# Salton Sea Long-Range Plan

***Appendix B: Hydrology and Climate Change***

***March 2024***

SALTON SEA MANAGEMENT PROGRAM

CALIFORNIA NATURAL RESOURCES AGENCY

DEPARTMENT OF WATER RESOURCES · STATE OF CALIFORNIA

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

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## Acronyms and Abbreviations

| | |
|---|---|
| AF | Acre-feet |
| AFY | Acre-feet per year |
| CMIP | Coupled Model Intercomparison Project |
| CRMMS | Colorado River Mid-term Modeling System |
| CRSS | Colorado River Simulation System |
| CVSC | Coachella Valley Stormwater Channel |
| CVWD | Coachella Valley Water District |
| DCP | Drought Contingency Plan |
| DWR | California Department of Water Resources |
| ET | Evapotranspiration |
| GCM | Global Climate Model |
| ICS | Intentionally created surplus |
| IID | Imperial Irrigation District |
| kAF | Thousand acre-feet |
| LRP | Long-Range Plan |
| MAFY | Million acre-feet per year |
| MSL | Mean sea level |
| QSA | Quantification Settlement Agreement |
| RCP | Representative Concentration Pathway |
| Reclamation | United States Bureau of Reclamation |
| SALSA2 | Salton Sea Elevation Model version 2 |
| SDCWA | San Diego County Water Authority |
| SSMP | Salton Sea Management Program |
| SSP | Shared Socioeconomic Pathway |
| TAFY | Thousand acre-feet per year |
| USGS | United States Geological Survey |
| WMP | Water Management Plan |

# 1 Introduction

Long-term management of the Salton Sea requires an understanding of historical and future hydrology at the Salton Sea and the connected Imperial Valley and Coachella Valley watersheds. This report describes the historical hydrology, baseline assumptions for projected hydrology, and the resulting projected future conditions at the Salton Sea, which can be used to inform long-term management and planning.

The study area is described in Section 2. Sources of information used to build this memo are identified in Section 3. Such background information is offered by a combination of historical observations, management plans, and hydrological studies. Prior modeling work pertaining to Imperial Valley and Salton Sea hydrology can be found in Section 4. In Section 5, each source of inflow and outflow is individually discussed to provide the foundation for development of future scenarios. Annual and sub-annual flows are studied to provide a holistic understanding. This is followed by a final table of future water management scenarios and assumptions in Section 6. Concluding remarks are in Section 7, and references are in Section 8.

# 2 Description of the Study Area

Agriculture in the Imperial Irrigation District (IID) and the Coachella Valley Water District (CVWD) is sustained by Colorado River water diverted at the Imperial Dam and delivered via the All-American and Coachella Canals. Total diversions of approximately 2.8 million acre-feet (AF)/year at the Imperial Dam support irrigated agriculture in the Imperial and Coachella Valleys.[1] Irrigated areas surrounding the Salton Sea are shown in relation to the entire Colorado River basin in Figure 1.

The Salton Basin is the northern arm of the former Colorado River delta system. Agricultural return flows and drainage from these valleys and parts of the Mexicali Valley, in addition to municipal and industrial discharges in the watershed, feed the major rivers flowing to the Salton Sea. The Salton Sea watershed encompasses an area of approximately 8,000 square miles from San Bernardino County in the north to the Mexicali Valley (Republic of Mexico) to the south.

The principal sources of inflow to the Salton Sea are the Whitewater River to the north (also know as the Coachella Valley Stormwater Channel [CVSC]), the Alamo and New Rivers to the south, and direct return flows from agricultural drains in the Imperial Valley and Coachella Valley. The riverine sources of inflow are recorded by United States Geological Survey (USGS) gage stations situated at the river mouths, with observations dating back to at least 1988 (Figure 2).

[1] This value is computed by averaging total consumptive use for Imperial Irrigation District (IID) and Coachella Valley Water District (CVWD) for the period of 2015 – 2020. Total consumptive use of (i.e., Colorado River inflows to) IID and CWVD are detailed in the Colorado River Accounting and Water Use Reports.


**Figure 1.** The Colorado River Basin. (SOURCE: U.S. Bureau of Reclamation)


**Figure 2.** USGS sampling locations for river flows and for Salton Sea elevation. The Whitewater River is also known as the CVSC.

The Whitewater River (CVSC) is the primary river drainage channel of CVWD. It brings stormwater runoff, agricultural return flows, and municipal and fish farm discharges from the Coachella Valley to the Salton Sea. In the last few years, flows recorded by the Whitewater River USGS gage (USGS Station ID: 10259540) have been less than 50,000 AF/year.[2]

[2] This estimate is based on the most recent USGS gage flows.

The Alamo River originates approximately two miles south of the International Border with Mexico and flows north and into the Salton Sea. The USGS station that records Alamo River inflows into the Salton Sea is located near this point of discharge into the Sea (USGS Station ID: 10254730). The Alamo River is dominated by agricultural return flows from IID. In recent years, this flow has averaged 560,000 AF/year.[2]

The New River also originates in Mexico. It travels through the Mexicali Valley, crosses the International Border, and flows into the Salton Sea. The New River carries urban runoff, industrial and municipal flows, and agricultural runoff from the Mexicali Valley. There are two USGS gages along the New River. One is in the Imperial Valley, near the mouth of the river at the Salton Sea (USGS Station ID: 10255550). The other is at the International Border (USGS Station ID: 10254970). Since 2018, flows at the New River (Imperial Valley) station have been consistently less than 350,000 AF/year.[2] At the New River (International Border) station, flows have remained stable between 60,000 AF/year and 64,000 AF/year in the same time frame.[2]

Other outflows to the Salton Sea include a system of agricultural drains in the Imperial Valley, which discharge surface runoff into the Alamo and New Rivers, and agricultural drains in the the Coachella Valley. The agricultural drains in the Imperial Valley introduce approximately 830,000 AF/year of surface runoff to the Alamo and New Rivers.[3]

The relationship between these flows, the Salton Sea, and the IID and CVWD watersheds are illustrated in Figure 3. Other losses are from IID and CVWD watershed evapotranspiration (ET) and evaporation out of the Salton Sea. Other inflows include precipitation, local watershed, and groundwater inflows into the Sea. The ungaged flows (italicized in Figure 3) can be estimated by using the reported irrigated acreage and ET rates in the valleys and local weather data that are available for Imperial County, California.

The background information presented in Section 3 is used to quantify the flows in Figure 3 based on historical observations and guidelines for water management in the IID and CVWD watersheds and in the Colorado River Lower Basin.

[3] This estimate is provided by California Water Boards (Salton Sea | Colorado River Basin Regional Water Quality Control Board (ca.gov)).

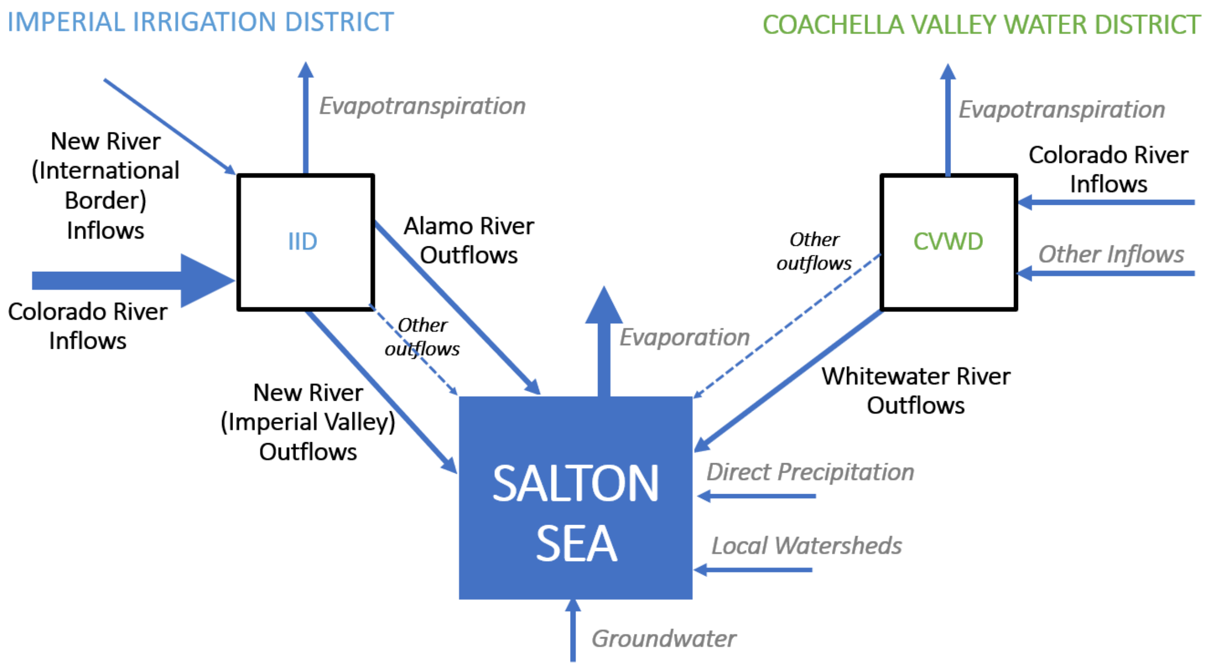



**Figure 3.** Flows into and out of the Imperial Irrigation District (IID), the Coachella Valley Water District (CVWD), and the Salton Sea. Flows that are italicized are ungaged but can be estimated.

# 3 Background Information

Background information sources are divided into observational data sets and management plans/hydrological studies. Observational data sets include historical readings and guidelines for hydrological management and planning in the Lower Basin of the Colorado River, in the Imperial and Coachella Valleys, and in the Salton Sea. Additional studies and plans provide context for developing future hydrological scenarios. Studies about the future management of Colorado River allocations and future climate scenarios for Imperial County, which provide insight into some aspects of the future water budget, are also included.

## 3.1 Observational Data Sets Relating to Irrigation Water Use

Data related to water use by the agricultural sector include Colorado River water use reports, satellite-based estimates of ET, and inventory and reports compiled by IID and CVWD. These data sources are described in the following sections.

### 3.1.1 Colorado River Accounting and Water Use Reports: Arizona, California, and Nevada. U.S. Bureau of Reclamation. 1964 – 2020.

Reclamation provides records of diversions, measured and unmeasured returns, and consumptive use of the Colorado River Lower Basin in a series of annual reports. These values are individually reported for the users of the basin, including IID and CVWD, from 1964 – 2020.

The term "diversions" refers to the routing of water from the Colorado River mainstream, through regulatory structures, to entitled users of the Basin and includes each user's proportionate share of the total canal losses during diversion. "Measured and unmeasured returns" of such diverted water is subtracted from the diversion number to provide an estimate of the "consumptive use" of such water.[4] "Consumptive use,"which diminishes the available supply of water, is defined as the depletion of water for domestic and agricultural beneficial uses, as outlined in the 1922 Colorado River Compact. For this reason, "consumptive use" values estimate the Colorado River inflows into the IID and CVWD water systems. These values were also used to inform future inflow scenarios based on averages over various time periods.

IID and CVWD consumptive use of Colorado River water is provided in Table 1. Data is collected by Reclamation's Boulder Canyon Operations Office, USGS, the International Boundary and Water Commission, water users, and other agencies. In general, the diversions of Colorado River water include reported diversions from the surface channel of the river and any reported volumes of water pumped by wells.

Table 1. Consumptive use of Colorado River water by the Imperial Irrigation District (IID) and Coachella Valley Water District (CVWD) (units: AF). (SOURCE: Reclamation, 1964 – 2020)

| CONSUMPTIVE USE | IMPERIAL IRRIGATION DISTRICT (IID) | COACHELLA VALLEY WATER DISTRICT (CVWD) |
|---|---|---|
| **1990** | 3,054,188 | 369,685 |
| **1991** | 2,898,963 | 317,563 |

[4] For IID, total consumptive use was computed by summing diversions at Imperial Dam and deliveries from Warren H. Brock Reservoir and then subtracting the measured and unmeasured returns.

| CONSUMPTIVE USE | IMPERIAL IRRIGATION DISTRICT (IID) | COACHELLA VALLEY WATER DISTRICT (CVWD) |
|---|---|---|
| **1992** | 2,572,659 | 309,367 |
| **1993** | 2,772,148 | 318,990 |
| **1994** | 3,048,076 | 326,102 |
| **1995** | 3,070,582 | 326,697 |
| **1996** | 3,159,609 | 331,473 |
| **1997** | 3,158,486 | 338,028 |
| **1998** | 3,101,548 | 337,466 |
| **1999** | 3,088,980 | 333,810 |
| **2000** | 2,931,251 | 329,367 |
| **2001** | 3,089,911 | 325,096 |
| **2002** | 3,152,984 | 331,107 |
| **2003** | 2,978,223 | 296,808 |
| **2004** | 2,743,909 | 318,616 |
| **2005** | 2,756,846 | 304,768 |
| **2006** | 2,909,680 | 329,322 |
| **2007** | 2,872,754 | 311,971 |
| **2008** | 2,825,116 | 299,064 |
| **2009** | 2,566,713 | 308,560 |
| **2010** | 2,545,593 | 306,141 |
| **2011** | 2,915,784 | 309,348 |
| **2012** | 2,903,216 | 329,576 |
| **2013** | 2,554,854 | 331,137 |
| **2014** | 2,533,414 | 349,372 |
| **2015** | 2,480,933 | 342,068 |
| **2016** | 2,504,258 | 356,358 |
| **2017** | 2,548,171 | 335,321 |
| **2018** | 2,625,422 | 338,035 |
| **2019** | 2,335,136 | 343,971 |

In general, IID's consumptive use of Colorado River water was largely steady at an average of 3,003,800 AF/year from 1991 to 2002 but has since been decreasing. The last time inflows exceeded 3,000,000 AF/year was in 2002, after which the implementation of water transfers via the Quantification Settlement Agreement (QSA) (discussed below) have decreased agricultural consumptive use over time.

CVWD's consumptive use of Colorado River water has increased most noticeably from less than 300,000 AF/year in 2008 to 350,618 AF in 2020. Before 2008, consumptive use was relatively stable at an average of 306,600 AF/year (average excludes 1990).

### 3.1.2 Estimates of Evapotranspiration and Evaporation Along the Lower Colorado River. U.S. Bureau of Reclamation. 1995 – 2014.


**Figure 4.** Landsat satellite image showing agricultural fields in the Imperial Irrigation District with digitized field borders as part of the effort to estimate ET and evaporation along the Lower Colorado River. (SOURCE: Reclamation, 1995 – 2014)

Reclamation uses satellite and aerial imagery and field-based inspections to map irrigated agricultural fields, riparian vegetation, and open water in the Lower Colorado River Basin to estimate ET and evaporation rates (Figure 4). This is done by classifying various crop types, estimating total acres of each type, and computing ET coefficients, which can be used to estimate total ET from each crop within the area in AF/year. Total acres of open water are also estimated, and a separate evaporation coefficient is computed. From 1995 – 2014, these evaporation and ET estimates have been recomputed every year with change detection analyses of the satellite and aerial imagery. Since 2004, the study area has been expanded to include IID and CVWD. In 2014, 173,273 AF of ET was attributed to irrigated agriculture and 5,760 AF of evaporation was attributed to open water in CVWD. In the same year, 1,515,621 AF of ET was attributed to irrigated agriculture and 12,939 AF of evaporation was attributed to open water in IID. Both IID and CVWD are considered devoid of riparian vegetation.

As part of this estimation effort, Reclamation develops area-specific reference ET rates for the Imperial and Coachella Valleys and for other areas served by the Lower Colorado River. These reference ET and average precipitation rates are provided in Table 2.

Table 2. Reference ET and average precipitation rates used to estimate ET in the Imperial/Coachella Valleys (units: inches). (SOURCE: Reclamation, 1995 – 2014)

| YEAR | REFERENCE EVAPOTRANSPIRATION | AVERAGE PRECIPITATION |
|---|---|---|
| 2004 | 72.85 | 3.97 |
| 2005 | 73.31 | 4.15 |
| 2006 | 77.84 | 0.38 |
| 2007 | 71.04 | 1.26 |
| 2008 | 68.63 | 1.74 |
| 2009 | 70.69 | 0.78 |
| 2010 | 71.40 | 3.45 |
| 2011 | 73.09 | 3.73 |
| 2012 | 72.60 | 2.30 |
| 2013 | 69.60 | 2.80 |
| 2014 | 72.10 | 0.80 |

Large fluctuations in average precipitation have been observed over the years from over 4 inches/year to less than 1 inch/year. Reference ET values were the greatest in 2006. Consequently, estimated agricultural ET in IID and in CVWD was greatest in 2006 (Table 3).

Table 3. Annual agricultural ET and open water evaporation estimated for the Imperial Irrigation District (IID) and the Coachella Valley Water District (CVWD) (units: AF). (SOURCE: Reclamation, 1995 – 2014)

| YEAR | IMPERIAL IRRIGATION DISTRICT (IID) | | COACHELLA VALLEY WATER DISTRICT (CVWD) | |
|---|---|---|---|---|
| | AGRICULTURAL EVAPOTRANSPIRATION | OPEN WATER EVAPORATION | AGRICULTURAL EVAPOTRANSPIRATION | OPEN WATER EVAPORATION |
| **2004** | 1,711,737 | 1,690 | 212,298 | N/A |
| **2005** | 1,707,998 | 6,080 | 226,102 | 19,041 |
| **2006** | 1,889,373 | 6,916 | 257,257 | 34,609 |
| **2007** | 1,730,300 | 9,168 | 183,160 | 18,271 |
| **2008** | 1,563,637 (+ 1,454) | 11,199 | 182,321 | 17,849 |
| **2009** | 1,514,046 | 10,415 | 164,239 | 5,634 |
| **2010** | 1,448,441 | 10,457 | 153,872 | 5,521 |
| **2011** | 1,528,247 | 13,302 | 163,897 | 5,583 |
| **2012** | 1,618,502 | 13,179 | 159,131 | 5,458 |
| **2013** | 1,468,642 | 12,761 | 153,725 | 5,588 |
| **2014** | 1,515,621 | 12,939 | 173,273 | 5,760 |

In 2008, riparian vegetation growth was observed in the Colorado River floodplain within IID (noted in parentheses). On average, open water evaporation increased greatly in IID from around 6,000 AF/year in 2005 to nearly 13,000 AF/year in 2014. On the other hand, agricultural ET consistently fluctuated around an average of 1,610,000 AF/year.

Open water evaporation at CVWD drastically decreased in 2009, likely due to the completion of the All-American Canal lining project.[5] The lining prevents seepage and flooding which otherwise inflate estimates of evaporation from the canal. From 2004 – 2008, agricultural ET in CVWD averaged over 212,000 AF/year. From 2009 – 2014, agricultural ET in CVWD fluctuated around 161,000 AF/year.

### 3.1.3 Annual Inventory of Areas Receiving Water. Imperial Irrigation District. 2002 – 2021.

IID maintains an annual inventory of areas receiving water. This dataset was used to corroborate Reclamation's estimates of ET described above. The archived data spans 2002 – 2021. This data includes annual crop surveys (including garden, field, and permanent crops), accounting of farms and their acreages, and a summary of the total area served. Within these annual inventories, the reported "Net Area Irrigated" was used to estimate the rate of ET at IID. Total ET from agriculture and evaporation from open water was reported in AF/year.

In general, the recorded net irrigated acreage fluctuated between 405,000 and 453,500 acres over the last two decades with a net decrease over the first five years (Table 4). "Net Area Irrigated" includes areas

[5] According to IID's website at https://www.iid.com/water/library/all-american-canal-lining-project

with one or many crops (including field, garden, and permanent crops), and areas being reclaimed by leaching.

Table 4. Net area irrigable in the Imperial Irrigation District (IID) from 2002 – 2021 (units: acres). (SOURCE: IID, 2002 – 2021)

| YEAR | IMPERIAL IRRIGATION DISTRICT (IID) NET AREA IRRIGATED |
|---|---|
| 2002 | 453,409 |
| 2003 | 450,571 |
| 2004 | 435,866 |
| 2005 | 433,321 |
| 2006 | 426,244 |
| 2007 | 423,617 |
| 2008 | 429,717 |
| 2009 | 432,158 |
| 2010 | 431,823 |
| 2011 | 440,650 |
| 2012 | 432,555 |
| 2013 | 411,195 |
| 2014 | 405,246 |
| 2015 | 426,607 |
| 2016 | 432,797 |
| 2017 | 425,006 |
| 2018 | 444,098 |
| 2019 | 443,226 |
| 2020 | 446,049 |
| 2021 | 446,670 |

### 3.1.4 Coachella Valley Water District Crop Reports. Coachella Valley Water District. 2013 – 2019.

From 2013 – 2019, CVWD summarized crop types, acreage, irrigation methods, and estimated gross value of agricultural production within CVWD. Within these annual reports, reported “Irrigable Acres” was used to estimate the rate of ET at CVWD. Total ET from agriculture and evaporation from open water was reported in AF/year. This dataset was used to corroborate Reclamation’s estimates of ET described above.

In general, the recorded number of acres of irrigated lands was consistently between 75,000 and 77,200 acres across the years (Table 5). “Irrigable Acres” is the sum of commercial acres, non-commercial acres, acres irrigated but not harvested, and acres not irrigated that were fallow and idle.

Table 5. Irrigable acres in Coachella Valley Water District (CVWD) from 2013 – 2019 (units: acres). (SOURCE: CVWD, 2013 – 2019)

| YEAR | COACHELLA VALLEY WATER DISTRICT (CVWD) IRRIGABLE ACRES |
|---|---|
| 2013 | 75,144 |
| 2014 | 76,354 |
| 2015 | 76,465 |
| 2016 | 76,411 |
| 2017 | 77,101 |
| 2018 | 76,364 |
| 2019 | 77,103 |

## 3.2 Management Plans and Hydrological Studies

Management plans and forecasts of the Colorado River water supply and demand are provided in several data sources and reports described in the following sections.

### 3.2.1 Colorado River Basin Water Supply and Demand Study. U.S. Bureau of Reclamation. December 2012.

The Colorado River Basin Water Supply and Demand Study was conducted by Reclamation's Upper and Lower Colorado regions and other agencies. The study defined current and future imbalances in water supply and demand in the Basin and in the adjacent areas of the Basin states, which will receive Colorado River water over the next 50 years (i.e., through 2060). The study was motivated by the worst 11-year drought in the 20th century, which required tapping into the Colorado River system's 60 million AF stores to meet the Lower Basin states' requested deliveries. Additionally, periodic shortages in the Upper Basin introduced variability that required a reassessment of future supply of and demand for water from the over-allocated Colorado River system. The study also provided a technical foundation for understanding the likelihood of increased demand for water and projections of reduced supply due to climate change.

