + O_{WMPD} \tag{1}$$

$$I_{SEA} = (O_E + O_{SP} + O_{WMPD}) - (I_P + I_R)$$

The targeted salinity for the management ponds is 30 ppt, therefore, assuming salt balance in the pond – that is, salt brining in the pond equals the salt delivered out of the pond:

$$I_P \times S_P + I_{Sea} \times S_{Sea} + I_R \times S_R = O_E \times S_E + O_{SP} \times S_{SP} + O_{WMPD} \times S_{WMPD} \tag{2}$$

Where *S* indicates salinity. Assuming salinities for precipitation, evaporation, and seepage are zero, and obtain:

$$I_{Sea} = \frac{(O_{WMPD} \cdot S_{WMPD} - I_R \cdot S_R)}{S_{Sea}}$$

$$(O_E + O_{SP} + O_{WMPD}) - (I_P + I_R) = \frac{(O_{WMPD} \cdot S_{WMPD} - I_R \cdot S_R)}{S_{Sea}}$$

$$-I_R + (O_E + O_{SP} + O_{WMPD} - I_P) = -\frac{S_R}{S_{Sea}} \cdot I_R + \frac{O_{WMPD} \cdot S_{WMPD}}{S_{Sea}}$$

$$\left(\frac{S_R}{S_{Sea}} - 1\right) \cdot I_R = \frac{O_{WMPD} \cdot S_{WMPD}}{S_{Sea}} - (O_E + O_{SP} + O_{WMPD} - I_P)$$

$$I_R = \frac{\left(\frac{O_{WMPD} \cdot S_{WMPD}}{S_{Sea}}\right) - (O_E + O_{SP} + O_{WMPD} - I_P)}{\frac{S_R}{S_{Sea}} - 1} \tag{3}$$

$$I_{Sea} = \frac{O_{WMPD} \cdot S_{WMPD} - \left(\frac{\frac{O_{WMPD} \cdot S_{WMPD}}{S_{Sea}} - (O_E + O_{SP} + O_{WMPD} - I_P)}{\left(\frac{S_R}{S_{Sea}} - 1\right)}\right) \cdot S_R}{S_{Sea}} \tag{4}$$

The water management pond inflow demand (I_R and I_{Sea}) will be then solved from equations (3) and (4), respectively.

Water Balance in Habitat and Dust Mitigation Area

$$I_P + I_{WMPD} = O_E + O_{SP} + O_{OL} \tag{5}$$

$$I_{WMPD} = O_E + O_{SP} + O_{OL} - I_P = O_{WMPD}\ in\ water\ management\ pond$$

Assuming no storage change in this area, equation (5) is the mass balance of inflows and outflows. Outlet discharge, O_{OL}, is the outflow from the habitat and dust mitigation areas to account for the turn-over rate of water in water management pond to maintain dissolved oxygen levels and nutrient balance. It is assumed as a percentage of water losses due to evaporation and seepage.

Water Demands and Pumping Requirements

The water demands from the Salton Sea and rivers were estimated on a daily basis starting from January 1, 2018 to January 1, 2028. The water demands of the mitigation areas for 2018 – 2022 start from January 1, 2018 to December 31, 2022; the water demands of mitigation area for 2023 – 2028 start from January 1, 2023 to January 1, 2028. The demands will determine the pumping requirements for the river and saline pump stations.

Assumptions

Salinity

- River

  Salinity in the New River was determined to be 3.0 ppt based on converting the specific conductivity of field measurement data that the California Regional Water Quality Control Board, Colorado River Basin Region (Regional Board) conducted on June 14, 2017 (Regional Board, 2017).

  Salinity in Alamo River was obtained from the Draft Salton Sea Restoration and Renewable Energy Initiative (SSRREI) Framework (County of Imperial, 2015). The measured salinity ranges approximately 1.82 ppt to 2.25 ppt for 2004 to 2014. 2.1 ppt was selected for this study.

  Salinity in Whitewater River is 0.9 ppt that was obtained from the Salton Sea Funding and Feasibility Action Plan (SSFFAP), Benchmark 4 report (Tetra Tech 2016). Table *2* summarizes the salinities for the three rivers.

Table 2. Salinity in New River, Alamo River, and Whitewater River

River	Salinity	Source
New River	3.0 ppt	Regional Board[1]
Alamo River	2.1 ppt	SSRREI
Whitewater River	0.9 ppt	Benchmark 4

Note: [1] Regional Board: specific conductivity = 5,579 (μS/cm)[3]; specific conductivity to salinity conversion tool – http://www.chemiasoft.com/chemd/salinity_calculator.

- Salton Sea

  DWR conducted a Salton Sea salinity simulation using the SALSA2 model for the period of 2013 to 2046 (DWR 2016). The result for “No Action” scenario was applied in this study to estimate the SSMP projects water demands with increasing brine pool salinity (see Table *3*).

Table 3. Salinity in Salton Sea

Calendar Year	Salinity [ppt]
2018	60
2019	63
2020	67
2021	71
2022	75
2023	80
2024	84
2025	88
2026	93
2027	97
2028	101

- Water Management Pond

  The targeted salinity in water management pond was assumed to be between 20 ppt and 40 ppt in SCH EIR/EIS documents (DWR and CDFW, 2013) and previous project pumping rate studies (Wisheropp, 2013). This memo applies an average value, 30 ppt, for the following analysis.

Residence Time

The residence time is the period of time that a drop of water remains in a habitat mitigation area between being spilled into the habitat area from the water management pond and being lost to the environment or discharged to the Salton Sea. The residence time is calculated as:

$$RT = \frac{Habitat\ Storage}{Inflow} \quad (3)$$

Where,

RT = Resident time

Habitat Storage = (habitat area) x (habitat water depth) x (water coverage percentage)

Inflow = habitat inflow plus precipitation to maintain desired water coverage and depth.

Seepage

The vertical seepage of the pond is estimated as potentially less than 2 feet per year (ft/yr, 0.07 in/day) to up to greater than 15 ft/yr (0.5 in/day), with a mid-range around 5 ft/yr (0.2 in/day) (Wisheropp, 2013). This analysis applies the mid-range value, 5 ft/yr, for the following analysis.