Four scenarios for future water supply and six scenarios for future water demand were developed in this study. Water supply scenarios were assumed to fall under four categories:

1. Observed resampled: Future hydrologic trends and variability were assumed to be similar to the past 100 years of observations.
2. Paleo resampled: Future hydrologic trends and variability were assumed to be similar to the past 1,250 years, so reconstruction of streamflow over this longer period was used to account for enhanced variability.
3. Paleo conditioned: Future hydrologic trends and variability were represented by a blend of wet-dry states of the past 1,250 years but with magnitudes that were more similar to the last 100 years of observations. This scenario provided greater weight to the most recent period within the expanded, paleo-scaled variability.
4. Downscaled global climate models (GCMs) projected: Future climate was predicted to warm, and regional precipitation and temperature trends were represented by an ensemble of 112 GCMs with projected outputs downscaled to the Colorado River Basin study area. In general, this would result in a trend towards drying with increased ET and decreased snowpack, which would

culminate in a 9% decrease in mean natural flow and a 50% increase in droughts lasting longer than 5 years over the total simulation period of 50 years.

Prior to this study, Reclamation used a single projection of future demands in Colorado River Basin planning studies. This supply and demand study implemented scenario planning with information and data provided by the Basin states, tribes, federal agencies, and other users. Scenarios were described by demographic and economic storylines and were denoted as:

1. Current projected (A): where population growth, development patterns, and operations continue along recent trends.
2. Slow growth (B): where population growth slows with an emphasis on economic efficiency.
3. Rapid growth (C1 and C2): where there is an economic resurgence in population and energy, and current preferences towards environmental conservation values are preserved.
4. Enhanced environment (D1 and D2): where the economy grows but with expanded environmental awareness and stewardship.

These scenarios were then quantified by associated changes in agricultural, municipal, and industrial; energy; fish and wildlife; and tribal demand for total Colorado River water, which could then be divided by states and study areas. California's demand for Colorado River water, for example, was projected to grow by about 0.2 - 0.35 million AF/year, primarily due to population growth.[6] The resultant changes in Lake Mead pool elevation due to specific supply and demand scenario combinations are presented in Figure 5.

[6] The reduction in fish and wildlife demand for Colorado River water in the Lower Basin is noted to be caused by the cessation of mitigation water provided to the Salton Sea, in accordance with the Colorado River Water Delivery Agreement which was approved in 2003. There is also projected to be a small reduction in demand for Colorado River water for agriculture in California across scenarios, as suggested by the California Department of Water Resources 20 x 2020 Water Conservation Plan. Additionally, almost all of the growth in water demand for energy in the Lower Bain occurs in California due to the projected expansion of geothermal and solar projects.

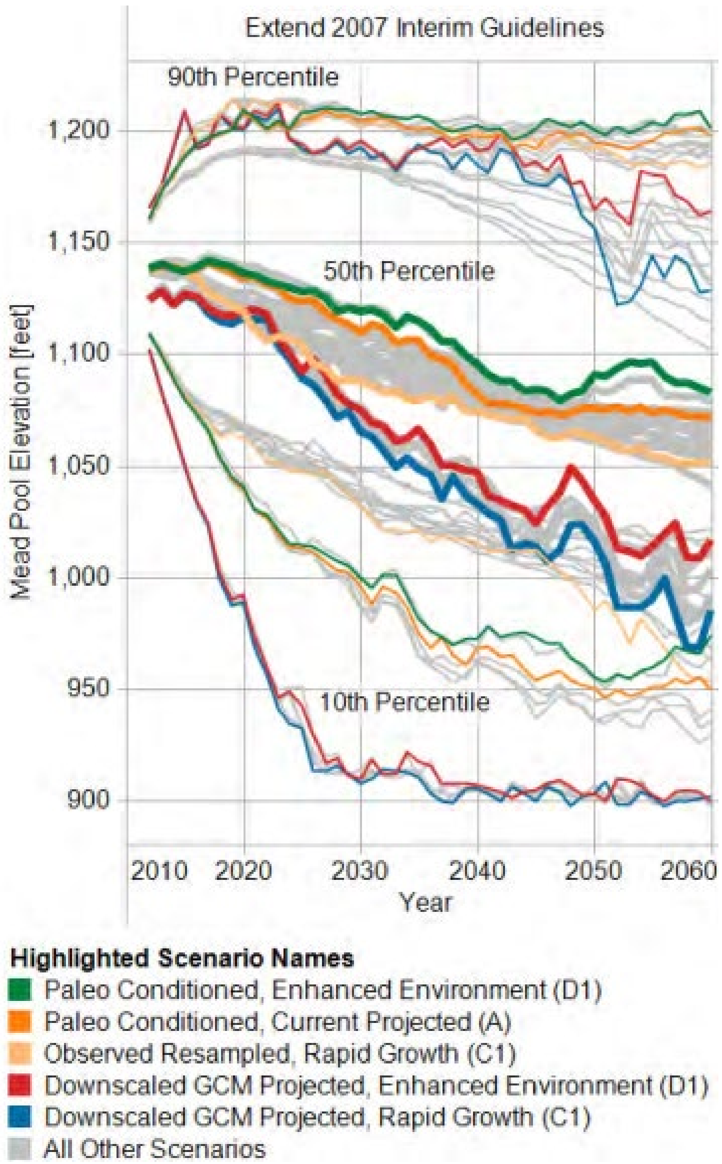



**Figure 5.** 10$^{th}$, 50$^{th}$, 90$^{th}$ percentiles for Lake Mead pool elevation by demand and supply scenario combinations. Scenarios assume that the 2007 Interim Guidelines for Lower Basin Shortage (see below) are extended beyond 2026, when they are currently due to expire.[7] (SOURCE: Reclamation, 2012a)

[7] Other operational assumptions, aside from the extension of the 2007 Interim Guidelines past 2026, are explored in the demand and supply study; however, the 2007 Interim Guidelines (see below for more details) are the operational guidelines that are currently in practice.

### 3.2.2 Review of the Colorado River Interim Guidelines for Lower Basin Shortage and Coordinated Operations for Lake Powell and Lake Mead. U.S. Bureau of Reclamation, U.S. Department of the Interior. December 2020.

The 2007 Interim Guidelines were a collaborative approach to establishing Colorado River operations during drought and low reservoir conditions. They provided a degree of certainty to the volume of future annual water deliveries to the Lower Basin water users until 2026. Four key components of the guidelines include:

1. An intentionally created surplus (ICS) mechanism for shortage and delivery of conserved water in Lake Mead, which provides credits for the delivery of conserved system water, thereby promoting water conservation in the Lower Basin.
2. Modification and extension of elements in the 2001 Interim Surplus Guidelines, including a determination of conditions under which surplus water is available for use by Lower Basin states and an elimination of liberal surplus conditions to ensure that more water is stored in reservoirs in preparation for longer drought periods.
3. Coordinated operations of Lake Powell and Lake Mead, to minimize overall shortages in the Lower Basin and to reduce the risk of water-use curtailments in the Upper Basin by re-balancing reservoir supplies.
4. A shortage strategy for Lake Mead, wherein Lake Mead elevations on January 1 of each year determine how much water deliveries are to be reduced during low reservoir conditions. Curtailments for each of the Lower Basin States are defined individually with Minute 323 separately delineating curtailments for Mexico.

The Lower Basin Drought Contingency Plan (DCP) authorizes additional ICS contributions (i.e., water conservation) by the Lower Basin water users when Lake Mead elevations fall below 1,090 ft above mean sea level (MSL). The DCP introduces formal requirements for California's allocations, which were otherwise absent from the 2007 Interim Guidelines. The Metropolitan Water District (MWD) is responsible for 85% of California's DCP contribution (up to 297,500 AF/year).[8] The maximum curtailment to California's allocations is 350,000 AF/year, which is equivalent to 7.95% of the allocations for the state.

The combined total volumes of curtailments outlined in these documents is presented in Table 6. Total volumes are in units of 1,000 AF (kAF). The highlighted row defines the shortage operating parameters for 2022, given that Lake Mead elevations were between 1,050 and 1,075 ft above MSL on January 1, 2022.

[8] As stated in IID's 2021 Colorado River Update: Operating Criteria, Current Hydrology, and 2022 Shortage Determination.

Table 6. Sources of total Colorado River water allocation curtailments to the Lower Basin, including the 2007 Interim Guidelines Shortages, Minute 323 Delivery Reductions, DCP Water Savings Contributions, and Binational Water Scarcity Contingency Plan Savings. Of these, only DCP outlines curtailments for California (units: thousand AF). (SOURCE: Reclamation, 2020)

| Lake Mead Elevation (feet msl) | 2007 Interim Guidelines Shortages | | Minute 323 Delivery Reductions | Total Combined Reductions | DCP Water Savings Contributions | | | Binational Water Scarcity Contingency Plan Savings | Combined Volumes by Country *US: (2007 Interim Guidelines Shortages + DCP Contributions) Mexico: (Minute 323 Delivery Reductions + Binational Water Scarcity Contingency Plan Savings)* | | | | | Total Combined Volumes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AZ | NV | Mexico | ***Lower Basin States + Mexico*** | AZ | NV | CA | Mexico | *AZ Total* | *NV Total* | *CA Total* | *Lower Basin States Total* | *Mexico Total* | ***Lower Basin States + Mexico*** |
| 1,090 - 1,075 | 0 | 0 | 0 | ***0*** | 192 | 8 | 0 | 41 | 192 | 8 | 0 | *200* | *41* | **241** |
| 1,075 - 1050 | 320 | 13 | 50 | ***383*** | 192 | 8 | 0 | 30 | 512 | 21 | 0 | *533* | *80* | ***613*** |
| 1,050 - 1,045 | 400 | 17 | 70 | ***487*** | 192 | 8 | 0 | 34 | 592 | 25 | 0 | *617* | *104* | ***721*** |
| 1,045 - 1,040 | 400 | 17 | 70 | ***487*** | 240 | 10 | 200 | 76 | 640 | 27 | 200 | *867* | *146* | ***1,013*** |
| 1,040 - 1,035 | 400 | 17 | 70 | ***487*** | 240 | 10 | 250 | 84 | 640 | 27 | 250 | *917* | *154* | ***1,071*** |
| 1,035 - 1,030 | 400 | 17 | 70 | ***487*** | 240 | 10 | 300 | 92 | 640 | 27 | 300 | *967* | *162* | ***1,129*** |
| 1,030 - 1,025 | 400 | 17 | 70 | ***487*** | 240 | 10 | 350 | 101 | 640 | 27 | 350 | *1,017* | *171* | ***1,188*** |
| <1,025 | 480 | 20 | 125 | ***625*** | 240 | 10 | 350 | 150 | 720 | 30 | 350 | *1,100* | *275* | ***1,375*** |

The Secretary of the Interior will take affirmative actions to implement programs designed to create or conserve 100,000 acre-ft per annum or more of Colorado River System water to contribute to conservation of water supplies in Lake Mead and other Colorado River reservoirs in the lower basin. All actions taken by the United States shall be subject to applicable law, including availability of appropriations.

These operational guidelines do not detail formal requirements for IID delivery curtailments under the Lower Basin DCP. However, while IID can utilize its full consumptive use of entitlements of 3.1 million AF, IID is not authorized to take delivery of its Lake Mead ICS (i.e., water conservation credits).[8]

On August 16, 2022, Reclamation released the Colorado River Basin August 2022 24-Month Study, which sets the annual operations for Lake Powell and Lake Mead in 2023 in light of critically low reservoir conditions. The August 2022 24-Month Study projects Lake Mead's Jan. 1, 2023 operating determination elevation to be 1,047.61 feet.[9] This projected elevation reflects a Level 2a Shortage Condition, within the DCP elevation band of 1,045 and 1,050 feet, with required shortage reductions and water savings contribution for the Lower Basin States and Mexico, pursuant to Minute 323, as shown in Table 6.

### 3.2.3 Colorado River System Projections Overview. U.S. Bureau of Reclamation. May 2022.

Reclamation also projects Colorado River Basin system-wide conditions up to five years in the future for determining reservoir operations and planning scenarios. Projections are probabilistic and generated using Colorado River Mid-term Modeling System (CRMMS) implemented in RiverWare, a river modeling platform (Figure 6). The model is maintained and updated continually by Reclamation's Upper and Lower Colorado regions. Output variables include the volume of water in shortage, reservoir elevations, releases from the dams, energy generation, streamflow, and diversions to and return flows from water users

[9] https://doi.gov/pressreleases/interior-department-announces-actions-protect-colorado-river-system-sets-2023

throughout the system. Simulations use a mass balance calculation which accounts for all water entering, stored in, and leaving the system. The model uses a set of rules to inform how water is released and delivered under various hydrologic conditions.

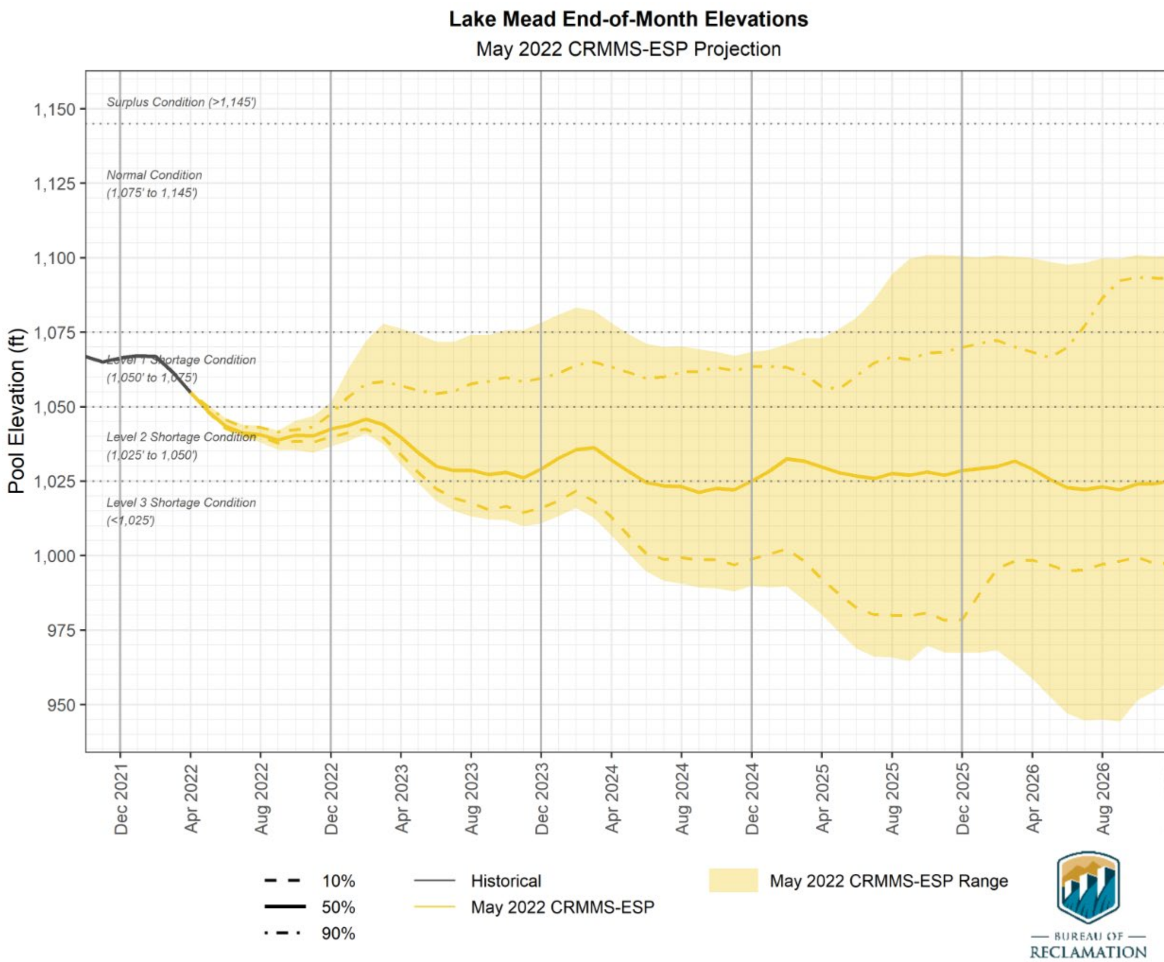



**Figure 6.** Projected Lake Mead elevations based on the latest model run from May 2022 using CRMMS. The colored region associated with the model run represents the minimum and maximum of the projected reservoir elevations. Solid lines represent historical elevations (black) and median projected elevations for the May 2022 CRMMS model run (yellow). Dashed and dot-dashed lines represent the $10^{th}$ and $90^{th}$ percentiles, respectively. Horizontally labeled conditions are important elevations for operations, including surplus condition (> 1,145 ft above MSL), normal condition (> 1,075 ft above MSL), and Level 1-3 shortage conditions (> 1,050, > 1,025, and < 1,025 ft above MSL, respectively). (SOURCE: Reclamation, 2022a)

For the 5-year time-period probabilistic projections, CRMMS was initialized using current basin soil moisture and snowpack and was forced with a 1991 to 2020 calibration period time series of precipitation and temperature. The result was a 30-member ensemble of streamflow forecasts which provided more information about risk and uncertainty for operations. The most recent 5-year projections of future Colorado River system conditions were produced in May 2022 with reservoir elevations initialized based on previous end-of-the-month values, historical intervening flows from 1991 to 2020 in the Lower Basin, and reflecting 2007 Interim Guidelines, Lower Basin DCP, and Minute 323 policies (Table 7).

Table 7. Results of the most recent CRMMS run (from May 2022), showing the probability of falling below critically low Lake Mead pool elevations in any month in the calendar year. Results are visually depicted in the yellow-colored region of the accompanying figure. (SOURCE: Reclamation, 2022)

| | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|
| **Lake Mead elevation < 1,020 ft above MSL** | 0% | 40% | 50% | 47% | 50% |
| **Lake Mead elevation < 1,000 ft above MSL** | 0% | 0% | 13% | 20% | 20% |
| **Lake Mead elevation < 950 ft above MSL** | 0% | 0% | 0% | 0% | 3% |
| **Lake Mead elevation < 900 ft above MSL** | 0% | 0% | 0% | 0% | 0% |

Uncertainties aim to consider variability in future climate scenarios, hydrology, and water demands. Reclamation works with stakeholders and scientists to develop the best modeling practices and to calibrate using the most appropriate assumptions. For projections beyond 2026, when the 2007 Interim Guidelines, the Colorado River Basin DCP, and the Minute 323 to the 1944 Treaty with Mexico expire, models are generated for specific study purposes designed by Reclamation and other agencies.

### 3.2.4 Management of the Colorado River: Water Allocations, Drought, and the Federal Role*.* Congressional Research Service R45546. August 2021.

This document summarizes the *Law of the River*, a commonly used shorthand to refer to the multiple laws, court decisions, and other documents that govern Colorado River operations. Where possible, each operational guideline within the *Law of the River* is an individual input for the modeling exercises described above. The combination of this document and the model outputs are referred to as the *Annual Operating Plan*, which uses projected water conditions on January 1 to establish a baseline for future annual operations.

### 3.2.5 Annual Operating Plan for Colorado River Reservoirs 2022*.* U.S. Bureau of Reclamation, U.S. Department of the Interior. December 2021.

In December 2021, the *Annual Operating Plan* for calendar year 2022 was drafted. It indicated that Lake Mead elevation was 1,067.68 ft above MSL on October 1, 2021, with 9,020,000 AF in storage (i.e., the reservoir was at 35% capacity). Under the most probable inflow scenario, Lake Mead was projected to end water year 2022 at elevation 1,051.90 ft above MSL. Lake Mead was projected to decline to elevation 1,050.42 feet with 7.71 million acre-feet (MAF) in storage (30 percent of capacity) at the end of 2022. Flows arriving at Imperial Dam for 2022 were projected to be 5,300,000 AF. Diversions from Imperial Dam provide water to IID and CVWD, among other regions.

### 3.2.6 Water & Quantification Settlement Agreement Implementation Annual Report. Imperial Irrigation District. 2020.

Prior to 2002, California had been using approximately 5.2 million AF/year of Colorado River water. Under the QSA, an agreement between several California water districts and the Department of the Interior, California agreed to reduce its use to 4.4 million AF/year under the *Law of the River*. This was achieved through conservation efforts (e.g., lining the All-American Canal to reduce seepage and increase usable supplies) and providing for several large-scale long-term agriculture-to-urban water transfers. As specified in the QSA, IID will transfer nearly 415,000 AF annually over a 35-year or longer period. The QSA also committed the state of California to a path for the ecological restoration of the Salton Sea. QSA transfers from IID to San Diego, Los Angeles, and Coachella Valley began in 2003. Since the signing of the QSA, approximately 777,000 AF of conserved water has also been used to mitigate salinity at the Salton Sea, and over 159,000 AF of ICS has been generated, often by fallowing (Figure 7).

For IID, ICS is surplus water created through extraordinary conservation, including but not limited to the lining of canals or land fallowing. ICS water is available for use under the terms and conditions of water delivery agreements under the 2007 Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead. Under the current guidelines, the total amount of ICS that IID may store in any year is limited to a 25,000 AF annual cap and a cumulative 50,000 AF total.