Evaporation

- Yearly Amount

  The annual evaporation rate was estimated as 5.7 ft/yr in the SSFFAP Benchmark 4 report (Tetra Tech 2016), 5.5 ft/yr in the Bureau of Reclamation's Salton Sea Accounting Model (Tetra Tech, 2016) when the Salton Sea salinity is at or below 20 ppt, and 5.75 ft/yr (69 in/yr) in Salton Sea Hydrology and Hydrologic Modeling report (CH2MHILL, 2014). This analysis applies 5.7 ft/yr for the following analysis.

- Monthly Pattern

  The yearly amount of evaporation was broken down into monthly pattern, which was obtained from an evaporation and radiation measurements conducted at Salton Sea by Sturrock (1978). He used three different method to analyze data and compute monthly evaporation (see Table *4*). This analysis used the average monthly evaporation of the three methods in percentage to break down the annual 5.7 ft/yr of evaporation.

Table 4. Monthly evaporation from Salton Sea in 1968. Unit: [inches]

Month	Energy budget	Mass transfer	Water budget	Average	Average in percentage
Jan	1.65	1.54	1.12	1.44	2%
Feb	1.97	1.42	0.71	1.37	2%
Mar	5.94	4.50	4.96	5.13	7%
Apr	6.87	7.18	6.75	6.93	10%
May	8.61	8.29	8.49	8.46	12%
Jun	7.60	8.20	7.83	7.88	11%
Jul	9.06	8.16	7.24	8.15	11%
Aug	10.09	10.93	8.94	9.99	14%
Sep	8.69	9.39	8.39	8.82	12%
Oct	5.73	5.00	5.99	5.57	8%
Nov	4.67	4.68	4.57	4.64	6%
Dec	2.60	3.01	3.65	3.09	4%
Total	73.48	72.30	68.64	71.47	100%

<u>Precipitation</u>

The precipitation data was obtained from the California Irrigation Management Information System (CIMIS) at station Westmorland No. 181 for the period of March 2004 to July 2017. The average monthly precipitation is shown in Table *5*.

Table 5. Monthly Precipitation at Westmorland. Unit: [inches]

Month	Precipitation
Jan	0.27
Feb	0.24
Mar	0.18
Apr	0.14
May	0.06
Jun	0.01
Jul	0.11
Aug	0.11
Sep	0.15
Oct	0.17
Nov	0.18
Dec	0.23
Total	1.84

River Water Supply

The river water supply for blended water will be diverted from New River, Alamo River, or Whitewater River, depending on the location of the project site. The estimated water demand for the water management ponds as well as habitat and dust mitigation areas will be compared with discharges in the rivers to evaluate the reliability of water supply.

Discharges in rivers were obtained from USGS gage stations. The monthly mean flows for the recent period 2012 – 2016 in each river are listed in Table *6*.

Table 6. 2012-2016 Monthly Mean Flow of New, Alamo, and Whitewater Rivers. Unit: [cfs]

Month												Mean
1	2	3	4	5	6	7	8	9	10	11	12	
New River (USGS #10255550)												
510	560	660	720	610	530	480	480	520	640	570	480	560
Alamo River (USGS #10254730)												
640	730	910	990	940	830	770	740	740	890	750	620	800
Whitewater River (USGS #10259540)												
60	60	60	50	50	50	50	50	60	60	60	60	55

Note: Numbers are rounded.

Results

The need to pump water from the Salton Sea and the nearby river is first driven by maintaining the desired water depth and salinity in the ponds and mitigation areas by replacing the water losses.

Results show a monthly pattern and a yearly pattern of the water demands. The water losses reach high values in summer time because of high evaporation rate; therefore, increased pumping of Sea and river water is needed to compensate the losses, as shown below as a rate (cfs) and a volume (acre-feet) in *Table 7 – Table 11*. *Figure 3* - *Figure 7* also show the monthly (seasonal) pattern of both Sea and river diversions.

The blended water will require more water from the river and less from the Salton Sea, when the Sea becomes saltier, as shown in *Figure 8* and *Figure 9*. Because the habitat and dust mitigation areas will be constructed in two phases between 2018 – 2022 and 2023 – 2028, the water demands rise up abruptly in the year of 2023 when the second phase mitigation areas are implemented.

In general, the blended water comes approximately 75% from the agricultural return flow and 25% from the Salton Sea. See *Figure 10*.

Table 7. New River East Project Water Demand

Site	New River East		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Sea	Maximum Monthly Diversion	[cfs]	6.1	5.8	5.5	5.2	4.9	12.2	11.5	10.9	10.4	9.9	9.5
	Average Monthly Diversion	[cfs]	5.1	4.9	4.6	4.3	4.1	10.1	9.6	9.1	8.6	8.2	7.9
	Minimum Monthly Diversion	[cfs]	4.0	3.8	3.6	3.4	3.2	7.9	7.5	7.1	6.7	6.4	6.2
River	Maximum Monthly Diversion	[cfs]	20.9	21.2	21.5	21.9	22.2	36.4	37.1	37.7	38.2	38.7	39.1
	Average Monthly Diversion	[cfs]	16.1	16.4	16.6	16.9	17.1	28.9	29.5	30.0	30.4	30.8	31.1
	Minimum Monthly Diversion	[cfs]	12.1	12.3	12.6	12.9	13.2	23.6	24.1	24.5	24.8	25.1	25.4
Sea	Maximum Monthly Diversion	[af]	377	359	339	319	300	751	709	672	639	611	586
	Average Monthly Diversion	[af]	309	294	278	262	246	611	577	547	520	497	477
	Minimum Monthly Diversion	[af]	236	224	212	200	188	470	443	420	400	382	367
	Total	**[af]**	**3,364**	**3,200**	**3,028**	**2,850**	**2,679**	**6,668**	**6,297**	**5,970**	**5,679**	**5,424**	**5,205**
River	Maximum Monthly Diversion	[af]	1,287	1,305	1,324	1,344	1,364	2,239	2,280	2,317	2,350	2,379	2,403
	Average Monthly Diversion	[af]	973	988	1,004	1,020	1,036	1,745	1,779	1,809	1,836	1,859	1,879
	Minimum Monthly Diversion	[af]	671	686	701	717	732	1,389	1,421	1,449	1,474	1,494	1,509
	Total	**[af]**	**10,923**	**11,087**	**11,259**	**11,437**	**11,608**	**19,362**	**19,733**	**20,060**	**20,351**	**20,607**	**20,825**