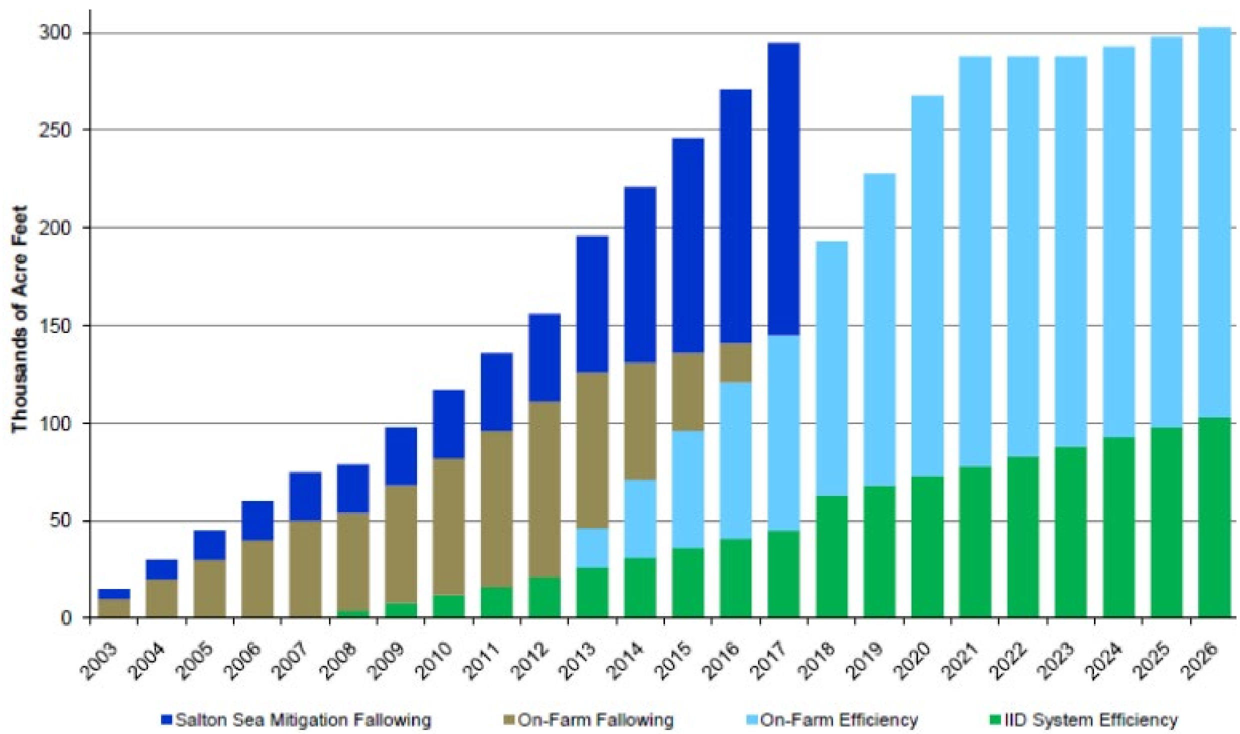



**Figure 7.** Imperial Irrigation District's (IID's) QSA transfer schedule showing sources of water conservation and ICS generation from 2003 – 2026. (SOURCE: IID, 2020)

An annual water accounting summary from the *Water & QSA Implementation Annual Report* (IID, 2020) tabulates the sources of water conservation (fallowing and efficiency) in addition to transfer obligations of the counties participating in the QSA, including San Diego County Water Authority (SDCWA) and CVWD (Table 8).

For the Salton Sea, the effects of the QSA transfers include an increasing rate of water elevation decline. Improved efficiency of irrigation has reduced rates of agricultural runoff that feed into the Sea and help maintain its size and water levels. Shrinking of the Salton Sea has negative impacts on public health as the exposed lakebed worsens dust-driven air pollution. Since 2018, total deliveries to the Salton Sea have been negligible as the transferring parties (SDCWA and CVWD) are no longer required to provide inflows to mitigate the reduced agricultural runoff into the Salton Sea.

Table 8. San Diego County Water Authority (SDCWA) and Coachella Valley Water District (CVWD) water conservation obligation and achievements (via fallowing and efficiency), and total delivery of water to the Salton Sea under QSA from implementation in 2003 to present (2020) and future obligations (units: AF). (SOURCE: IID, 2020). SDCWA under-obligations are denoted by a downward red triangle and over-obligations are denoted by an upward green triangle.

| **YEAR** | **SDCWA** | | | **CVWD** | | | **QSA MITIGATION WATER DELIVERED BY IID** |
|---|---|---|---|---|---|---|---|
| | **OBLIGATION** | **FALLOWING** | **EFFICIENCY** | **OBLIGATION** | **FALLOWING** | **EFFICIENCY** | |
| **2003** | **10,000**▼ | 3,445 | 0 | **0** | 0 | 0 | **0** |
| **2004** | **20,000** | 20,000 | 0 | **0** | 0 | 0 | **30,239** |
| **2005** | **30,000** | 30,000 | 0 | **0** | 0 | 0 | **21,476** |
| **2006** | **40,000** | 40,000 | 0 | **0** | 0 | 0 | **0** |
| **2007** | **50,000** | 50,000 | 0 | **0** | 0 | 0 | **23,306** |
| **2008** | **50,000** | 50,000 | 0 | **4,000** | 0 | 4,000 | **26,085** |
| **2009** | **60,000** | 60,000 | 0 | **8,000** | 0 | 8,000 | **30,158** |
| **2010** | **70,000** | 70,000 | 0 | **12,000** | 0 | 12,000 | **80,282** |
| **2011** | **80,000**▼ | 63,278 | 0 | **16,000** | 0 | 16,000 | **0** |
| **2012** | **90,000**▲ | 106,722 | 0 | **21,000** | 0 | 21,000 | **15,110** |
| **2013** | **100,000** | 80,000 | 20,000 | **26,000** | 0 | 26,000 | **71,470** |
| **2014** | **100,000** | 60,000 | 40,000 | **31,000** | 0 | 31,000 | **89,168** |
| **2015** | **100,000** | 40,000 | 60,000 | **36,000** | 8,983 | 27,017 | **153,327** |
| **2016** | **100,000** | 20,000 | 80,000 | **41,000** | 0 | 41,000 | **130,796** |
| **2017** | **100,000** | 0 | 100,000 | **45,000** | 0 | 45,000 | **105,155** |
| **2018** | **130,000** | 0 | 130,000 | **63,000** | 25,010 | 37,990 | **149** |
| **2019** | **160,000** | 0 | 160,000 | **68,000** | 65,782 | 2,218 | **16** |
| **2020** | **192,500** | 0 | 192,500 | **73,000** | 65,964 | 7,036 | **0** |
| **2021** | **200,000** | | | **78,000** | | | **0** |
| **2022** | **200,000** | | | **83,000** | | | **0** |
| **2023** | **200,000** | | | **88,000** | | | **0** |
| **2024** | **200,000** | | | **93,000** | | | **0** |
| **2025** | **200,000** | | | **98,000** | | | **0** |
| **2026** | **200,000** | | | **103,000** | | | **0** |
| **…** | **200,000** | | | **103,000** | | | **0** |
| **2047** | **200,000** | | | **103,000** | | | **0** |

# 4 Previous Modeling of Inflows to the Salton Sea with SALSA2

This section summarizes prior work performed by IID using the Salton Sea Elevation Model version 2 (SALSA2) to characterize inflows to the Salton Sea. This prior work is described because some of the methodologies and inflows became the basis for the inflow terms used for the purposes of the Long-Range Plan (LRP).

## 4.1 Modeling Set-up

SALSA2 , a computer program developed by IID, estimates future changes in Salton Sea elevation. SALSA2 follows certain assumptions regarding projected future inflows to calculate the elevation and salinity of the Salton Sea. The report *Salton Sea Hydrological Modeling and Results* (IID 2018a) describes the model, SALSA2, which simulates the overall water and salt balance for the Salton Sea under prescribed future conditions. SALSA2 is a stochastic simulation model that allows for analysis of uncertainty in the input flow assumptions.

The report *Salton Sea Hydrology Development* (IID 2018b) describes the development of input probability distributions for each of the inflow inputs. Inflows to the Salton Sea were categorized by the following geographical source area contributions: Mexico, Imperial Valley, Coachella Valley, and local watershed . Each of these inflow components, their historical (pre-2015) description, and assumptions for the future no-action condition are summarized in Table 9.

Table 9. Summary of SALSA2 model inflow assumptions. (SOURCE: IID, 2018a)

| INFLOW COMPONENT | HISTORICAL DESCRIPTION | FUTURE NO ACTION |
|---|---|---|
| **MEXICO** | Updated historical measured inflows from Mexico in New and Alamo Rivers (1950 – 2015) adjusted for Colorado River deliveries to Mexico variability. | Initial model conditions plus reduced New River flows for:<br>• Mexicali Wastewater Improvements<br>• Mexicali Power Plants<br>Further reductions based on recent water management trends |
| **IMPERIAL VALLEY** | Estimated flows for 1980 – 1999 cropping patterns under 1925 – 1999 climate conditions; IID Salton Sea simulations provided by IID.<br>Changes for projects in-place since 2002:<br>• QSA<br>• IID Water Conservation and Transfer Project<br>• Inadvertent Overrun and Payback Policy<br>• All-American Canal Lining Project | Initial model conditions plus changes for:<br>• QSA<br>• IID Water Conservation and Transfer Project<br>• Entitlement Enforcement<br>• Inadvertent Overrun and Payback Policy<br>• All-American Canal Lining Project<br>Further reductions based on water management trends, urban growth, and Colorado River drought |

| INFLOW COMPONENT | HISTORICAL DESCRIPTION | FUTURE NO ACTION |
|---|---|---|
| **COACHELLA VALLEY** | Updated historical inflows from Coachella Valley from Whitewater River (Coachella Valley Storm Channel), direct drains, and groundwater; includes Coachella Canal Lining Project. | Initial model conditions plus changes for:<br>• IID-CVWD Transfer<br>Coachella Valley WMP Update (2012) (uncertainty added to reflect current conditions and CVWD projected conditions) |
| **LOCAL WATERSHED** | Derived surface water and flow estimates from rainfall-runoff regressions and previous studies. | Initial model conditions plus reduced flows from Salt Creek due Coachella Canal Lining Project. |

## 4.2 Detailed Inflow Assumptions

The uncertainty in future inflows from Mexico is represented by a triangular probability distribution of future inflow reductions as shown in Figure 8. The probability distribution is described as a percent reduction and ranges from a 0% to a 100% reduction in inflows, with a future reduction in inflows from Mexico of 75% considered the most likely. Under the Future No Action condition, the mean of all traces sampled for Salton Sea inflows from Mexico averaged approximately 48,600 AF/year for the 2016 – 2077 period. The resulting inflow distribution over time is shown in Figure 9 below.

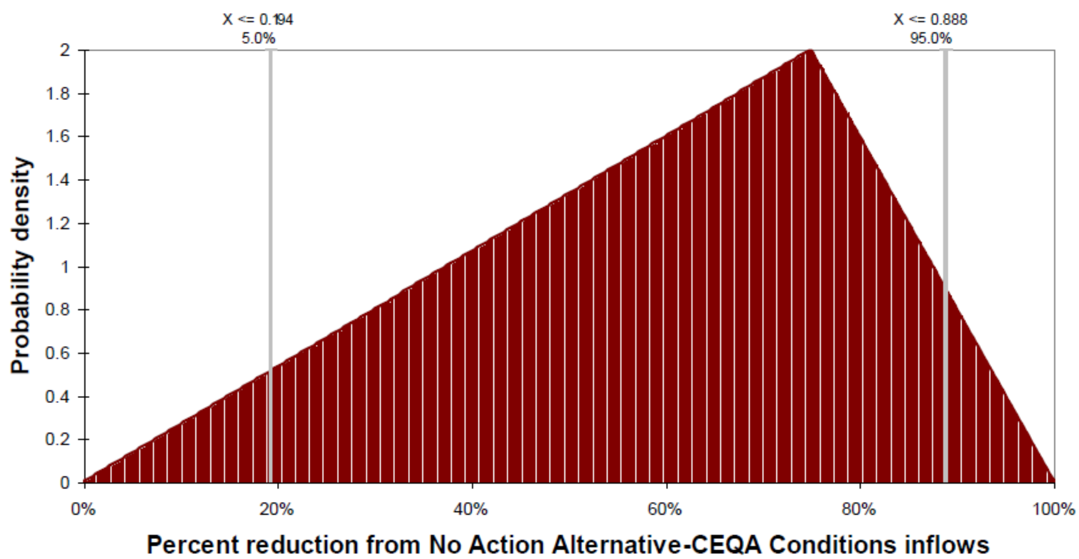



**Figure 8.** Probability distribution applied to reflect reductions in inflows from Mexico under the Future No Action condition, expressed as a percentage reduction from No Action Alternative-CEQA Conditions inflows. A 75% reduction in inflows from Mexico is considered most likely. (SOURCE: IID, 2018b)

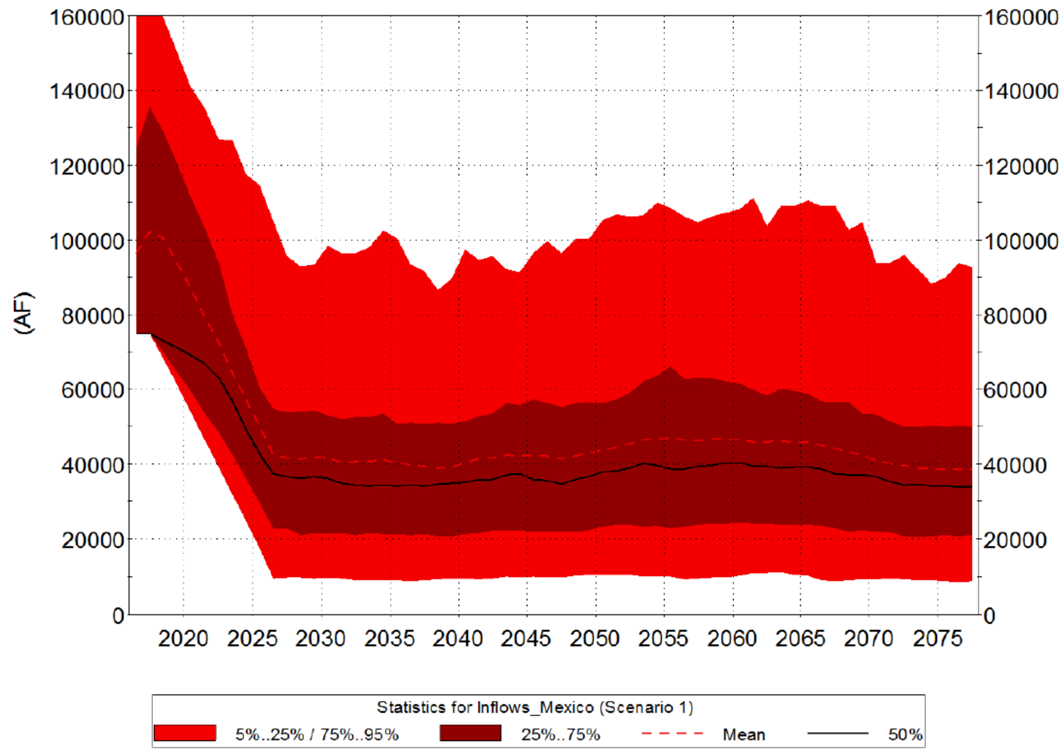



**Figure 9.** Possible future inflows from Mexico under the Future No Action condition. The dark red region denotes the range of uncertainty captured between the 25th and 75th percentiles. The light red region denotes the range of uncertainty captured between the 5th and 95th percentiles. After 2026, the 50th percentile of future inflows declines to an average below 40,000 AF/year. (SOURCE: IID, 2018b)

As a surrogate for the uncertainty associated with the water and land use changes within the Imperial Valley and management of the Colorado River (see Table 9), inflows from the Imperial Valley were reduced as a fraction of the estimated tailwater flows to the Salton Sea. Tailwater, representing the water that drains from the surface of a field during an irrigation event, was selected as a reasonable substitute for the future maximum change in Imperial Valley contributions to the Salton Sea inflow. The probability distribution of possible future reductions in tailwater was described as a percent reduction from 5% to 95% percent. A triangular distribution (Figure 10) was used to reflect the fact that greater reductions in tailwater will generally require more complex methods of water conservation at greater costs and are thus less likely than smaller reductions. Under the Future No Action condition, the mean of all traces sampled for Salton Sea inflows from Imperial Valley was approximately 586,000 AF/year for the 2016 – 2077 period. The resulting inflow distribution over time is shown in Figure 11.

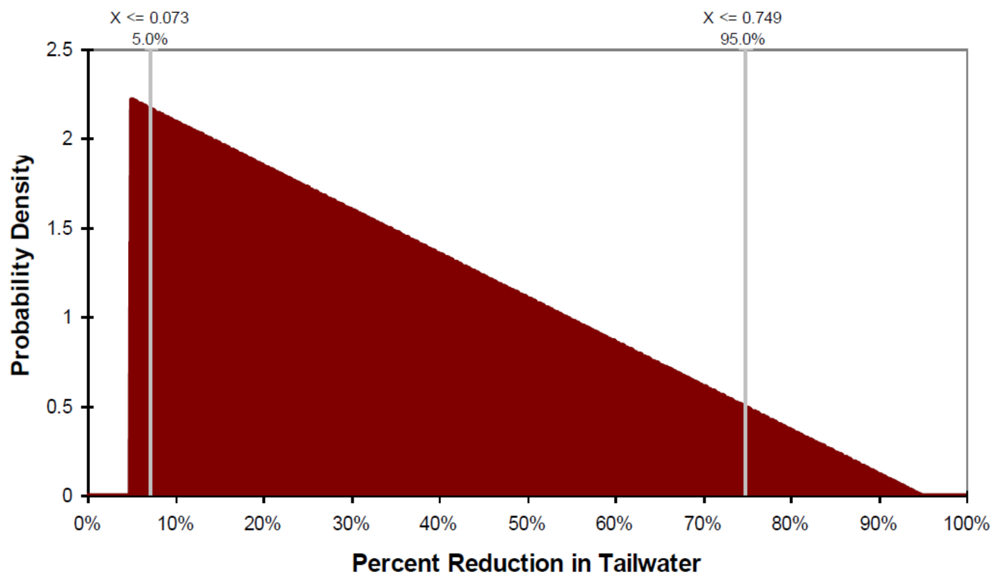



**Figure 10.** Probability distribution to describe the range of uncertainty in future Imperial Valley inflows to the Salton Sea under the Future No Action condition, as expressed by percentage reduction in tailwater. (SOURCE: IID, 2018b)

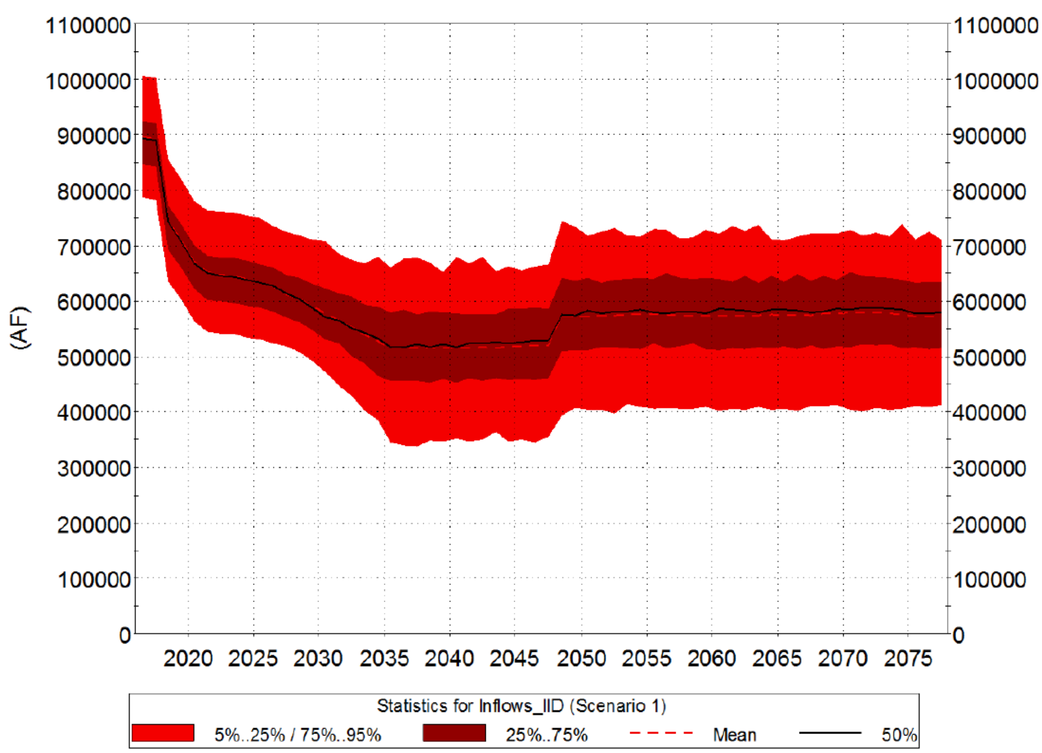



**Figure 11.** Possible future inflows from the Imperial Valley under the Future No Action condition. The dark red region denotes the range of uncertainty captured between the 25th and 75th percentiles. The light red region denotes the range of uncertainty captured between the 5th and 95th percentiles. After 2035, the 50th percentile of future inflows plateaus to an average just above 500,000 AF/year. After 2048, the 50th percentile of future inflows is projected to increase slightly but stabilize at an average just under 600,000 AF/year. (SOURCE: IID, 2018b)

Agricultural and storm water runoff in the Coachella Valley is conveyed to the Salton Sea in the Whitewater River/Coachella Valley Stormwater Channel (CVSC) and through drains that discharge directly to the Salton Sea. Projected future flows from the Coachella Valley to the Salton Sea are consistent with those included in the CVWD's Water Management Plan (WMP). Through implementation of the WMP, flows from the Coachella Valley to the Salton Sea are projected to increase, although there is uncertainty in the magnitude and timing of these changes. Annual inflows to the Salton Sea from the Coachella Valley are projected to grow from about 56,000 AF in 2015 to over 130,000 AF/year by 2060 without desalination of drain flows (Figure 12). The WMP includes several scenarios of varying quantities of desalination of drain flows. The range of potential drain flow desalination included in the WMP by 2045 is between 55,000 AF/year and 85,000 AF/year. Under the Future No Action condition, the range of future flows coming from the Coachella Valley has been estimated as the range reflecting minimum and maximum desalination as indicated in the WMP.[10]

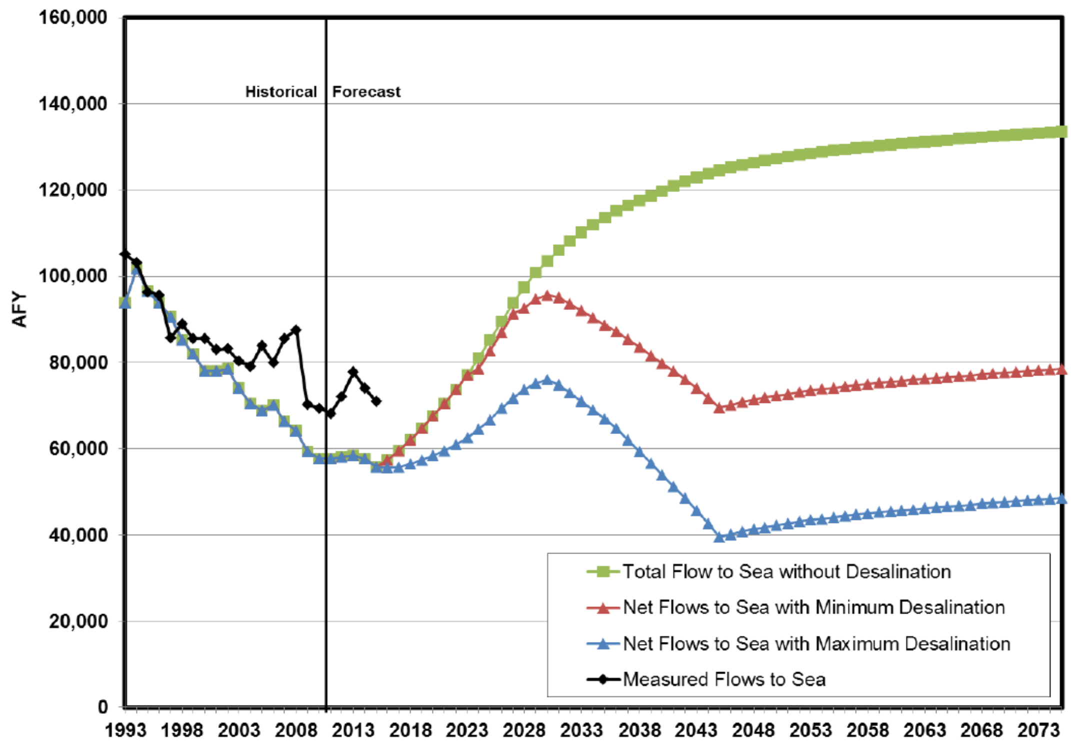



**Figure 12.** Possible future inflows from the Coachella Valley to the Salton Sea under the Future No Action condition. With desalination, flows are projected to peak in 2028. Without desalination, flows are projected to increase continuously but at a slower rate after 2028. (SOURCE: IID, 2018b)

The document *Salton Sea Hydrology Development* (IID, 2018b) reports that groundwater inflow to the Salton Sea from areas outside of Imperial and Coachella Valleys is estimated to be approximately 10,000 AF/year. The groundwater underflow entering the Salton Sea at the perimeter comes primarily from the

[10] Information in this section has been superseded by the 2022 Indio Subbasin Water Management Plan Update: Sustainable Groundwater Management Act (SGMA) Alternative Plan. The information provided here is for further context to describe modeling performed by IID in 2018 using the Salton Sea Elevation Model version 2 (SALSA2) to characterize inflows to the Salton Sea. Those inflow predictions are provided for context and comparison in Section 6.3 below.

alluvium underlying San Felipe Creek. Groundwater inflow from the Imperial and Coachella Valleys is accounted for in the values discussed above under their respective geographical source areas.

## 4.3 Future Climate Scenarios

The SALSA2 modeling assessment relies on projected temperature and precipitation changes using median values computed from 112 future climate projections, representing 16 different climate models under three emission scenarios. Figure 13 shows the range of simulated annual average temperature and precipitation derived from the 112 climate projections over the Salton Sea. As shown, annual temperatures are projected to continuously increase throughout the century. Conversely, projections of annual precipitation exhibit greater variability with some projections showing future decreases and some showing future increases.

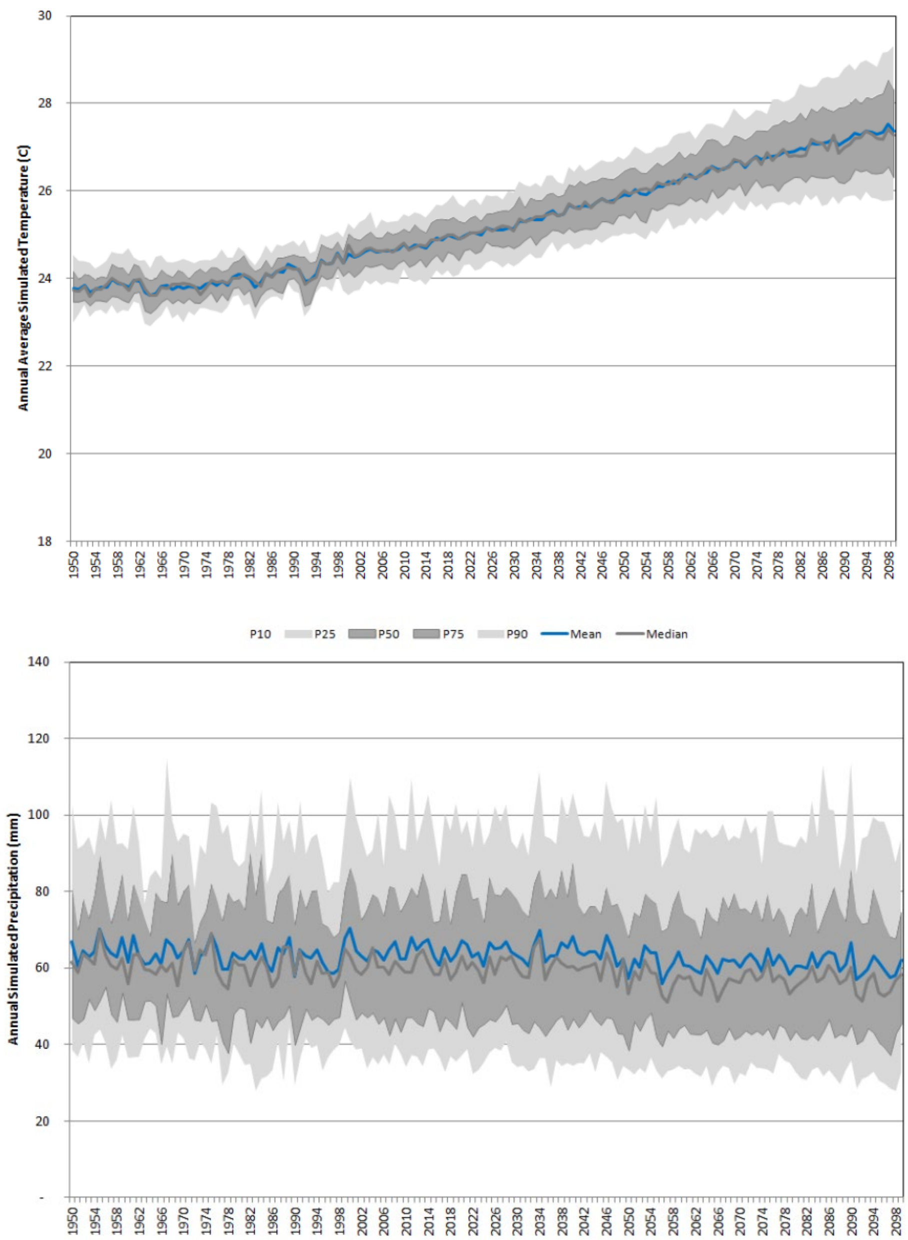



**Figure 13.** Simulated historical and future average annual temperature (top) and precipitation (bottom). Mean and median projections are denoted by the solid blue and grey lines, respectively. (SOURCE: IID, 2018b)

In SALSA2, the net evaporation rate was adjusted for increasing temperature (approximately 2$^{o}$C by 2050 and up to 3$^{o}$C by 2075) and a negligible change in precipitation. The effect on future evaporation was evaluated through an analysis of reference ET rates, temperature, wind, net radiation, and other meteorological data.

## 4.4 Model Inflow Summary

Figure 14 presents graphical representation of the projected Salton Sea inflows for the Future No Action condition over the period 2015 to 2077.

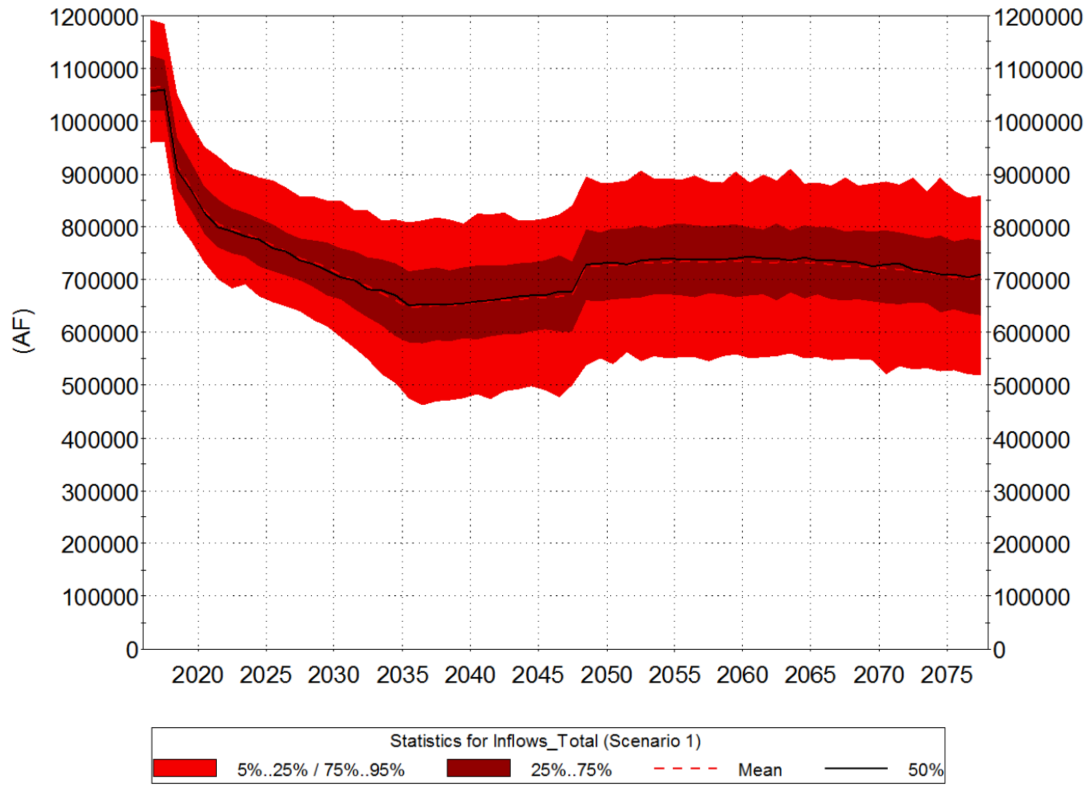



**Figure 14.** Projected future total inflows into the Salton Sea under the Future No Action condition. The dark red region denotes the range of uncertainty captured between the 25th and 75th percentiles. The light red region denotes the range of uncertainty captured between the 5th and 95th percentiles. In 2035, the 50th percentile of future inflows is at its minimum but increases slightly. After 2048, the 50th percentile of future inflows is projected to plateau at an average just under 750,000 AF/year. (SOURCE: IID, 2018b)

# 5 Data and Methodology

This section provides a detailed discussion of the data sources and methodology used to develop the inflow scenarios discussed in Section 6. Discussed below are Colorado River allocation trends and observations, followed by a discussion of how climate change is considered, and an accounting of inflow terms to the Salton Sea. Additionally, outflow terms from the Salton Sea watershed, including ET losses from agriculture and evaporation from the Salton Sea itself are characterized.

## 5.1 Colorado River Allocations

California is allocated 4.4 million AF of the Colorado River's total 16.5 million AF of allocations that are made available to the Basin states and to Mexico (Reclamation, 2020). Canals and aqueducts deliver most of California's allocation to agricultural and urban export areas outside the river basin. Due to the Lower Basin states' higher consumption and reduced runoff, there exists an imbalance between water supplies and demands. Laws and policies require Upper Basin states to allow an average of 8.25 million AF/year to reach the Lower Basin. However, shortages will trigger usage cuts for Arizona, Nevada, and Mexico. Even though California has senior and relatively more secure water rights, any negotiations in voluntary use-reduction agreements to slow the decline of Lake Mead elevations will ultimately benefit California and minimize mandatory usage cuts (PPIC Water Policy Center, 2018).

Additionally, trading water and carrying over supplies for use in later years can alleviate the cost of expected shortages. However, such practices are stringently governed. Some workarounds include the storage of water, that is to be directed to California and Nevada, in Arizona's groundwater basins (PPIC Water Policy Center, 2018).

Within California, irrigators have the first right to use 3.85 million AF of the total allocated 4.4 million AF/year. Recent adaptations to reduced Colorado River supplies include regional collaboration and more flexible management, as exemplified by the QSA. The two major changes that have been implemented include the establishment of state funding for lining of canals and the establishment of long-term trades between urban agencies and irrigators. Lining the All-American Canal, for example, reduced seepage and increased usable supplies. Alternatively, trade agreements for over 500,000 AF/year make water available from land fallowing and encourage investment in more efficient irrigation practices. In particular, the acquiring of water for the Metropolitan Water District of Southern California from Palo Verde Irrigation District, the Bard Water District, and IID is one such agreement. SDCWA's purchase agreement with IID is another. These responses are quantified below.

Figure 15 shows the Colorado River inflows into IID and CVWD as reported over the last two decades by Reclamation in the Colorado River Accounting and Water Use Reports. Also shown is the 1995 – 2002 average inflow, which was historically much higher in Imperial Valley but slightly lower in Coachella Valley than the reported inflows in the latest 2015 – 2020 period. Colorado River allocations for IID have decreased in the last two decades but allocations for CVWD have been steady and have even increased on average in the last seven years.

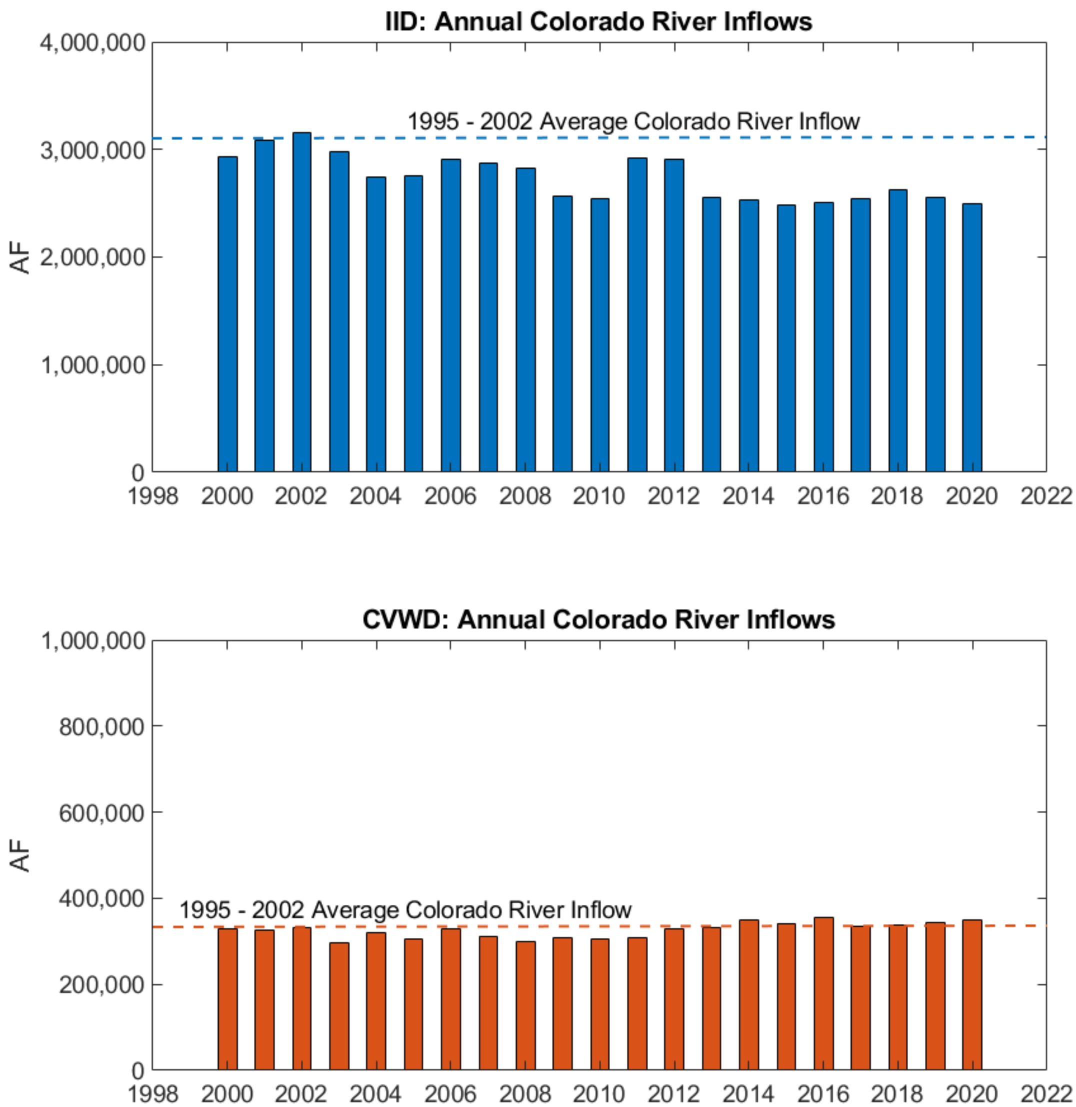



**Figure 15.** Annual Colorado River inflows into IID and CVWD from 2000 to 2020. From 1995 – 2002, Colorado River allocations for IID averaged 3.09 million AF. During the same period, Colorado River allocations for CVWD averaged 331,600 AF. (SOURCE: Reclamation, 1964 – 2020)

Sub-annual Colorado River allocations for IID show that allocations are the lowest in December and January and that they increase sharply each month until May through July (Figure 16). In recent years, allocations have fallen below 300,000 AF/month on average from May through July, but historically exceeded 350,000 AF/month. From the summer peak onwards, allocations slowly decrease for the remaining months to a similar minimum in December of around 131,000 AF/month. This overall sub-annual flow has been consistent over the last two decades.

For CVWD, allocations are also lowest in January and peak from May to July as well (Figure 17). Between 2002 and 2016, flows increased most substantially during and directly following peak irrigation in May. Overall, the difference in sub-annual flows is not as pronounced as at IID.

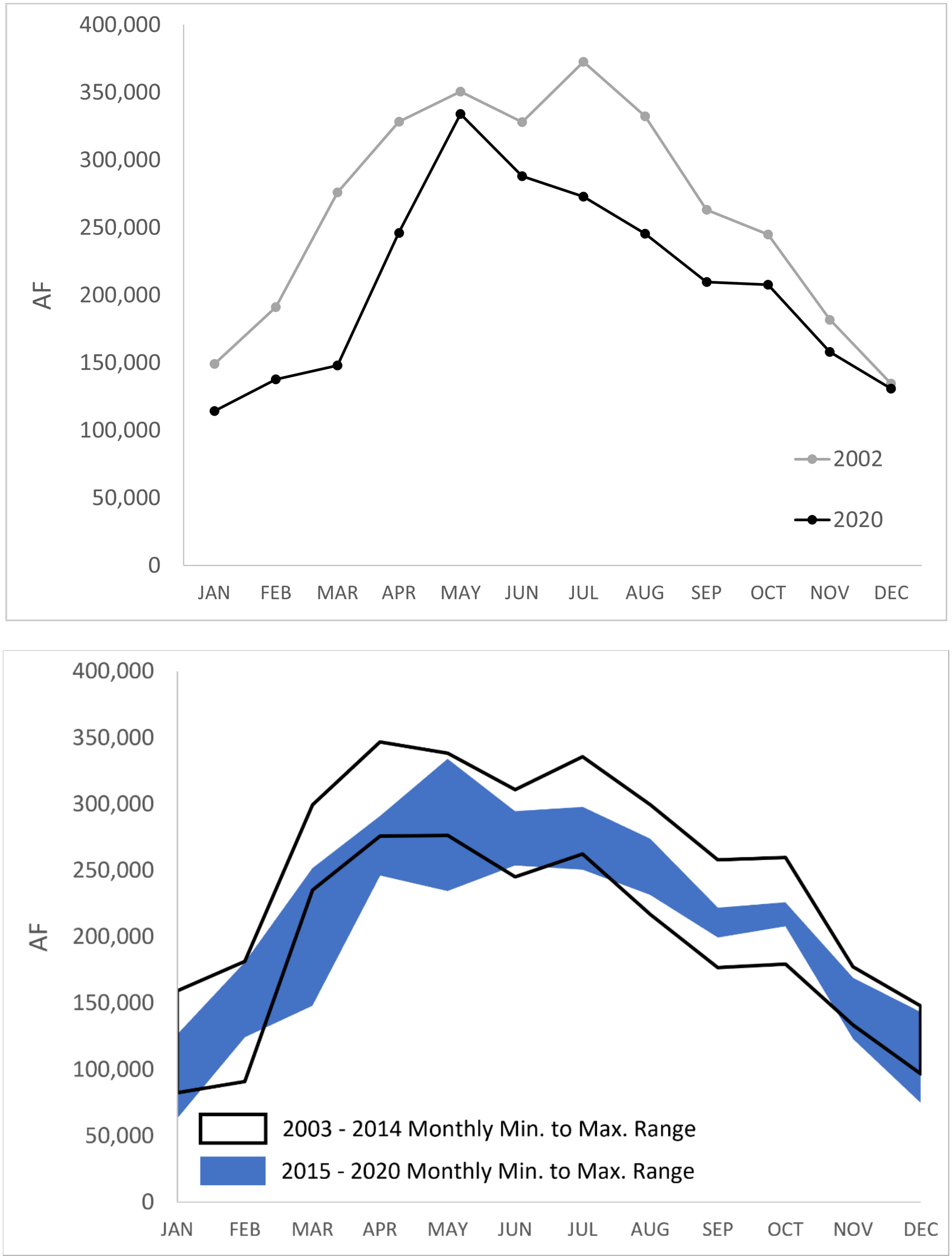



**Figure 16.** Sub-annual Colorado River inflows (top) and variability (bottom) at IID in 2002, pre-QSA, and in 2020, most recently. Trends show that the peak inflows occur during the summer for both time periods but that the magnitude of these flows has decreased. (SOURCE: Reclamation, 1964 – 2020)

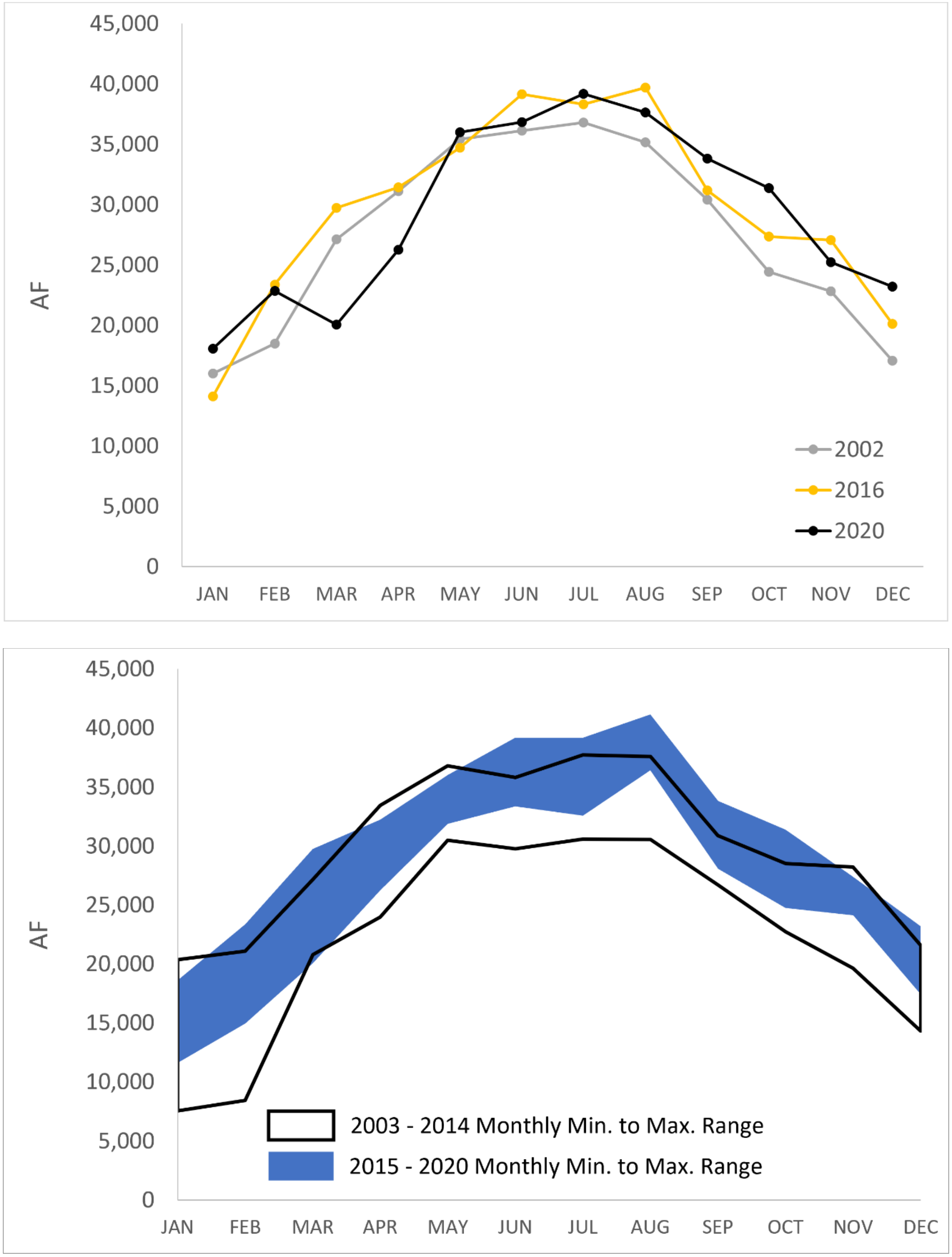



**Figure 17.** Sub-annual Colorado River inflows (top) and variability (bottom) at CVWD in 2002, pre-QSA, in 2020, most recently, and in 2016, when Colorado River allocations were their highest in the last 20 years. Trends show that the peak inflows occur during the summer for each time period. (SOURCE: Reclamation, 1964 – 2020)

In developing future scenarios, Colorado River allocation curtailments for California can be generalized to extend to IID. Curtailments for California will be introduced when Lake Mead elevation is less than 1,045 ft above MSL on January 1 (see Table 6). The maximum curtailment for California is 350,000 AF or 7.9% of California's total allocation and is reached when Lake Mead elevations fall below 1,030 ft above MSL on January 1.