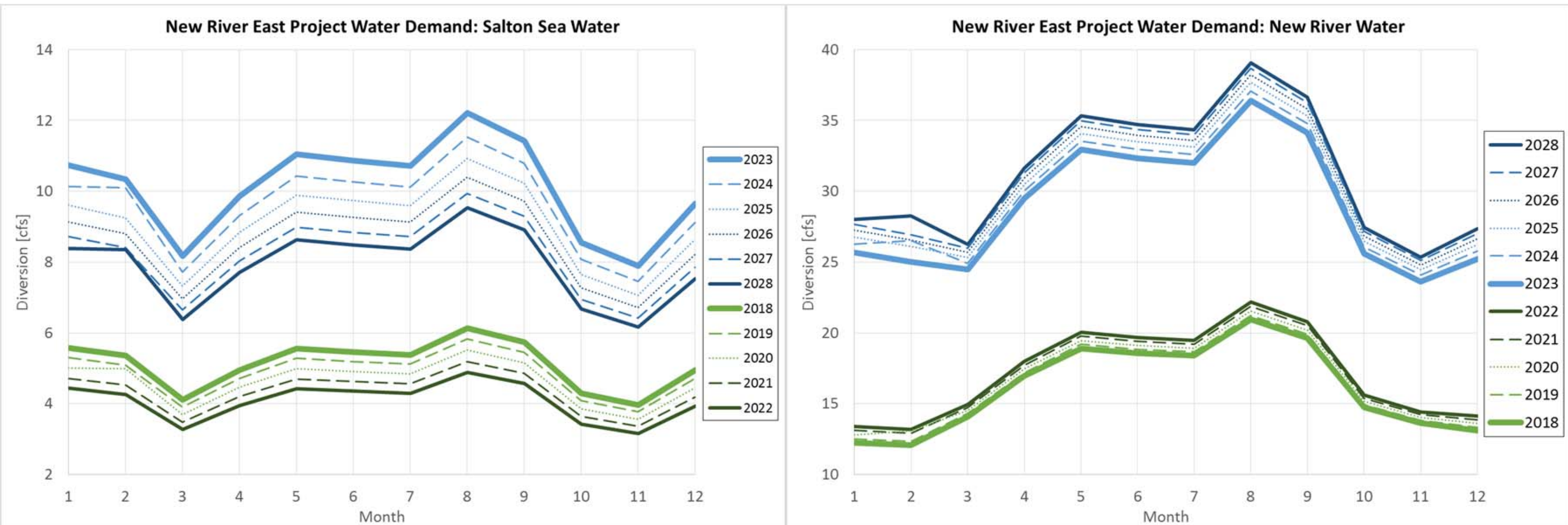

Figure 3. New River East Project Water Demand: Salton Sea Water (left); New River Water (right)

Table 8. New River West Project Water Demand

Site	New River West		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Sea	Maximum Monthly Diversion	[cfs]	16.6	15.8	14.9	14.1	13.2	29.6	27.9	26.5	25.2	24.1	23.1
	Average Monthly Diversion	[cfs]	12.3	11.7	11.1	10.4	9.8	21.9	20.7	19.6	18.6	17.8	17.1
	Minimum Monthly Diversion	[cfs]	7.6	7.2	6.8	6.4	6.0	13.5	12.7	12.1	11.5	11.0	10.5
River	Maximum Monthly Diversion	[cfs]	38.4	39.2	40.1	41.0	41.8	74.0	75.6	77.1	78.3	79.5	80.4
	Average Monthly Diversion	[cfs]	28.4	29.0	29.6	30.3	30.9	54.7	55.9	57.0	57.9	58.8	59.5
	Minimum Monthly Diversion	[cfs]	16.9	17.3	17.7	18.1	18.5	33.1	33.8	34.5	35.1	35.6	36.1
Sea	Maximum Monthly Diversion	[af]	1,021	971	919	865	813	1,819	1,717	1,628	1,549	1,479	1,420
	Average Monthly Diversion	[af]	743	707	669	629	592	1,323	1,249	1,184	1,127	1,076	1,033
	Minimum Monthly Diversion	[af]	426	405	383	361	339	757	715	678	645	616	591
	Total	**[af]**	**8,447**	**8,035**	**7,604**	**7,156**	**6,728**	**15,043**	**14,206**	**13,469**	**12,813**	**12,236**	**11,744**
River	Maximum Monthly Diversion	[af]	2,363	2,413	2,465	2,519	2,571	4,548	4,649	4,738	4,817	4,887	4,946
	Average Monthly Diversion	[af]	1,716	1,752	1,790	1,829	1,867	3,305	3,378	3,443	3,501	3,552	3,595
	Minimum Monthly Diversion	[af]	952	973	995	1,018	1,039	1,861	1,903	1,940	1,973	2,002	2,027
	Total	**[af]**	**19,549**	**19,960**	**20,392**	**20,839**	**21,267**	**37,622**	**38,459**	**39,196**	**39,852**	**40,429**	**40,921**

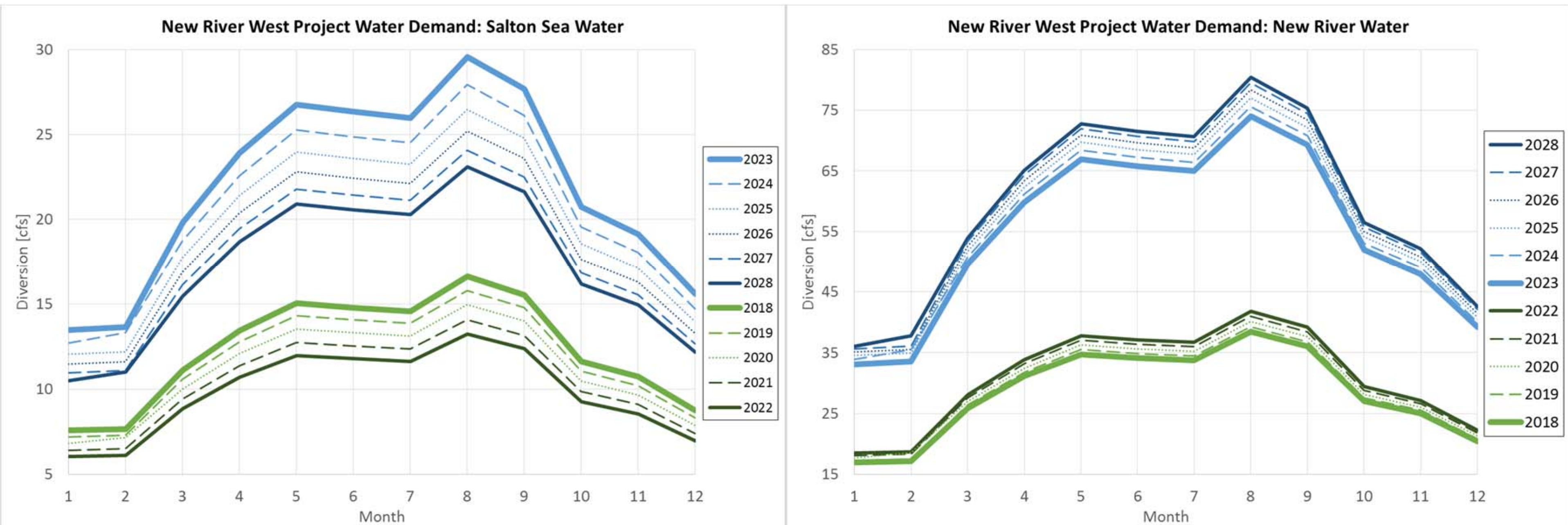

Figure 4. New River West Project Water Demand: Salton Sea Water (left); New River Water (right)

Table 9. Alamo River South Project Water Demand

Site	Alamo River South		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Sea	Maximum Monthly Diversion	[cfs]	11.4	10.9	10.3	9.7	9.1	22.7	21.4	20.3	19.3	18.5	17.7
	Average Monthly Diversion	[cfs]	7.8	7.4	7.0	6.6	6.2	15.9	15.1	14.3	13.6	13.0	12.5
	Minimum Monthly Diversion	[cfs]	5.7	5.4	5.1	4.8	4.6	12.0	11.4	10.8	10.3	9.8	9.4
River	Maximum Monthly Diversion	[cfs]	34.6	35.0	35.3	35.6	36.0	52.0	53.2	54.3	55.3	56.2	56.9
	Average Monthly Diversion	[cfs]	28.8	29.2	29.6	30.0	30.4	48.6	49.5	50.3	51.0	51.6	52.1
	Minimum Monthly Diversion	[cfs]	24.2	24.7	25.3	25.9	26.4	45.6	46.3	46.9	47.4	47.8	48.2
Sea	Maximum Monthly Diversion	[af]	703	670	634	597	562	1,394	1,317	1,249	1,189	1,136	1,091
	Average Monthly Diversion	[af]	470	447	423	399	375	960	908	861	819	783	752
	Minimum Monthly Diversion	[af]	345	328	311	293	275	727	687	651	620	592	569
	Total	**[af]**	**4,932**	**4,696**	**4,447**	**4,188**	**3,941**	**10,131**	**9,573**	**9,082**	**8,644**	**8,258**	**7,929**
River	Maximum Monthly Diversion	[af]	703	670	634	597	562	1,394	1,317	1,249	1,189	1,136	1,091
	Average Monthly Diversion	[af]	470	447	423	399	375	960	908	861	819	783	752
	Minimum Monthly Diversion	[af]	345	328	311	293	275	727	687	651	620	592	569
	Total	**[af]**	**19,399**	**19,636**	**19,885**	**20,143**	**20,390**	**32,002**	**32,560**	**33,051**	**33,489**	**33,875**	**34,204**

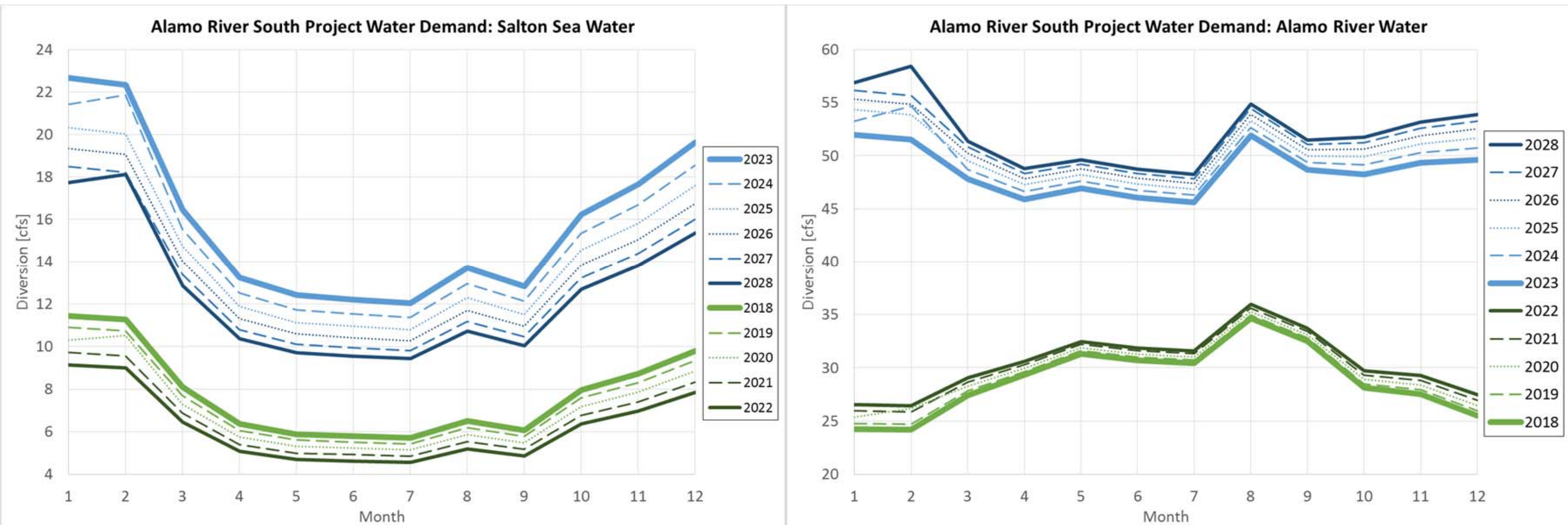

Figure 5. Alamo River South Project Water Demand: Salton Sea Water (left); Alamo River Water (right)