As stated in the 2007 Interim Guidelines, there are no formal requirements for IID delivery curtailments under the Lower Basin DCPs. However, future scenarios can be built based on the assumption that curtailments for IID are proportional to curtailments for California, as a percentage of allocation. That is, if California is to be allocated 4.5% less water than the California allocation in any given year, IID will also be allocated 4.5% less water than the IID allocation in that same year. By extension, such future allocations for IID also inform allocations for the management of the Salton Sea.

Stream flow observations provide insight into the changes in the hydrology of the Salton Sea basin. Recent changes include reductions in flows from Mexico, and with long-term QSA water transfer commitments, stream flows are expected to decrease further. To provide a general understanding of the flow contributions in the basin, and to provide a baseline for this work, historical flow from the Alamo and New River Basins, focusing on the last two decades, are summarized in Section 5.3 below.

## 5.2 Climate Change Effects on Hydrology

Climate change effects on the hydrology of the Salton Sea were examined using three methodologies. The first assessed the climate change effects on the climate and hydrology of Upper Colorado River Basin. The second analyzed the climate change impacts on inflow to the Imperial Valley. The third examined climate change impacts on ET.

### 5.2.1 Climate Change Effects on Upper Basin Climate and Hydrology

Historical and Future climate and hydrology of Upper Colorado River Basin are discussed in this section to provide background information on historical and future projected natural flows of Colorado River Basin, with an emphasis on the effect from climate variability and climate change. As Upper Colorado River Basin contributes to 92% of basin-wide total natural flow (Lukas and Payton, 2020), the analyses presented in this work focus on the upper basin. Three types of climate hydrology information are discussed: the historical observations; the reconstruction of historical hydrology from tree ring datasets; and the climate model projections of future conditions.

#### 5.2.1.1 Historical Climate and Hydrology

Historical natural flows and temperature and precipitation records were obtained from Bureau of Reclamation (Reclamation, 2022c) and a NOAA database (NOAA, 2022). Specifically, annual natural flows of water years at the Lees Ferry, Arizona for the Colorado River were obtained, whereas the annual temperature and precipitation records of water years were aggregated for Upper Colorado River Basin by NOAA (NOAA, 2022) and were calculated as changes from the means of the first 30-year period (1895–1924) in this section. The time series of annual natural flows, temperature changes, and precipitation changes are presented in Figure 18.

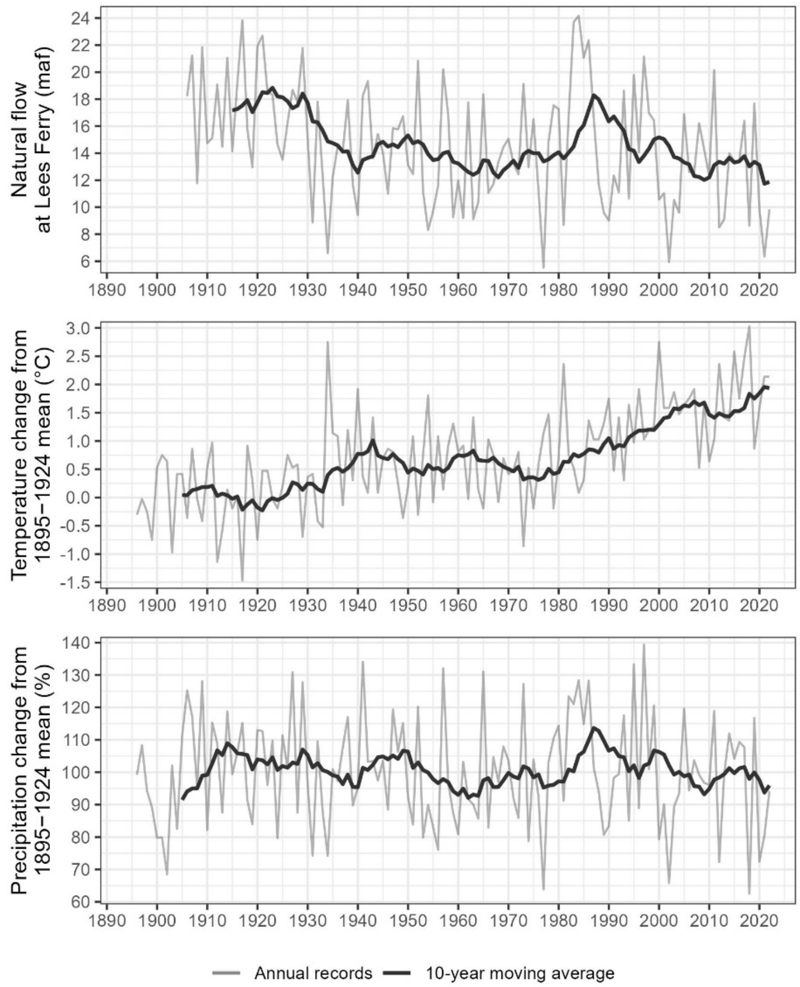



**Figure 18.** Historical annual natural flows, temperature changes, and precipitation changes of water years for Upper Colorado River Basin.

As presented in Figure 18, although some year-to-year and decadal variability can be observed, natural flow decreases and temperature increases over the periods of records. The natural flow level during the 1906–1930 period, for example, has an average value of around 18 maf/year, whereas the recent 2000–2022 period has an average of around 13 maf/year. Using the 1895–1924 period as a reference period, annual average temperature increased slightly less than 2°C for the upper basin. Long-term precipitation changes are not observable, with the recent precipitation level slightly lower than the 1895–1924 reference period. In addition to the year-to-year variability (as presented in all three time series), some decadal variations can be identified in Figure 18. For example, the temperature level during 1930s exhibit a sudden increase, whereas the natural flows and precipitation during 1930s are generally lower than the previous and subsequent years.

As the increase of temperature and decrease of precipitation resulted in the deduction of natural flows as presented in Figure 18, the effect of annual temperature and precipitation on natural flows were further assessed. The relationships between annual natural flows and temperature (or precipitation) were plotted in Figure 19. Each point in Figure 19 represents the natural flow and temperature (or precipitation) from one water year (same data records presented in Figure 18).

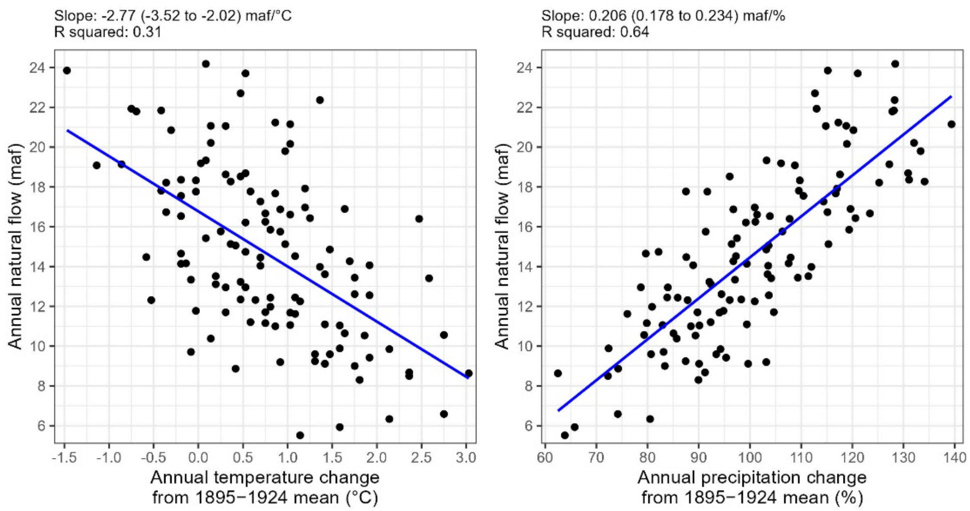



**Figure 19.** Scatter plots of annual natural flows vs. (left) annual temperature changes and (right) precipitation changes of water years for Upper Colorado River Basin. The blue lines present the linear regression lines with the slopes (values inside parentheses: 95% confidence intervals) and R squared values presented at the top left of the graphs.

As suggested in right graph of Figure 19, annual natural flows are largely affected by annual precipitation. The annual natural flows and precipitation are consistent with dry and wet years (as also indicated by the time series plots of Figure 18), i.e., for a high-precipitation water year, the natural flow is likely high for the upper basin and a lower precipitation value generally corresponds to a year with a lower natural flow. Additionally, the slope of the linear regression line suggests that 1% of increase of precipitation in average leads to an additional 0.206 maf of natural flow.

The temperature effect on natural flows exhibits greater noise, while a greater temperature value generally corresponds to a deduction of natural flows. As suggested by the R squared values, temperature effect on natural flows is subject to greater uncertainty compared to the precipitation effect. The annual natural flows are negatively correlated with annual temperature, with 1 °C increase of temperature corresponding to an estimated 2.77 maf decrease of natural flow. Previous studies such as Lukas and Payton (2020) have suggested a similar negative correlation between temperature and natural flow and a positive correlation between precipitation and natural flow, although the quantitative estimates of the temperature and precipitation effects vary. For example, a range of -3%/°C to -10%/°C temperature sensitivity (approximately -0.44 to -1.46 maf per °C) was assumed and used in Udall and Overpeck, (2017), lower than the estimated -2.77 maf per °C in Figure 19. Although quantification of temperature sensitivity is suject to uncertainty, this deduction of natural flows as a result of temperature increase is critical for understanding and assessing the implication of climate change on water availability of Colorado River Basin.

#### 5.2.1.2 Paleohydrology

Long-term historical natural flows reconstructed from tree ring data are available for Upper Colorado River Basin (Lukas and Payton, 2020), offering important insight on variability of climate and natural flows. The time series of reconstructed natural flow were assessed in this section.

The reconstructed water year natural flow series completed in 2017 by Meko et al. (2017) were obtained and assessed in this work (several other reconstructed series in earlier studies are also available). The reconstructed natural flow series consists of one with a shorter period but will a higher accuracy and one series with the longest period of reconstruction (Meko et al., 2017).

A comparison of natural flows from historical observed natural flows and the two reconstructed time series is presented in Figure 20.

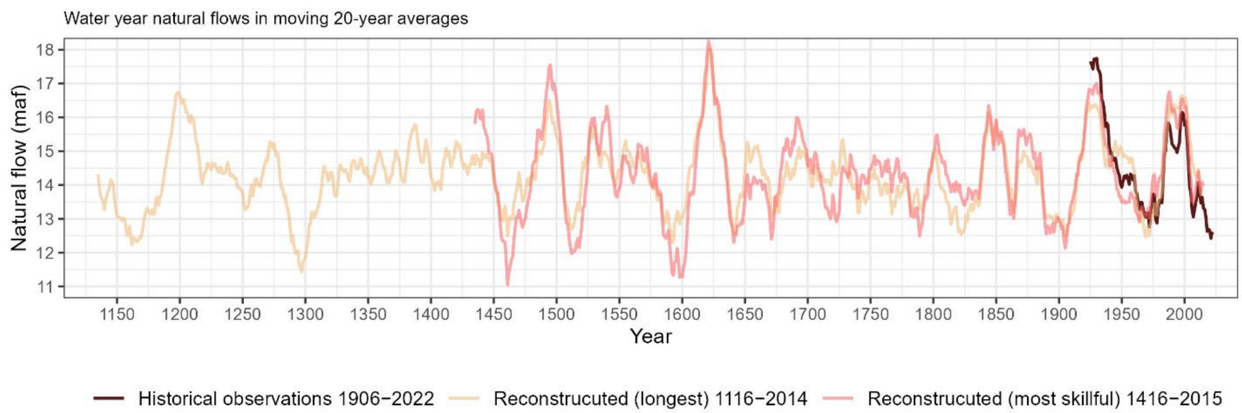



**Figure 20.** Moving 20-year averages of historical observed and reconstructed water year natural flows for Upper Colorado River Basin.

As presented in Figure 20, the two reconstructed series are generally comparable to historical records of natural flows and notably, low natural flow levels (similar to the recent 20-year level) can be found in the reconstructed series during historical periods. For example, the natural flows during 1460s and 1600s (note that the 20-year moving averages were calculated and were assigned to the last years) from the most skillful reconstructed series are generally below 12 maf/year, lower than the average of recent 20 years. Such results suggest that the large variability of natural flows in the upper basin. Together with future climate change effects, the natural flows can be lower than the flow level of the recent 20 years given with this large variability of natural flows.

#### 5.2.1.3 Climate Model Projected Future Climate and Hydrology

Water supply for Colorado River Basin will experience further challenges from climate change and it is therefore crucial to assess how future climate change conditions can affect regional water supply and in this case, the annual natural flows in the upper basin. As presented previously, the annual natural flows are correlated to both temperature and precipitation changes, and consequently future climate change (such as increase of temperature and reduction of precipitation) can result in deduction of natural flows and subsequently stresses the already challenging regional water supply.

GCMs serve as an important tool to provide projections of future climate conditions and were subsequently used in this section to assess the projected future changes in Upper Colorado River Basin. Bureau of Reclamation, for example, has conducted a comprehensive study in 2012 (Reclamation, 2012a) on the water supply and demand of Colorado River Basin including the use of GCM projections from the Coupled Model Intercomparison Project phase 3 (CMIP3). Progress has been made to improve the GCMs, with the release of CMIP phase 5 (CMIP5; Taylor et al., 2012) and CMIP phase 6 (CMIP6; Eyring et al.,

2016) results. Comparisons of the Upper Colorado River Basin projections from these different CMIP phases were consequently performed in this section to assess the evolution of the future projections from the different CMIP phases and to offer some insight on interpreting the previous results such as from Reclamation, (2012a).

Two similar future scenarios of GCM projections from the three phases were obtained and assessed for the upper basin. Specifically, shared socioeconomic pathways (SSP) 2-4.5 and SSP5-8.5 of CMIP6 (Eyring et al., 2016) were assessed, along with the equivalent representative concentration pathway (RCP) 4.5 and RCP8.5 scenarios (Taylor et al., 2012) from CMIP5 and similar B1 and A2 scenarios from CMIP3 (USGCRP, 2014). Additionally, as GCM projections were provided in relatively course resolution, fine-resolution projections from using a same statistical downscaling method (the bias-correction spatial disaggregation method) were obtained and assessed for the results of the three CMIP phases. Downscaled CMIP3 and CMIP5 projections were obtained from LLNL (2022), whereas the CMIP6 projections were obtained from NASA (2022). The obtained downscaled projections were aggregated for the upper basin and were calculated as the temperature and precipitation changes from the historical 1895–1924 average. Note that as the downscaled projections are available starting from 1951 water year, a change factor method was used (Lai et al., 2022), i.e., calculating the future changes from downscaled projections for each year and adding to the 1951–1980 historical observed level.

Comparison results of annual average temperature and total precipitation changes from historical observations and the three CMIP phases for Upper Colorado River Basin are presented in Figure 21.

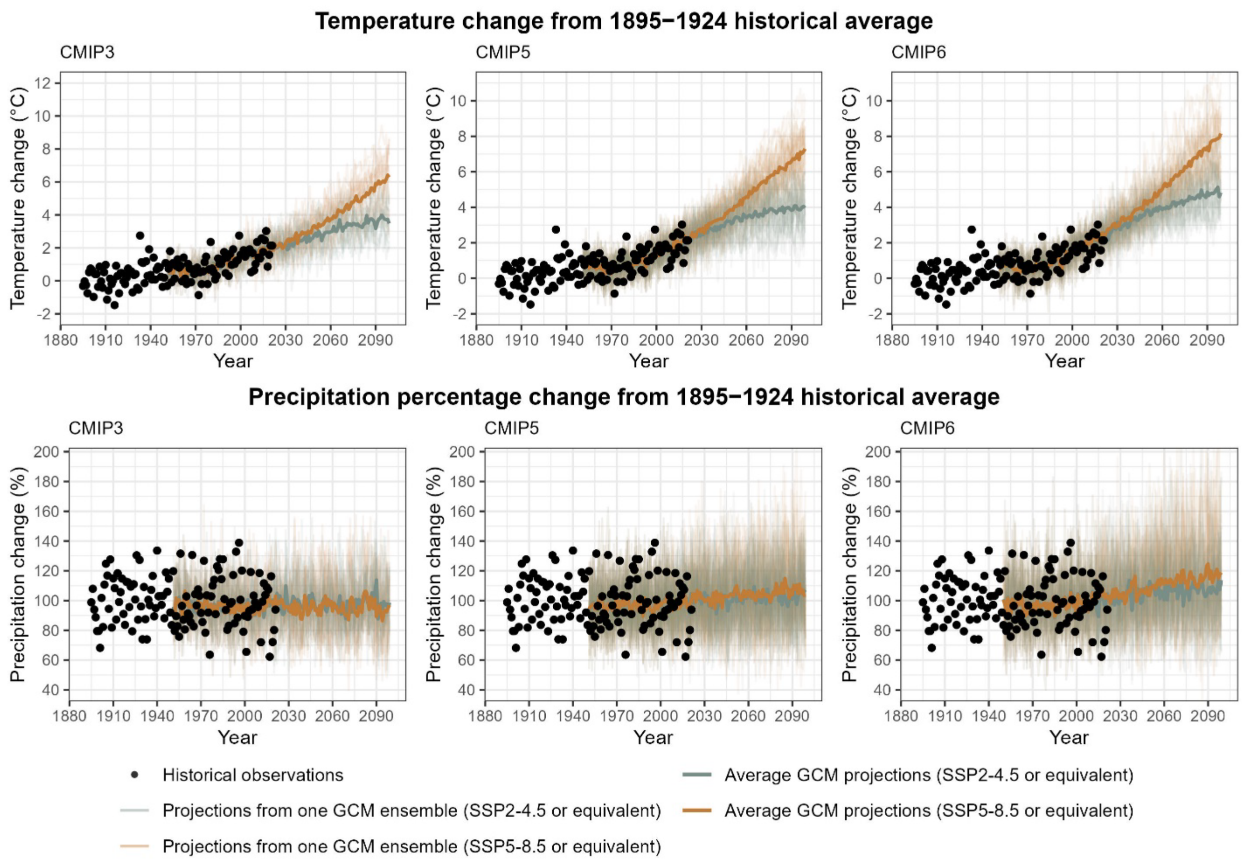



**Figure 21.** Comparisons of historical observed and GCM-projected (left: from CMIP3; middle: CMIP5; right: CMIP6) annual temperature and precipitation changes from the 1895–1924 average for Upper Colorado River Basin.

As presented in Figure 21, the obtained GCM projections are generally comparable to historical observations during historical period, while some differences among the three CMIP phases are noticeable including the projected greater increasing trends for both temperature and precipitation in CMIP6.

Further analyses on temperature and precipitation projections were carried out to assess their effects on natural flows. Specifically, the annual temperature and precipitation changes are plotted in scatter plots with x-axes presenting annual temperature changes and y-axes presenting the annual precipitation changes, commonly used in “bottom-up” (Brown et al., 2012) engineering studies. The results are presented in Figure 22, with historical observations and estimated confidence levels from CMIP projections presented as well.