Table 10. Alamo River North Project Water Demand

Site	Alamo River North		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Sea	Maximum Monthly Diversion	[cfs]	17.6	16.8	15.9	15.0	14.1	27.4	25.9	24.6	23.4	22.3	21.4
	Average Monthly Diversion	[cfs]	13.5	12.8	12.1	11.4	10.8	20.9	19.8	18.8	17.9	17.1	16.4
	Minimum Monthly Diversion	[cfs]	9.3	8.8	8.4	7.9	7.4	14.4	13.6	12.9	12.3	11.8	11.3
River	Maximum Monthly Diversion	[cfs]	44.6	45.5	46.4	47.3	48.2	74.1	75.6	76.9	78.1	79.1	80.0
	Average Monthly Diversion	[cfs]	33.4	34.1	34.8	35.5	36.1	55.9	57.1	58.1	59.0	59.8	60.5
	Minimum Monthly Diversion	[cfs]	22.3	22.8	23.3	23.9	24.4	39.3	40.1	40.8	41.4	42.0	42.4
Sea	Maximum Monthly Diversion	[af]	1,082	1,031	976	919	865	1,685	1,592	1,510	1,438	1,373	1,319
	Average Monthly Diversion	[af]	813	774	733	691	650	1,265	1,195	1,134	1,079	1,031	990
	Minimum Monthly Diversion	[af]	570	543	514	484	456	888	839	796	758	724	695
	Total	**[af]**	**9,081**	**8,646**	**8,188**	**7,712**	**7,256**	**14,129**	**13,352**	**12,666**	**12,056**	**11,518**	**11,059**
River	Maximum Monthly Diversion	[af]	2,745	2,797	2,851	2,908	2,962	4,555	4,647	4,729	4,802	4,866	4,921
	Average Monthly Diversion	[af]	2,021	2,060	2,101	2,144	2,184	3,379	3,449	3,510	3,565	3,613	3,654
	Minimum Monthly Diversion	[af]	1,240	1,268	1,297	1,327	1,356	2,196	2,245	2,288	2,327	2,361	2,390
	Total	**[af]**	**22,845**	**23,281**	**23,739**	**24,215**	**24,671**	**38,021**	**38,799**	**39,485**	**40,095**	**40,633**	**41,092**

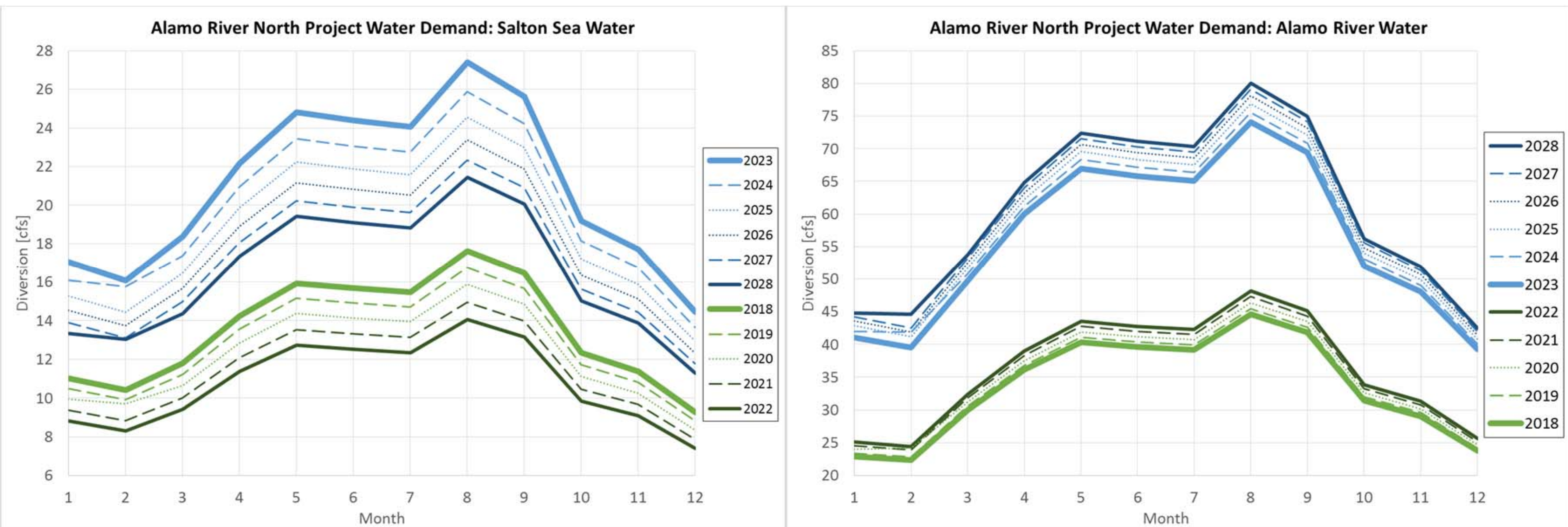

Figure 6. Alamo River North Project Water Demand: Salton Sea Water (left); Alamo River Water (right)

Table 11. Whitewater River Project Water Demand

Site	Whitewater River		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Sea	Maximum Monthly Diversion	[cfs]	10.2	9.8	9.3	8.7	8.2	15.8	15.0	14.2	13.5	12.9	12.4
	Average Monthly Diversion	[cfs]	7.5	7.2	6.8	6.4	6.0	11.6	11.0	10.4	9.9	9.5	9.1
	Minimum Monthly Diversion	[cfs]	4.2	4.0	3.8	3.6	3.4	6.5	6.2	5.9	5.6	5.3	5.1
River	Maximum Monthly Diversion	[cfs]	19.9	20.3	20.8	21.4	21.9	36.1	36.9	37.7	38.4	38.9	39.5
	Average Monthly Diversion	[cfs]	14.6	14.9	15.3	15.7	16.1	26.5	27.1	27.7	28.1	28.6	29.0
	Minimum Monthly Diversion	[cfs]	8.3	8.5	8.7	9.0	9.2	15.0	15.4	15.7	16.0	16.2	16.4
Sea	Maximum Monthly Diversion	[af]	630	600	569	537	505	972	920	873	832	795	764
	Average Monthly Diversion	[af]	454	433	410	387	364	701	663	629	599	573	550
	Minimum Monthly Diversion	[af]	238	227	215	203	191	368	348	330	315	301	289
	Total	**[af]**	**5,188**	**4,944**	**4,686**	**4,419**	**4,162**	**8,008**	**7,574**	**7,190**	**6,848**	**6,546**	**6,289**
River	Maximum Monthly Diversion	[af]	1,221	1,251	1,282	1,314	1,346	2,217	2,270	2,317	2,358	2,395	2,426
	Average Monthly Diversion	[af]	882	904	926	950	972	1,600	1,638	1,672	1,702	1,728	1,751
	Minimum Monthly Diversion	[af]	468	480	491	504	516	845	865	883	899	913	924
	Total	**[af]**	**10,077**	**10,321**	**10,578**	**10,846**	**11,103**	**18,281**	**18,715**	**19,099**	**19,441**	**19,743**	**20,001**