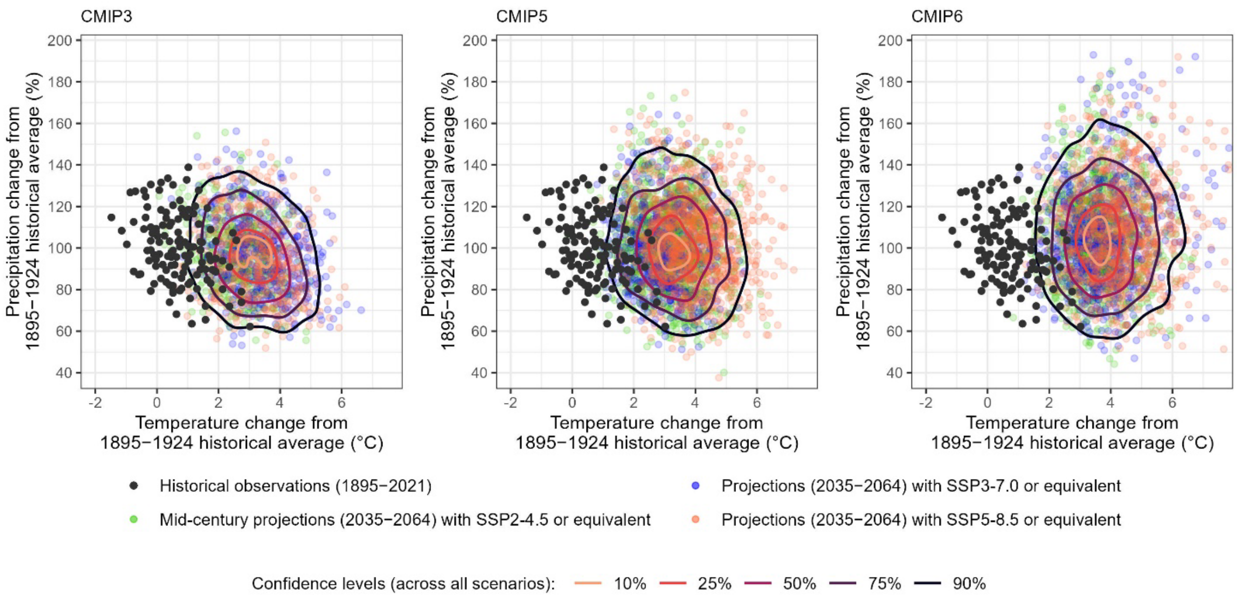



**Figure 22.** The estimated GCM mid-century downscaled projections (left: CMIP3; middle: CMIP5; right: CMIP6) of annual average temperature and precipitation changes from the 1895–1924 average for Upper Colorado River Basin and compared with historical observations. Each colored point represents a one-year result during the 2035–2064 period from one GCM and for one future scenario. The contour lines represent confidence levels and were estimated based on all colored points and are based on the Kernel density estimation.

As presented in Figure 22, the GCM projections from the three phases are generally similar, with the most recent CMIP6 results providing slightly higher temperature and precipitation projections but also greater uncertainty. Additionally, while the CMIP3 results suggest moderately negative correlation between temperature and precipitation changes (e.g., warm and dry years), such a negative correlation is not observable in CMIP5 and CMIP6 results.

Given with the previous estimated temperature and precipitation effects, the results of Figure 22 serve as a basis to assess projected future natural flows. A preliminary approach of utilizing a linear regression model was applied and assessed in this section, i.e., using annual temperature and precipitation changes (such as presented in Figure 22) to predict annual natural flows. This linear regression model was then used to provide results of natural flows with different incremental changes of temperature and precipitation, which were subsequently superimposed to the results of temperature and precipitation projections. The results of the linear regression model and the combination of climate projections and natural flow estimates are presented in Figure 23.

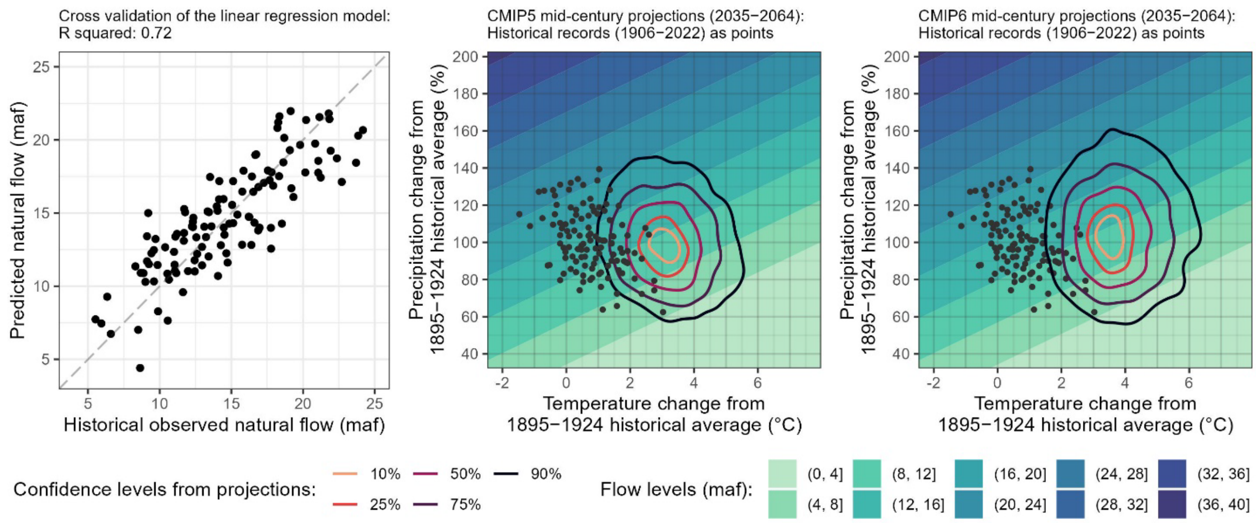



**Figure 23.** (Left) the performance of the linear regression model for predicting annual natural flows (produced from a 5-fold cross validation) and (right two graphs) the climate projections from CMIP5 and CMIP6 superimposed with natural flow estimates from the linear regression model. Historical observations and GCM projections (including CMIP6 scenarios SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 and equivalent RCP scenarios) of annual temperature and precipitation changes from the 1895–1924 average for Upper Colorado River Basin. GCM projections are presented as contour lines as confidence levels.

As presented in Figure 23, the GCM projections suggest a deduction of natural flows in average, although such projections are subject to great uncertainty. For example, the projected mid-century natural flow in average is 8-12 maf/year, with a possible variation from above 4 maf/year to slight less than 20 maf/year. However, it should be noted that such estimates are preliminary, given with the limitation from the linear regression model (the extrapolations were made in right two graphs of Figure 23 for the ranges of temperature and precipitation changes greater than the available observed ranges) and the uncertainty with respect to the temperature and precipitation effects [the estimated quantitative temperature and precipitation effects on natural flows can be different in previous studies (Lukas and Payton, 2020)].

### 5.2.2 Climate Change Effects on Inflow

Projections of future IID water delivery were produced using the Colorado River Simulation System (CRSS) model (Reclamation, 2022b). The input of hydrological conditions for the CRSS model, the results of projected Lake Mead elevation, and the results of IID water delivery and corresponding probabilities are discussed below.

The CRSS model was developed and is used by Reclamation to provide long-term projections at the Colorado River Basin (Reclamation, 2012b). The June 2021 version of the CRSS model was obtained from Wheeler et al. (2022) and was provided with the initial conditions in June 2021. Future water demands as the “2016 demands” (2016 Upper Colorado River Commission Schedule for the Upper Division States; and 2007 Final Environmental Impact Statement for the Colorado River Interim Guidelines with the update on Nevada demand in 2019 for the Lower Division States) provided in CRSS June 2021 version (Wheeler et al. 2022) were used. The projections of water delivery and other conditions at the Colorado River Basin were obtained from the CRSS model during the period 2022–2060.

#### 5.2.2.1 Using CMIP3 Projections and Resampled 2000–2018 Hydrology as CRSS input

Two hydrological conditions were used as the input for the CRSS model: from the global climate model projections of Coupled Model Intercomparison Project Phase 3 (CMIP3; Meehl et al. 2007) and from the resampled 2000–2018 historical hydrology. For the CMIP3 projections, 112 traces of the Colorado River Basin hydrology were available and were produced by Reclamation (2012b) using CMIP3-GCM downscaled projections and the Variable Infiltration Capacity model with different future emission scenarios. Alternatively, the obtained June 2021 version of the CRSS model included the resampled 2000–2018 historical hydrology with 100 traces utilized in Wheeler et al. (2022). The 100 traces of resampled 2000–2018 historical hydrology along with the 112 traces from the CMIP3-projected hydrology were used as the input for the CRSS model and were assessed.

Figure 24 presents the time series of the 112 (CMIP3) and 100 (resampled 2000–2018) traces of annual natural flow from the Upper Basin and their comparisons with the historical period (historical estimates provided by Reclamation, 2022c).

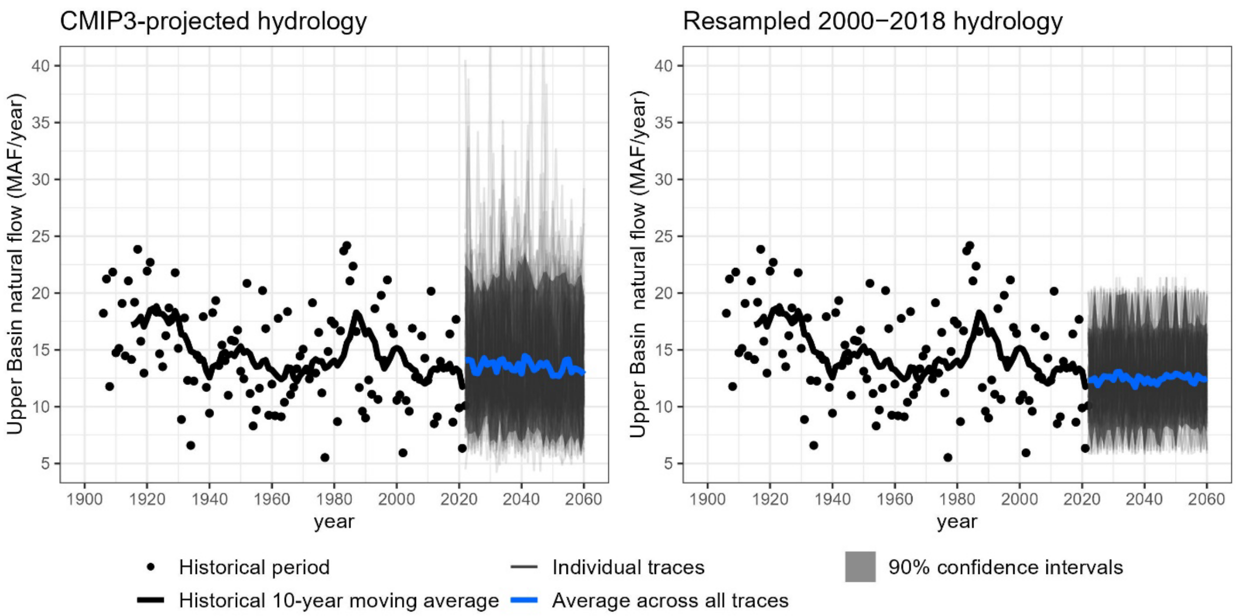



**Figure** 24. Time series of historical, CMIP3-projected (left) and resampled 2000–2018 (right) Upper Basin annual natural flow. The historical 10-year moving averages are presented as the bold black lines, whereas the average flows and 90% confidence intervals from the 112/100 traces from the CMIP3 and resampled 2000–2018 hydrology are presented as the bold red lines and grey shaded area, respectively.

As presented in Figure 24, the CMIP3-projected hydrology generally exhibits a greater range of annual flow conditions across different traces, whereas the resampled 2000–2018 hydrology exhibits drier flow conditions which are consistent with the post-2000 historical flows. Some traces from the CMIP3 hydrology have lower flows than those of the resampled 2000–2018 hydrology, and some CMIP3 traces in some years have substantially greater flow conditions (e.g., more than 25 MAF/year) than historical estimates and the resampled 2000–2018 hydrology. The average flows from both CMIP3 and resampled 2000–2018 hydrology do not exhibit a substantial future trend.

When applying the CRSS model for future simulations, the existing policies related to water deliveries and cuts were used. The on-going negotiations in voluntary use-reduction agreements or possible mandatory usage cuts will affect the regional water allocations and deliveries, although additional assumptions regarding future policies and agreements were not made during the use of the CRSS model. The 2000–2018 historical natural flow sequences were resampled and used in the CRSS model to consider the reductions in water supply and water deliveries.

#### 5.2.2.2 Results of Lake Mead elevation

Based on the input of CMIP3 and resampled 2000–2018 hydrology, the future simulations of operation and water delivery were produced from the CRSS model. The results of Lake Mead December elevation are presented in Figure 25 for the two hydrological conditions.

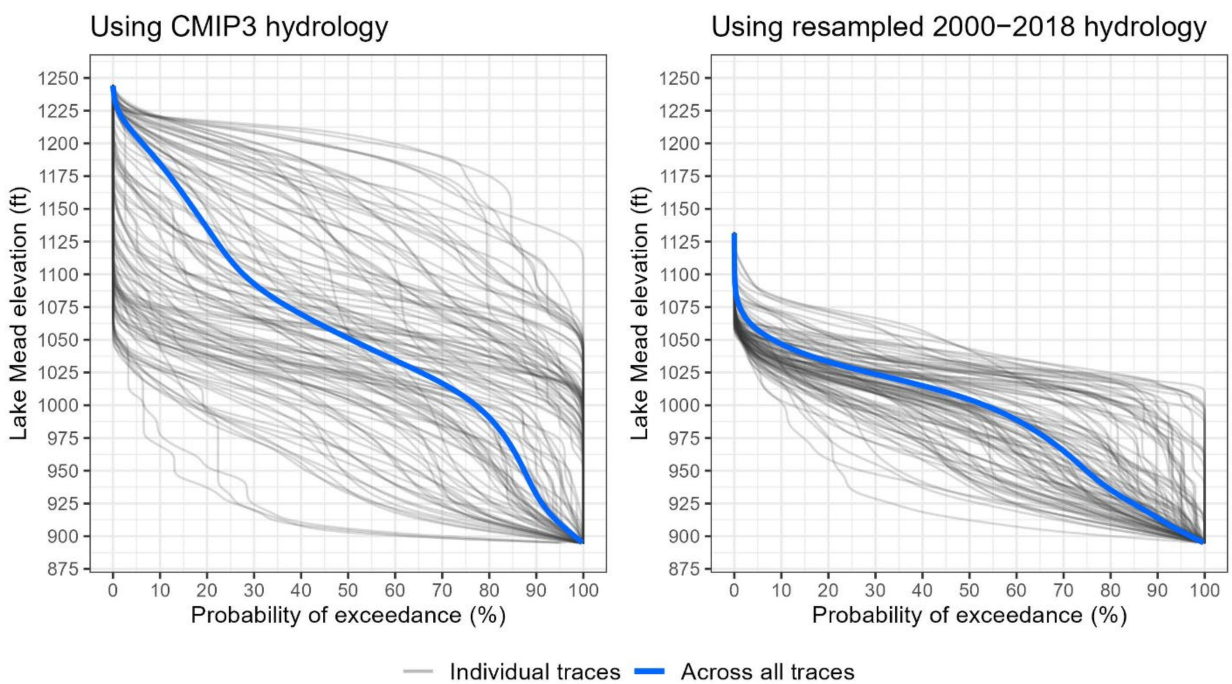



**Figure** 25**.** Exceedance probabilities of Lake Mead December elevation from using the CMIP3-projected (left) and resampled 2000–2018 hydrology (right).

Consistent to the input hydrology presented in Figure 24, the results of Figure 25 suggest that the CMIP3-projected Lake Mead elevation exhibit a greater range than the elevation results from using the resampled 2000–2018 hydrology. The elevations from using the resampled 2000–2018 hydrology generally exhibit a lower level than the elevations from using the CMIP3 projections, although some traces from the CMIP3 (i.e., with drier conditions than the resampled 2000–2018 conditions) lead to greater probabilities with low Lake Mead elevations.

#### 5.2.2.3 Results of IID water delivery

The results of annual water delivery to IID were produced from the CRSS model with the 112 (CMIP3) and 100 traces (resampled 2000–2018) and the results are presented in Figure 26.

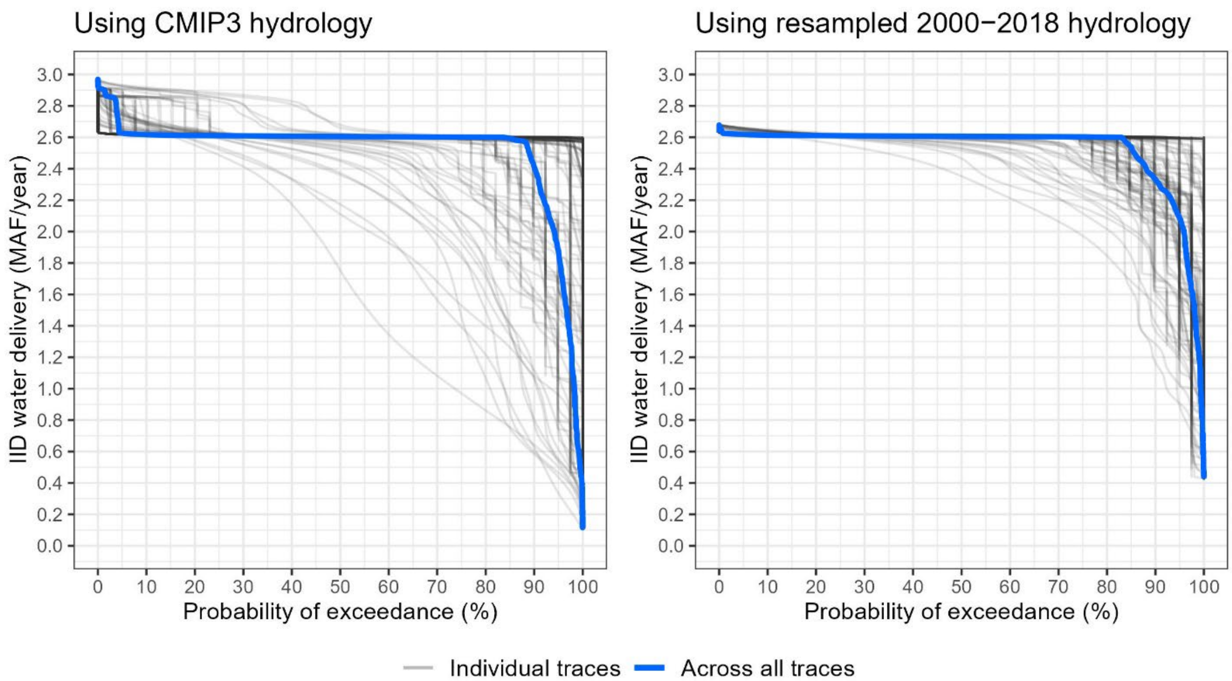



**Figure** 26. Exceedance probabilities of IID annual water delivery from using CMIP3-projected hydrology (left) and resampled 2000–2018 hydrology (right).

As presented in Figure 26, the results from using the CMIP3 and resampled 2000–2018 hydrology on average do not result in decreases in IID water delivery. Given a relatively higher exceedance probability (e.g., 90% probability), the resampled 2000–2018 hydrology can have a greater decrease in IID water delivery than the results produced from the CMIP3 hydrology. Consistent with previous results in Figure 24 and Figure 25, traces from the CMIP3 exhibit a greater variation, and some traces can result in substantially lower IID water delivery.

Probabilities and thresholds are summarized in Table 10 and Table 11 for IID water delivery using the CMIP3 and the resampled 2000–2018 hydrology. Because the resampled 2000-2018 hydrology represents more stress on future hydrology of the Salton Sea, the delivery thresholds from this scenario are utilized for future inflow scenarios as further described below.

Table 10. Probabilities of IID water delivery below different thresholds, and delivery thresholds given with different probabilities during the projected 2022–2060 period based on the CMIP3 hydrology.

| **Delivery thresholds (MAF/year)** | **2.5** | **2** | **1.5** | **1** | **0.5** |
|---|---|---|---|---|---|
| Probabilities below thresholds[1] | 11.0% | 5.8% | 3.3% | 1.7% | 0.5% |
| **Probabilities of delivery below thresholds** | **50%** | **25%** | **10%** | **5%** | **1%** |
| Delivery thresholds (MAF/year)[2] | 2.61 | 2.61 | 2.41 | 1.88 | 0.64 |

[1]For example, the probability of delivery below 2.0 MAF/year is 5.8%.

[2]For example, with a threshold of 2.41 MAF/year, the probability of delivery below 2.41 MAF/year is 10%.

Table 11. Probabilities of IID water delivery below different thresholds and delivery thresholds given with different probabilities based on the resampled 2000–2018 hydrology.

| **Delivery thresholds (MAF/year)** | **2.5** | **2** | **1.5** | **1** | **0.5** |
|---|---|---|---|---|---|
| Probabilities below thresholds | 14.4% | 4.1% | 2.0% | 0.7% | 0.1% |
| **Probabilities of delivery below thresholds** | **50%** | **25%** | **10%** | **5%** | **1%** |
| Delivery thresholds (MAF/year) | 2.61 | 2.61 | 2.33 | 2.09 | 1.22 |

### 5.2.3 Climate Change Effects on ET

Cal-Adapt is a peer-reviewed data tool that presents local, county, or state-level historical meteorological variables and their projected changes under future climate scenarios. In Cal-Adapt, global climate projection methodologies are downscaled to provide a relatively higher resolution of 7 km x 7 km that represent California's regional variability. Future climates are simulated based on two emission scenarios:

- Representative Concentration Pathway (RCP) 8.5, a high-emissions (business-as-usual) case where greenhouse gas emissions continue to rise during the 21st century, and
- RCP 4.5, a medium-emissions case where greenhouse gas emissions plateau in the mid-21st century.

For most climate variables, projections presented in Cal-Adapt are from three priority global climate models: a warmer/drier simulation (HadGEM2-ES), a cooler/wetter simulation (CNRM-CM5), and an average simulation (CanESM2). Historically, these models have been able to simulate California's climate well.

For Imperial County, the downscaled projections in temperature until 2100 show that annual average minimum temperatures are likely to increase to 62.2 – 67.5°F, depending on the emissions scenario (Figure 27). Alternatively, annual average maximum temperatures are likely to increase to 92.5 – 98.5°F, depending on the emissions scenario and climate model. Average wind speed is projected to decrease very slightly to 2.78 m/s – 3.12 m/s by the end of the century, depending on the emission scenario and climate model.