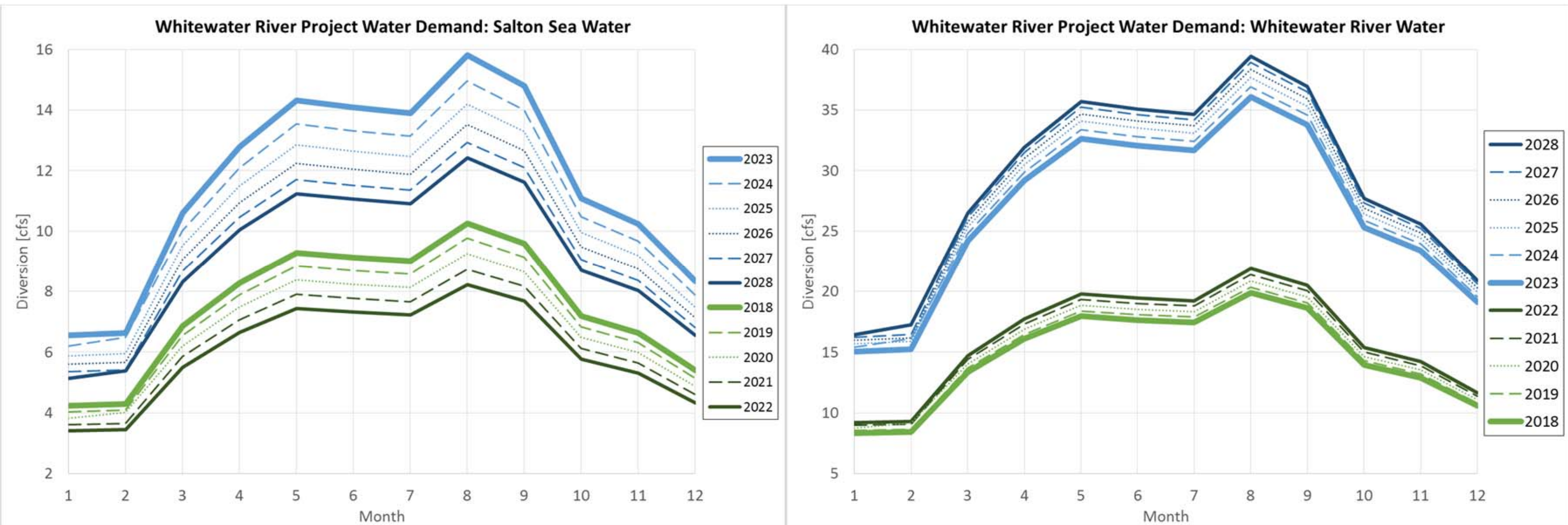

Figure 7. Whitewater River Project Water Demand: Salton Sea Water (left); Whitewater River Water (right)