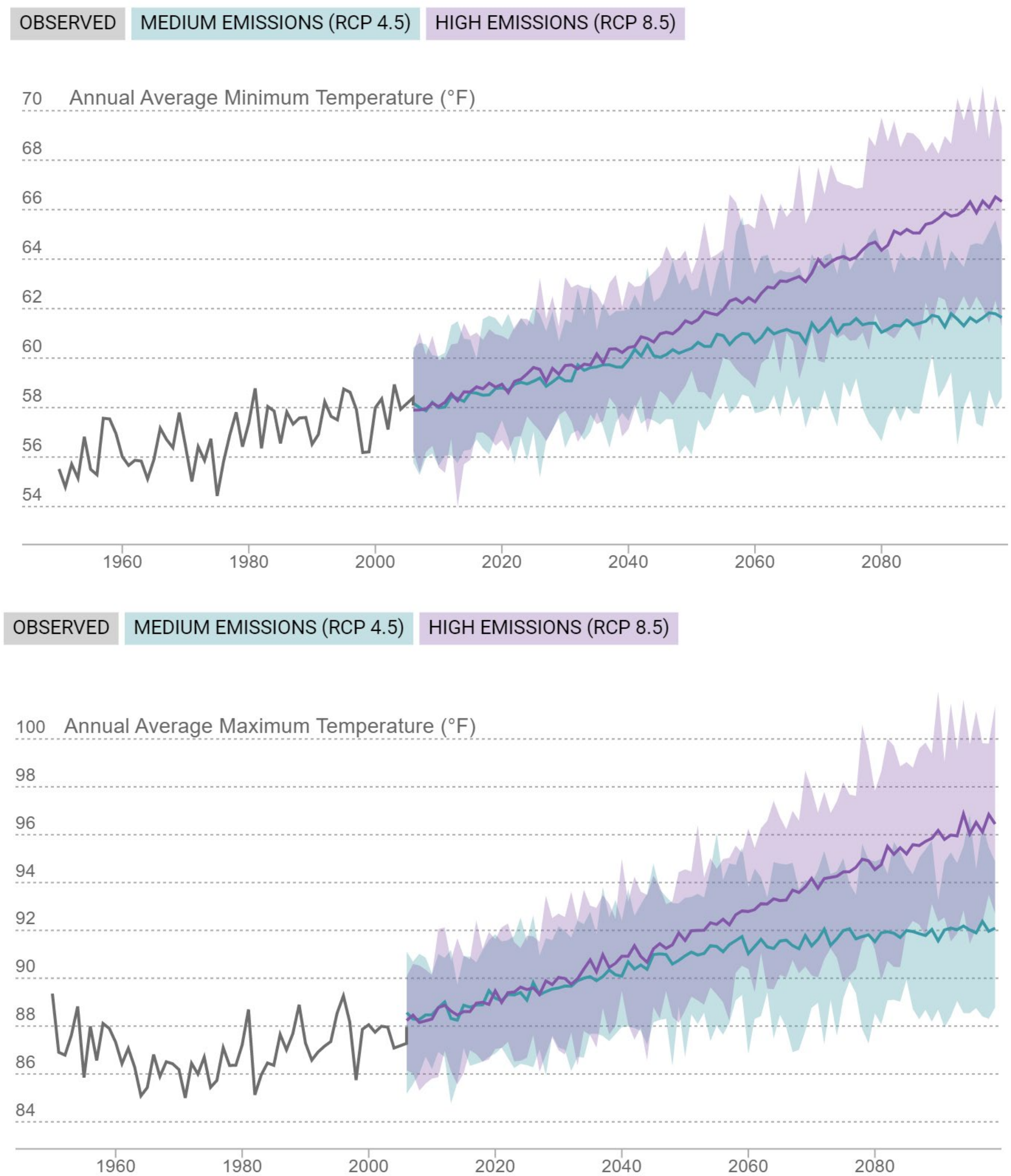



**Figure** 27. Annual average minimum (top) and maximum (bottom) temperatures projected for Imperial County, CA, under the RCP 4.5 and RCP 8.5 emissions scenarios until 2100. (SOURCE: Cal-Adapt)

The projected temperature and windspeed changes from Cal-Adapt RCP8.5 scenarios were incorporated into Penman-Monteith estimates of ET. For both maximum/minimum temperature and windspeed, the projected change between 1991-2020 and 2035-2064 was added to a set of baseline numbers. For temperature, the baseline numbers were a seasonal pattern (monthly) of maximum/minimum temperature observations from 2004-2021. For wind speed, the baseline number was based on an average of four windspeed stations near the Salton Sea from 2015-2021. The percentage change in the Penman-Monteith estimates for the baseline numbers vs. the baseline numbers plus the climate adjustments were used to estimate changes in ET. The range of temperature and wind speed changes described above correspond to ET increases of 3.56% to 5.02% (Table 12).

Table 12. Penman-Monteith estimates of ET.

| Trace | Annual average maximum temperature increase (°C) | Annual average minimum temperature increase (°C) | Average wind speed change (m/s) | Estimated % increase in ET (1971-2000 to 2035-2064) via Penman-Monteith Equations |
|---|---|---|---|---|
| Low | 1.69 | 1.66 | 0.987 | 3.56% |
| Average | 2.01 | 1.96 | 0.988 | 4.46% |
| High | 2.20 | 2.22 | 0.990 | 5.02% |

## 5.3 Inflows to the Salton Sea

The inflow categories discussed in this section include inflow from Mexico, inflow from the IID watershed, inflow from the CVWD watershed, groundwater inflow, and inflow from local watersheds not tributary to the IID or CVWD watersheds.

### 5.3.1 Inflows from Mexico

The New River originates in northern Mexico and terminates at the southern end of the Salton Sea. It receives runoff from agricultural drainage conveyed by a network of surface and subsurface tile drains, wastewater treatment effluent, industrial effluent, and stormwater runoff. The New River watershed is at or below sea level and receives up to 10 inches of precipitation from northern Mexico. Since 2005, IID and USGS have cooperatively measured streamflow data for the river; however, USGS observations are available from 1980 onward.

Inflows from New River International Border have dwindled in the last two decades independently of the QSA implementation timeline. From 1980 to 1990, inflows from Mexico consistently exceeded 150,000 AF/year and sometimes exceeded 250,000 AF/year (Figure 28). However, from 1990 to 2006, flows decreased to an average of 142,000 AF/year and from 2007 onwards, flows have averaged 75,000 AF/year.

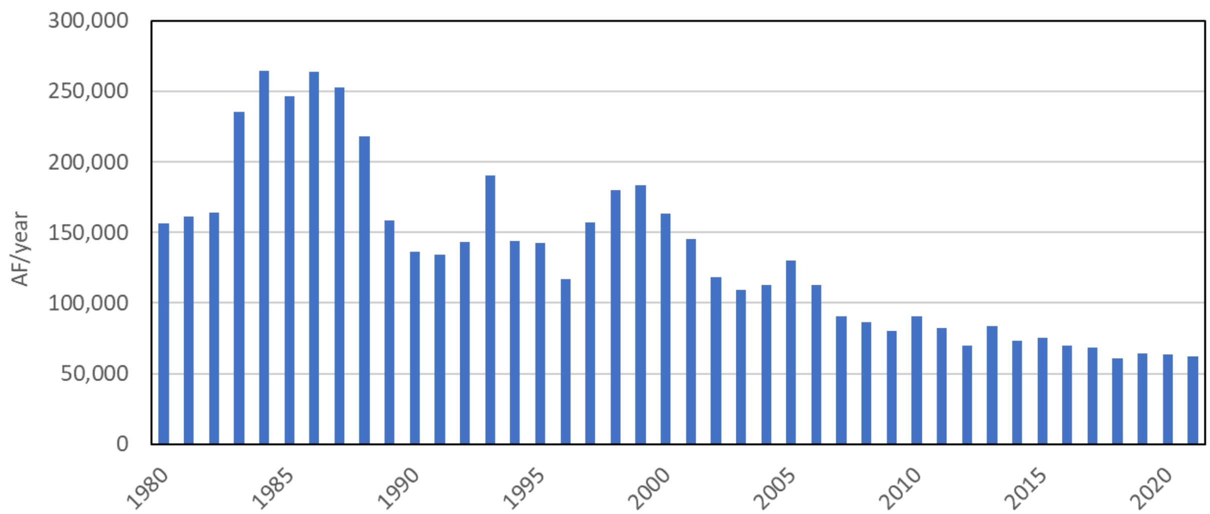
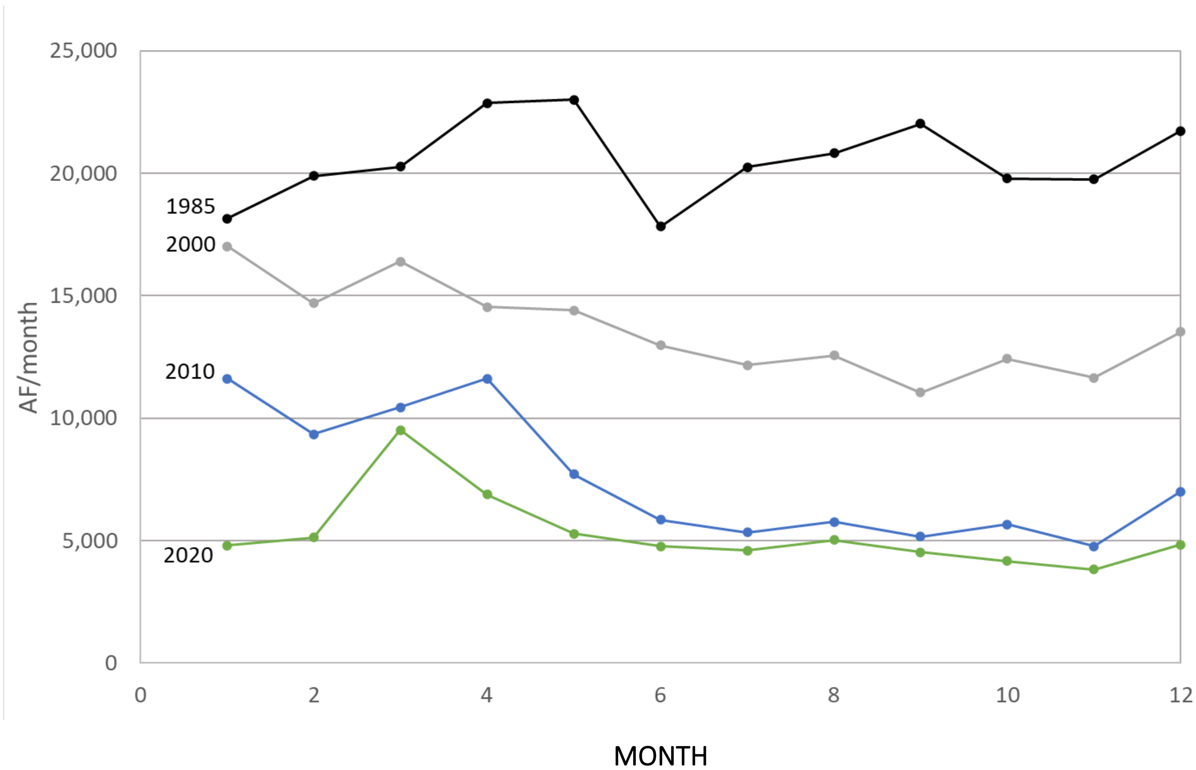



**Figure** 28**.** Average annual inflows recorded at the New River International Border USGS station from 1980 to 2021. (SOURCE: USGS)

Historically, inflows were quite consistently near 20,000 AF/month year-round (Figure 29). In 2000, flows showed a decreasing trend over the course of the year but remained above 10,000 AF/month. By 2010, January through April was a clear peak in the sub-annual time series and inflows quickly tapered down to near 5,000 AF/month thereafter. Between 2010 and 2020, annual flows have continued to decrease. Most recently, peak inflows are measured in March and April, with the baseline flow remaining at approximately 5,000 AF/month.



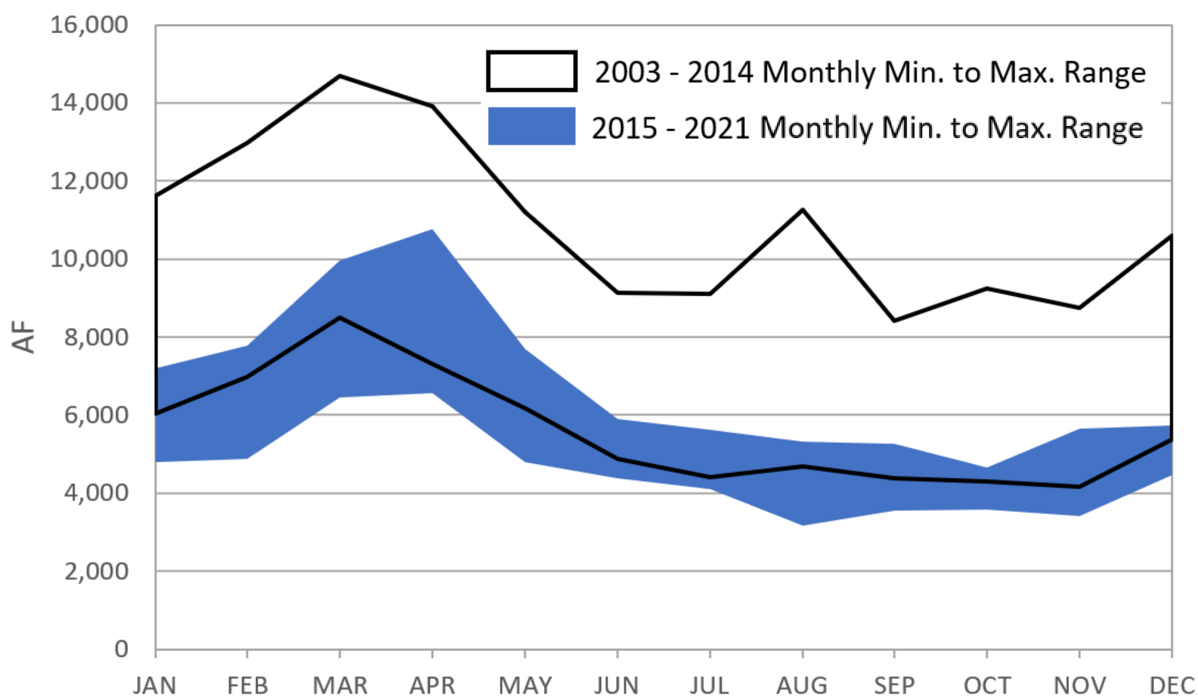




**Figure** 29. Sub-annual New River International Boundary inflows in 1985, 2000, 2010, and 2020 (top) and variability in the 2003 – 2014 and 2015 – 2021 periods (bottom). Historically, there was no strong sub-annual pattern. Most recently, inflows dominate in March and April and are near 5,000 AF/month in the remaining months. (SOURCE: USGS)

### 5.3.2 Inflows from IID Watershed

Major inflows from the IID watershed are recorded at the USGS gages at the mouth of the Alamo and New Rivers in Imperial Valley. At the New River Imperial Valley station, while flows were abnormally low in 1989 – 1992, the future high average inflow years never reached the high flows achieved in 1983 – 1988 (Figure 30 top panel). The decreasing trend has since become more prominent.

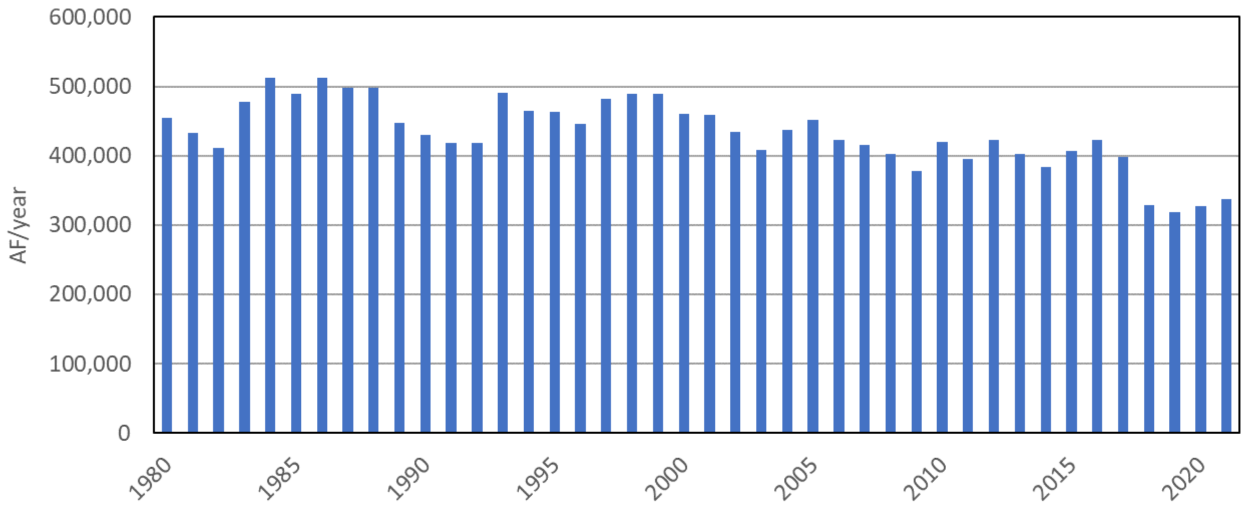
Monthly trends over three time periods (1980 – 2002, 2003 – 2014, and 2015 – 2021, Figure 30 bottom panel) showed similar sub-annual behavior, with monthly peak flows occurring in March – April and a secondary peak in October. This figure illustrates the same decreasing annual flow trend as shown in the top panel.

The Alamo River originates at the south side of the All-American Canal on the eastern boundary of Calexico and terminates at the Salton Sea. Source waters include seepage from the All-American Canal, runoff from the Chocolate Mountains, agricultural drain flows, and stormwater runoff. In general, flows from Alamo River are greater in magnitude than flows from New River and demonstrate less inter-annual variability, as shown in Figure 31 (top panel). The record annual maximum occurred in 2012.

Monthly trends over three time periods (1980–2002, 2003–2014, and 2015–2021) are presented in Figure 31 (bottom panel). As at the New River, monthly flows showed similar sub-annual behavior for the three time periods. Lowest flows were recorded in December – January, monthly flows sharply increased with a peak in April – May during the irrigation season, with a more gradual decrease in flows in the latter half of the year.

Figure 32 shows a different view of sub-annual variability for New River and Alamo River. Taking 2002 as a representative year for the historical sub-annual flows and 2020 as the most recent flows, the figure shows a similar sub-annual pattern throughout the last two decades for both New River and Alamo River. The total volume of these flows is smaller at the New River, which also has less sub-annual variability, as shown by the smaller differential between January and May recorded flows as compared to the Alamo River flows.

In addition to these two gaged flows, there are ungaged inflows into the Salton Sea from the Imperial Valley. IID (2018b) calculated the ungaged inflows into the Salton Sea from the Imperial Valley as equal to approximately 9% of the total volume of the gaged flows.



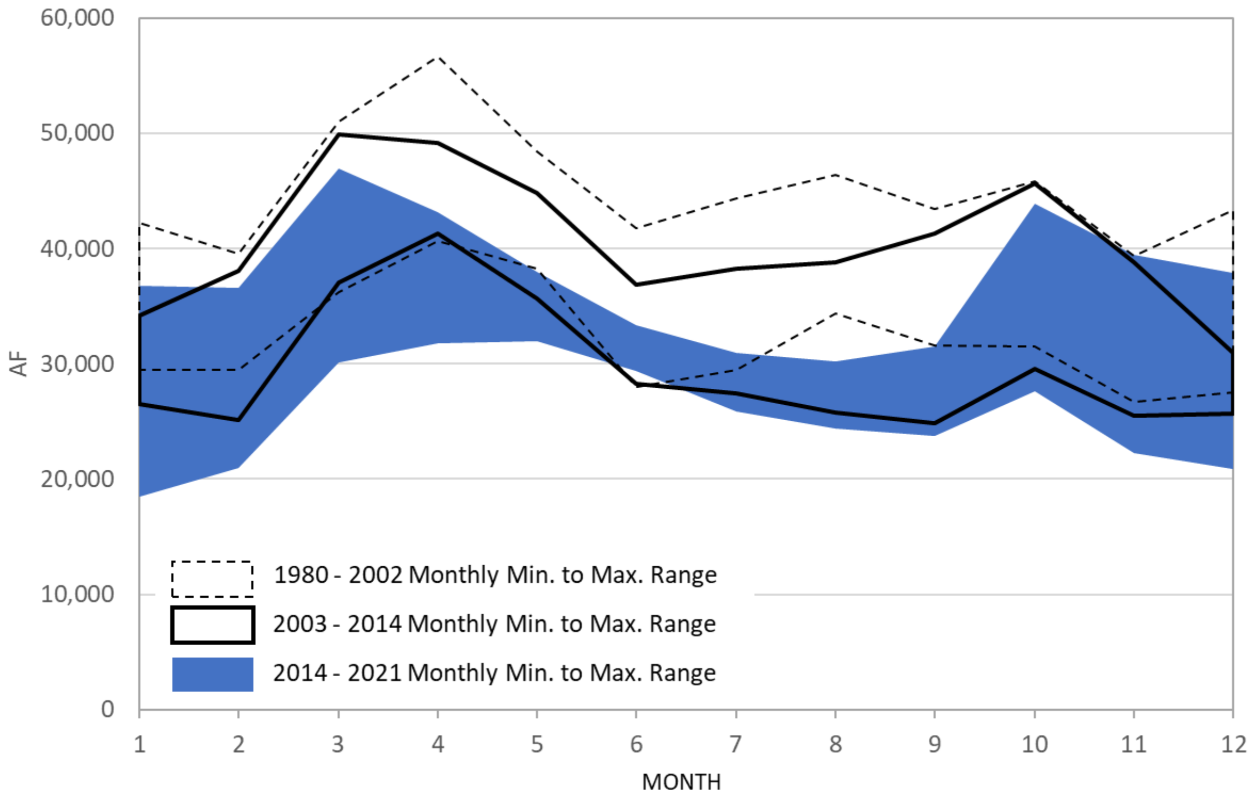




**Figure** 30. Average annual inflows (top) and average monthly inflows in the 1980–2002, 2003–2014, and 2015–2021 periods (bottom) recorded at the New River Imperial Valley USGS station from 1980 to 2021. (SOURCE: USGS)