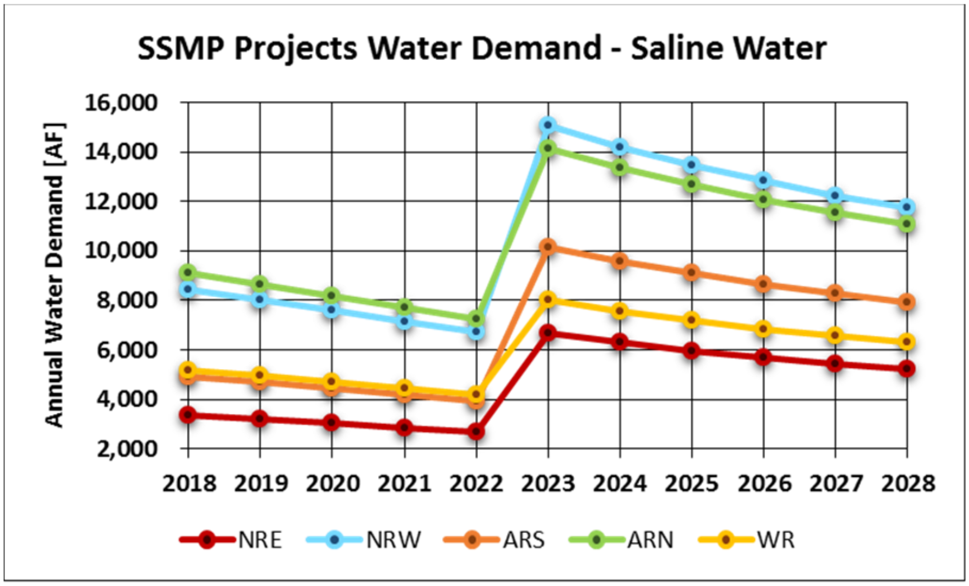

Figure 8. Annual Water Demands: Saline Water

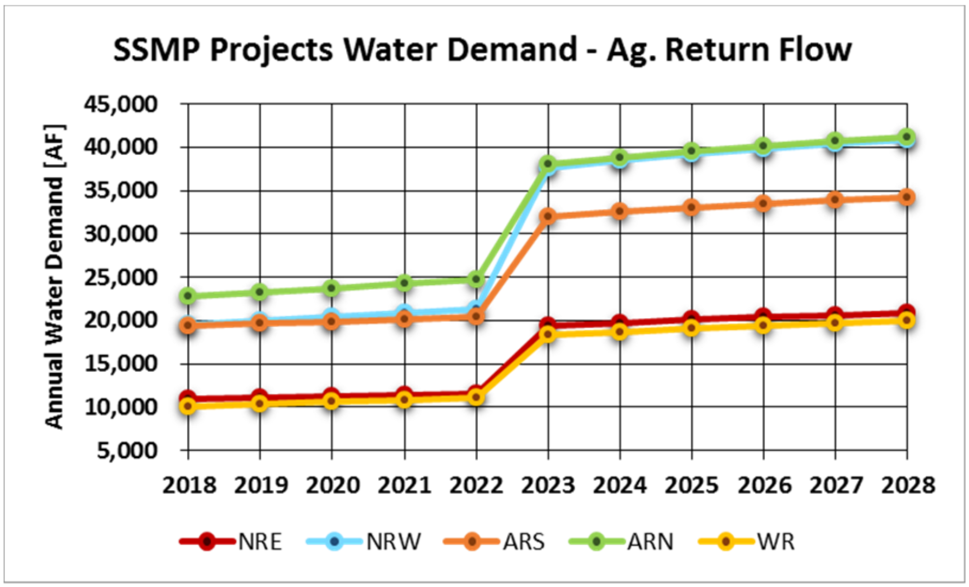

Figure 9. Annual Water Demands: Agricultural Return Flow

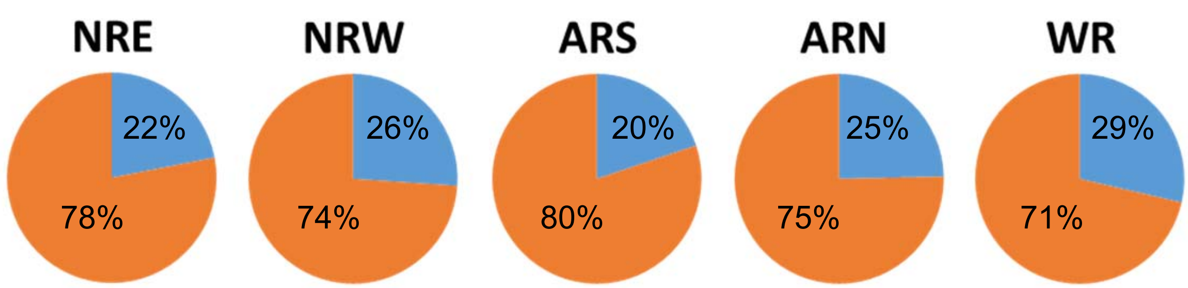

Figure 10. Average Blended Water Ratio (Orange: Ag. Return Flow; Blue: Saline Water)

Residence Time

The second driving factor of water demands is to meet a required residence time.

If there is no discharge to the mitigation area to create a flow-through condition, the residence time in the water management ponds would range from 8 to 17 weeks for projects adjacent to New River and 11 to 22 weeks for projects adjacent to Alamo River. Long residence time is due to low water demands in winter time, because less water is required to compensate evaporation loss. However, low water demand and long residence time will reduce the water exchange rate and could result in poor water quality in the ponds. Therefore, to improve water quality, residence time is restricted to be within 10 weeks for this study, i.e., water in addition to the amount needed to meet water demand must be supplied to the ponds to maintain dissolved oxygen levels and nutrient balance.

Table *12* and Table *13* show the result of the calculated residence time. Residence time less than 10 weeks indicates periods that the amount of diverted water is required to compensate water losses only; residence time equal to 10 weeks indicates periods that the residence time is capped off at 10 weeks and more water is required to increase water turn-over rate in the ponds for water quality considerations.

Table 12. Residence Time for Water Management Ponds. Unit: [week]

Year	Month	Residence Time				
		NRE	NRW	ARS	ARN	WR
2018 - 2022	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	7	10	8	6
	4	8	6	10	7	5
	5	8	5	10	6	5
	6	8	5	10	6	5
	7	8	5	10	6	5
	8	7	5	9	6	4
	9	7	5	10	6	5
	10	10	7	10	8	6
	11	10	7	10	8	7
	12	10	9	10	10	8
2023 - 2028	1	5	6	5	6	6
	2	5	5	5	6	6
	3	6	4	6	5	4
	4	5	3	6	4	3
	5	4	3	6	4	3
	6	4	3	6	4	3
	7	4	3	6	4	3
	8	4	3	6	3	2
	9	4	3	6	4	3
	10	5	4	6	5	4
	11	6	4	6	5	4
	12	5	5	5	6	5

Table 13. Residence Time for Habitat and Dust Mitigation Areas. Unit: [week]

Year	Month	Residence Time				
		NRE	NRW	ARS	ARN	WR
2018 - 2028	1	2	3	1	3	4
	2	2	3	1	3	4
	3	2	2	1	2	2
	4	2	2	2	2	2
	5	2	2	2	2	2
	6	2	2	2	2	2
	7	2	2	2	2	2
	8	2	2	2	2	2
	9	2	2	2	2	2
	10	2	2	1	2	2
	11	2	2	1	2	2
	12	2	3	1	3	3

<u>Outflow of Habitat and Dust Mitigation Areas</u>

The outlet discharges at the habitat and dust mitigation areas were estimated by meeting the residence time goal of being equal to or less than 10 weeks. In winter time, because of low evaporation and seepage losses, the water demands to maintain the desired water depth on the 50% covered playa areas decreases. The decreased water demand will also reduce the water turn-over rate in the water management pond that will potentially deteriorate water quality. To secure good water quality in the ponds, the flow-through is adjusted to meet both mitigation areas' water demand and residence time requirement.

Table *14*. shows the result of the outlet discharges presented as a percentage of sum of evaporation and seepage. The Alamo River South project requires a one- to three-fold adjustment in flow-through between December and March to maintain water quality. The Whitewater River project shows a minor adjustment need.

Table 14. Outflow of Habitat and Dust Mitigation Areas as a Percentage of Sum of Evaporation and Seepage

Year	Month	Outflow in Terms of Percentage of (Evaporation+ Seepage)				
		NRE	NRW	ARS	ARN	WR
2018 - 2028	1	120%	20%	300%	60%	10%
	2	110%	20%	290%	50%	10%
	3	10%	10%	90%	10%	10%
	4	10%	10%	30%	10%	10%
	5	10%	10%	10%	10%	10%
	6	10%	10%	10%	10%	10%
	7	10%	10%	10%	10%	10%
	8	10%	10%	10%	10%	10%
	9	10%	10%	10%	10%	10%
	10	10%	10%	80%	10%	10%
	11	10%	10%	110%	10%	10%
	12	60%	10%	180%	10%	10%

The flow-through adjustment is a result of the sizing between the water management pond and the habitat / dust mitigation area. If the mitigation areas are significantly larger than the pond, the high water demand in the mitigation area will drive the pond to pump a lot of water through it, so the residence time in the pond is decreased and the water quality is improved. If the mitigation areas are of similar size as the water management pond, their water demand is lower, thus increasing the residence time in the water management pond.

Water Availability

The maximum monthly water demands of each project are listed in Table *15* and Table *16*. Comparing the river water supply with the maximum river water demand that will occur in 2028 for the 2018 – 2028 period, as shown in *Figure 11*, projects located adjacent to New River and Alamo River have secured water supply because the maximum demand month, August, requires only 25% of the river water only. However, the maximum monthly demand in the Whitewater River can reach up to 77% of the river discharge. If the Whitewater discharge decreases due to drought or other reasons, the SSMP Whitewater River project will have the potential for water shortages during summer time. In practice, a pump can extract water at a certain vertical profile but not the near bottom 'dead pool'. The pump must be submerged and cannot take 100% of flow away. In addition, if all water from Whitewater River is pumped into SSMP project and there is no water to discharge at its river outlet, it will potentially jeopardize Whitewater River's health for mitigation in the habitat nearby.

Table 15. Maximum Monthly River Water Demand in Each SSMP Project. Unit: [cfs]

River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Project
New River	28	28	26	32	35	35	34	39	37	27	25	27	NRE
New River	36	38	54	65	73	72	71	80	75	56	52	43	NRW
Alamo River	57	58	51	49	50	49	48	55	51	52	53	54	ARS
Alamo River	45	45	54	65	72	71	70	80	75	56	52	42	ARN
Whitewater River	16	17	26	32	36	35	35	39	37	28	26	21	WR

Note: maximum demand occurs in 2028 for 2018-2028 period.

Table 16. Maximum Monthly Saline Water Demand in Each SSMP Project. Unit: [cfs]

River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Project
New River	11	10	8	10	11	11	11	12	11	9	8	10	NRE
New River	13	14	20	24	27	26	26	30	28	21	19	16	NRW
Alamo River	23	22	16	13	12	12	12	14	13	16	18	20	ARS
Alamo River	17	16	18	22	25	24	24	27	26	19	18	14	ARN
Whitewater River	7	7	11	13	14	14	14	16	15	11	10	8	WR

Note: maximum demand occurs in 2023 for 2018-2028 period.

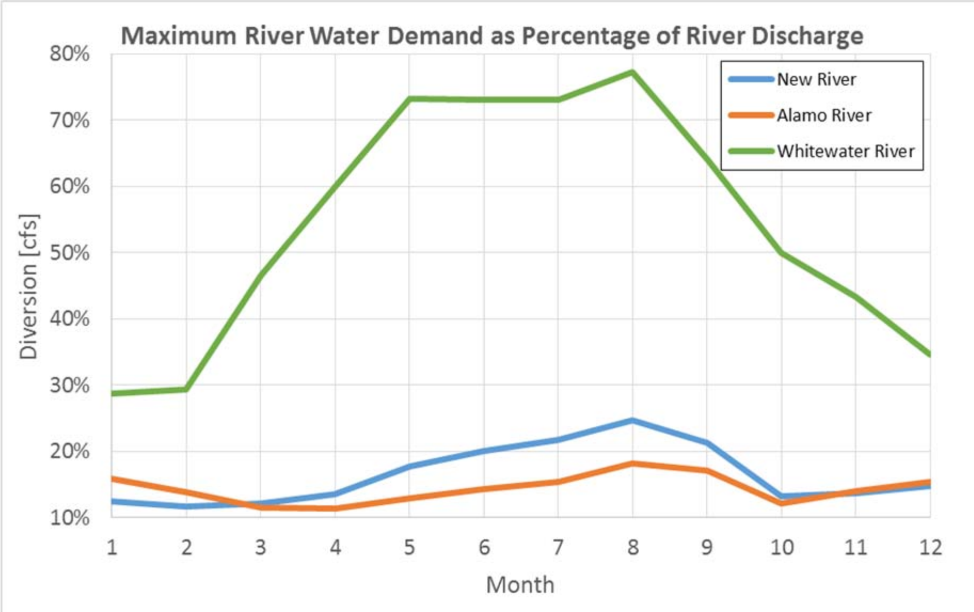

Figure 11. Maximum River Water Demand as Percentage of River Discharge (maximum demand occurs in 2028; river discharge is an average of recent five years, 2012 -2016, gage flows).

Conclusions

- The simulation is based on the assumption that salt will not be trapped and accumulated in the water management ponds, so that the targeted salinity can be controlled and will not increase as it is happening in the Salton Sea brine pool. Therefore, the water delivery system in the water management ponds and mitigation areas must be designed to divert, circulate, and discharge blended water and not cause salt accumulation in the ponds and mitigation areas.

- Residence time requirements should be reviewed, including whether to set different residence time for summer and for winter.

- The role of outflow in the habitat and dust mitigation areas should be discussed and clarified.

- The recommended pumping rates for Sea and river water diversions for each project site is summarized in Table *17*.

Table 17. Recommended Pump Station Diversion Rates. Unit: [cfs]

Site	Sea	River
New River East	12	40
New River West	30	80
Alamo River South	23	55
Alamo River North	27	80
Whitewater River	16	40

- Results show a strong monthly pattern (seasonal variation) in the water demands that must be considered in developing habitat and facilities design criteria.

- The habitat and dust management areas in the Whitewater River project are oversized and the water demand will potentially exceed the water supply from Whitewater River during summer time, if drought or any other condition that cause decrease of the river discharge occurs. A smaller habitat and dust mitigation area for the Whitewater project should be planned. The river pump station capacity will reduce accordingly.

Acronyms

ARN	Alamo River North
ARS	Alamo River South
DFW	Department of Fish and Wildlife
DWR	California Department of Water Resources
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
NRE	New River East
NRW	New River West
ft/yr	feet per year
ppt	parts-per-thousand
SSFFAP	Salton Sea Funding and Feasibility Action Plan
SSMP	Salton Sea Management Program
SSRREI	Salton Sea Restoration and Renewable Energy Initiative
WR	Whitewater River

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