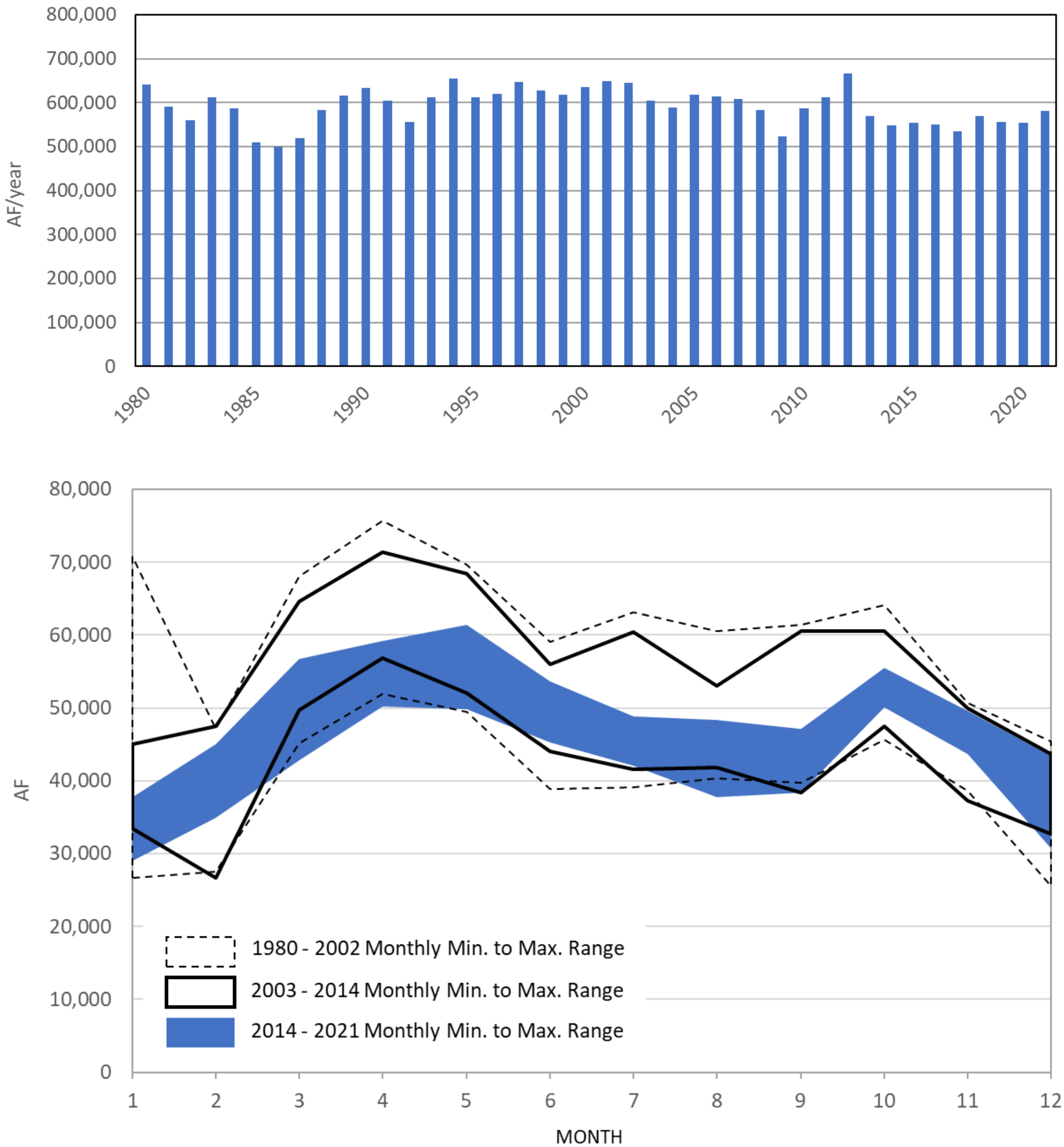



**Figure** 31. Average annual inflows (top) and average monthly inflows in the 1980 to 2002, 2003 – 2014, and the 2015 – 2021 periods (bottom) recorded at the Alamo River USGS station from 1980 to 2021. (SOURCE: USGS)

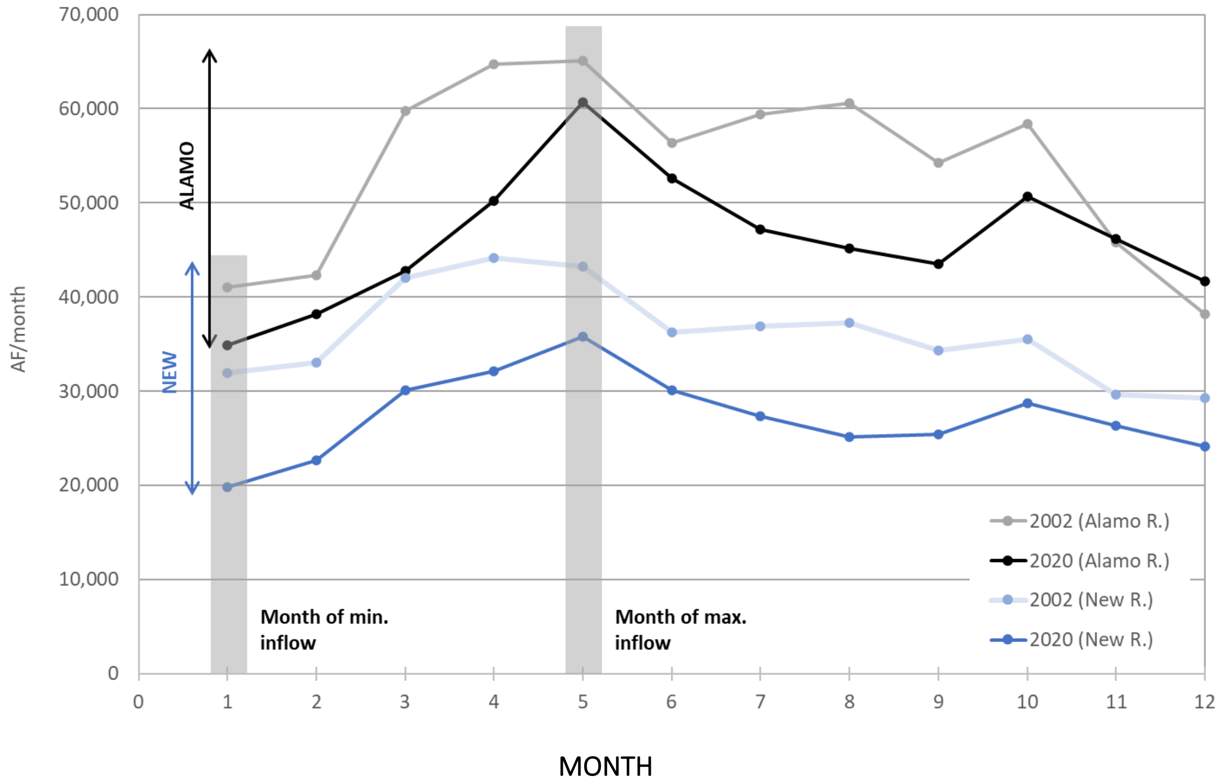



**Figure** 32**.** Sub-annual New River Imperial Valley and Alamo River inflows in 2002 and 2020. Historically and most recently, the same sub-annual pattern has been preserved wherein flows are lowest in January, increase dramatically up until May, and then decrease gradually thereafter. (SOURCE: USGS)

### 5.3.3 Inflows from CVWD Watershed

The Whitewater River, also referred to as the CVSC, originates in the San Bernardino Mountains and collects stormwater runoff, wastewater flows, and agricultural drainage flows in the Coachella Valley, and terminates at the Salton Sea. The Upper Whitewater River is considered fully appropriated by the State Water Resources Control Board (California Department of Water Resources [DWR] and DFW 2013). The upper reaches convey natural runoff and State Water Project exchange water to agricultural fields and to the Whitewater Spreading Facility for groundwater recharge (CVWD 2002). Lower reaches of the CVSC consist of unlined conveyance of stormwater, agricultural return flows, and wastewater discharge (CVWD 2012).

Inflows from the CVSC show a strong decreasing trend from 1980 to 2010 (Figure 33, top panel). The surface water supply has decreased since historical levels due to increased water use efficiency, drought, and decreased supply reliability. Since 2010, there has been an equally apparent increasing trend. Within the last two decades, flows decreased most significantly from 2008 to 2010 but have since been increasing.

Monthly trends over three time periods (1980 – 2002, 2003 – 2014, and 2015 – 2021) are presented in Figure 33 (bottom panel). During the earliest period (1980 – 2002), the maximum monthly flow peaked in February, but there was no evident pattern for monthly flows in the 2003 – 2014 and 2015 – 2021 periods. Figure 34 shows the sub-annual patterns at the end of the historical period (in 2002), in the year of lowest annual average flows (2010), and most recently (in 2020). Over these years, there was no uniform seasonality of relatively higher or lower flows.

Direct to sea agricultural drains collect subsurface drainage and provide inflow to the Salton Sea. Flows in drains other than the CVSC are measured by CVWD. Figure 35 presents the measured drain flows over the period 2000 – 2021. These drain flows varied from a high of 43,000 AFY in 2013 to a low of 27,000 AFY in 2019.

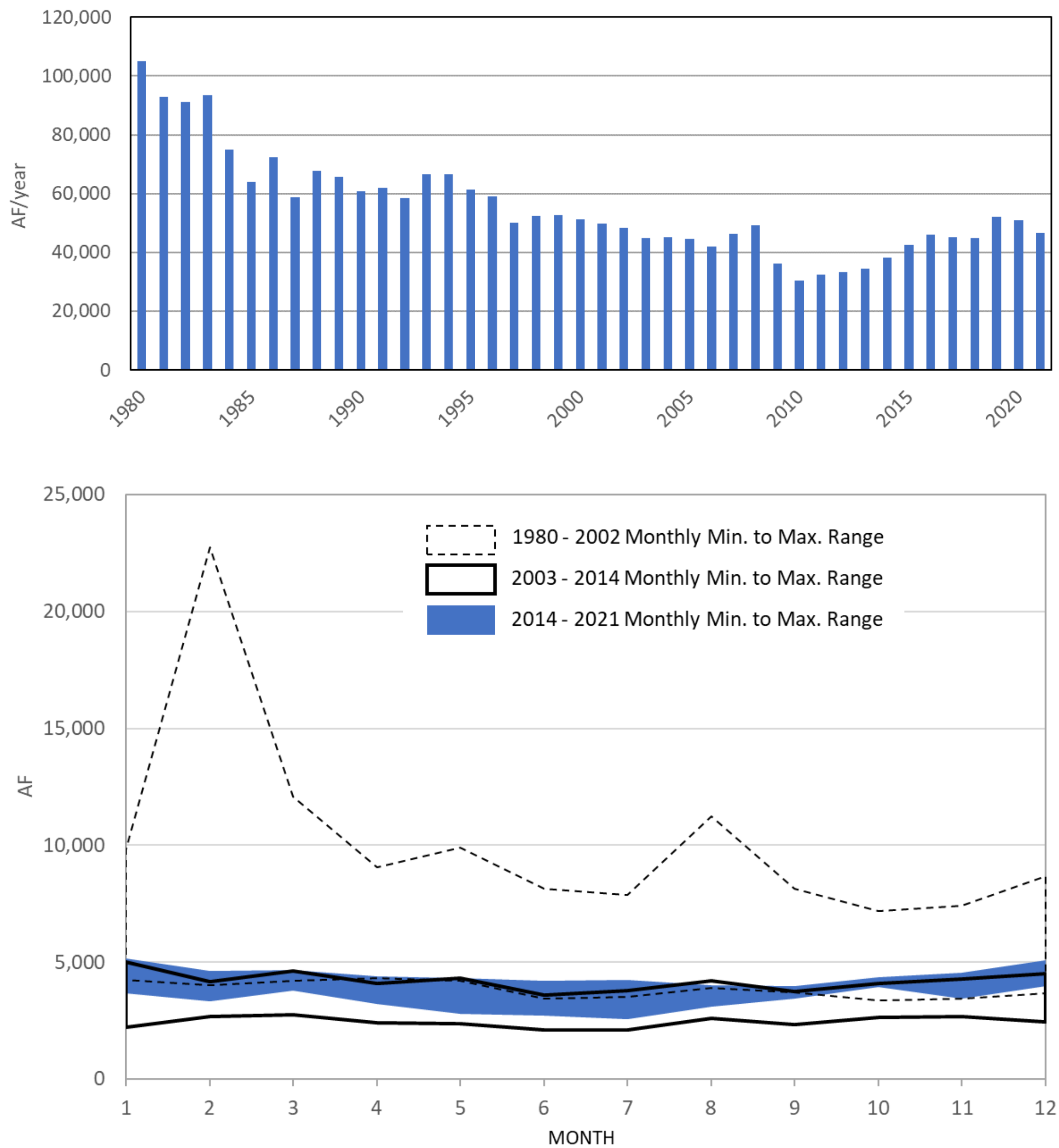



**Figure** 33. Average annual inflows (top) and average monthly inflows in the 1980 – 2002, 2003 – 2014, and 2015 – 2021 periods (bottom) recorded at the Whitewater River USGS station from 1980 to 2021. (SOURCE: USGS)

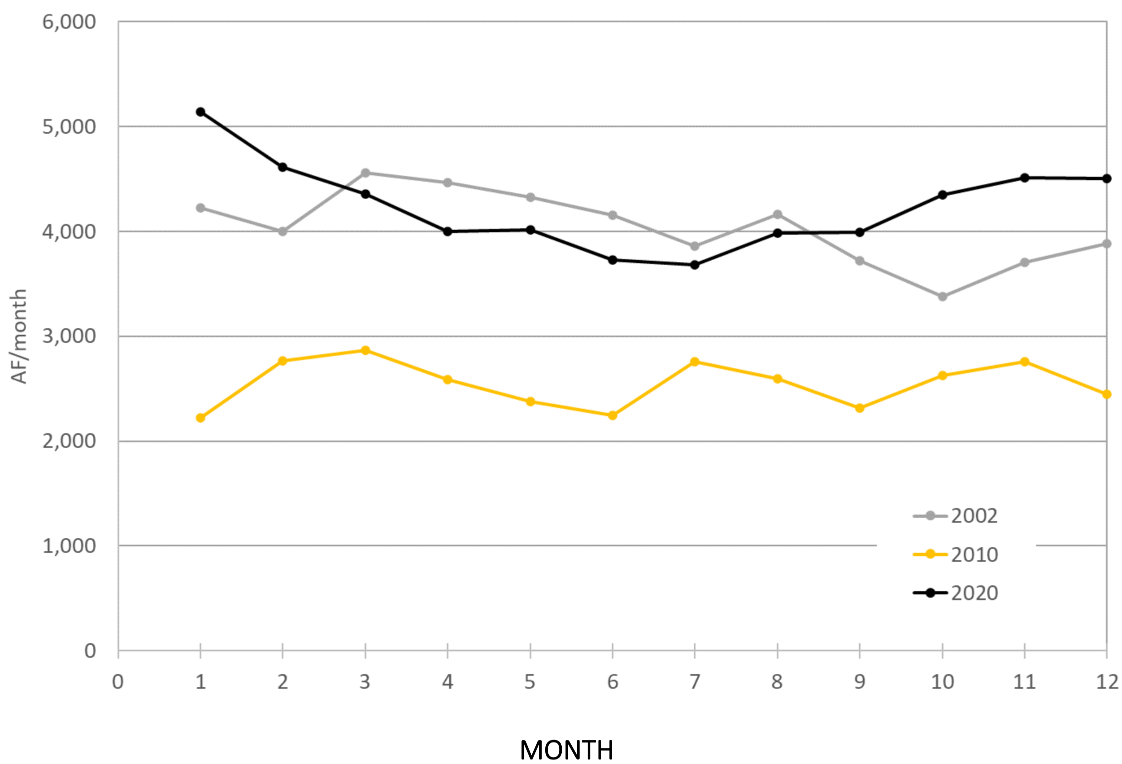



**Figure** 34. Sub-annual Whitewater River inflows in 2002, 2010, and 2020. There has been no consistent sub-annual pattern observed across the years. Inflows in 2020 have on average exceeded 2002 historical levels. (SOURCE: USGS)

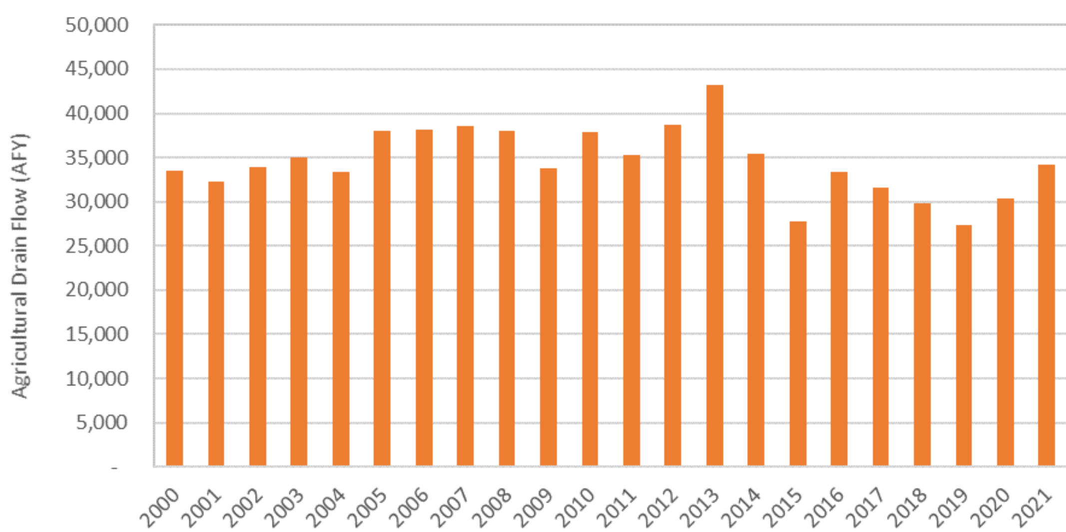



**Figure** 35. Inflow to the Salton Sea from Coachella Valley agricultural drains other than the CVSC. The period 2000-2016 is calendar year data and the period 2017-2021 is water year data. (SOURCE: CVWD personal communication)

### 5.3.4 Local Watershed Inflows

Several smaller creeks flow into the Salton Sea. The San Felipe Creek watershed drains about 1,693 square miles in the southwest Salton Sea watershed. Flows generally consist of desert summer storms and heavy winter storms (IID, 2018b). San Felipe Creek was measured by the USGS (station no. 10255885) from 1961 to 1991, located approximately four miles upstream of the Sea. Average flow to the Salton Sea from 1961 to 1991 was 4,532 AF/year with a minimum of 60 AF in 1973 and a maximum flow of 40,638 AF in 1976. IID (2018b) analyzed rainfall at Brawley and measured flow to develop a relationship between rainfall and runoff. For the period 2000 to 2021, annual flow varied from 2,834 AFY to 15,542 AFY and averaged 3,605 AFY.

Salt Creek is located in the northern portion of the Salton Sea watershed and drains about 269 square miles. The USGS monitors flow at Salt Creek at USGS Gage 10254050 (Salt Creek Near Mecca). From 2000 to 2021, annual flow varied from 295 AFY (2009) to 2,860 AFY (2006) and averaged 840 AFY.

IID (2018b) utilized an area-weighting methodology to estimate runoff from the remaining 330 square miles not flowing to Salt or San Felipe Creeks. However, instead of using the entire 1693 square miles of the San Felipe runoff area, only the lower hydrologic unit of the San Felipe Creek drainage (504 square miles) was assumed to contribute to discharge at the Salton Sea as most of the upper drainage runoff flows to sinks, groundwater recharge, or is consumed by phreatophyte vegetation. Table 13 presents the total inflow to the Sea from the smaller creeks, including San Felipe Creek, Salt Creek, and ungaged areas.

Table 13. Inflows to the Salton Sea from local creeks outside of the Imperial and Coachella Valleys.

| Year | San Felipe Creek (AFY) | Salt Creek (AFY) | Ungaged Areas (AFY) | Sum of local watershed inflows (AFY) |
|---|---|---|---|---|
| 2000 | 2834 | 542 | 1013 | 4388 |
| 2001 | 2834 | 562 | 1019 | 4415 |
| 2002 | 2834 | 485 | 996 | 4315 |
| 2003 | 2834 | 631 | 1039 | 4504 |
| 2004 | 7090 | 898 | 2396 | 10384 |
| 2005 | 2834 | 2215 | 1515 | 6564 |
| 2006 | 2834 | 2860 | 1708 | 7402 |
| 2007 | 2835 | 1216 | 1215 | 5267 |
| 2008 | 2834 | 570 | 1021 | 4425 |
| 2009 | 2836 | 295 | 939 | 4071 |
| 2010 | 15542 | 464 | 4802 | 20808 |
| 2011 | 2834 | 633 | 1040 | 4508 |
| 2012 | 2834 | 525 | 1008 | 4367 |
| 2013 | 2834 | 724 | 1067 | 4625 |
| 2014 | 2834 | 473 | 992 | 4299 |
| 2015 | 2834 | 458 | 987 | 4279 |
| 2016 | 2834 | 570 | 1021 | 4425 |
| 2017 | 2834 | 804 | 1091 | 4729 |

| | | | | |
|---|---|---|---|---|
| 2018 | 2834 | 818 | 1096 | 4748 |
| 2019 | 2834 | 985 | 1146 | 4964 |
| 2020 | 2834 | 956 | 1137 | 4927 |
| 2021 | 2834 | 789 | 1087 | 4710 |
| **AVG 2000-2021** | **3605** | **840** | **1333** | **5778** |
| **AVG 2015-2021** | **2834** | **768** | **1081** | **4683** |

### 5.3.5 Groundwater Inflows

The SALSA2 modeling performed by IID (IID, 2018b) used a constant annual groundwater inflow from the Imperial Valley of 1,000 AFY, citing IID (2002). Updated groundwater modeling was performed for the Indio Subbasin WMP Update (Indio Subbasin GSAs, 2021). The simulated groundwater flow between the Sea and the groundwater system is presented in Figure 36 below. The net flow, shown as the black line, was *to* groundwater from the Sea prior to 2015, and after 2015 was *from* groundwater to the Sea.

The SALSA2 modeling performed by IID used a constant annual groundwater inflow of 10,000 AFY from areas not tributary to the Imperial and Coachella valleys. This value is from Hely et al. (1966), which states that the groundwater underflow entering the Salton Sea at the perimeter comes primarily from the alluvium underlying San Felipe Creek.

Therefore, total groundwater inflow to the Salton Sea was computed by using annual values from the black line, combined with a constant value of 10,000 AFY from San Felipe alluvium and a constant value of 1,000 AFY from Imperial Valley. The total net inflow to the Sea from groundwater varied from 8,500 AFY in 2000 to 12,300 AFY in 2019. Constant values of 12,300 AFY were also assumed in 2020 and 2021.

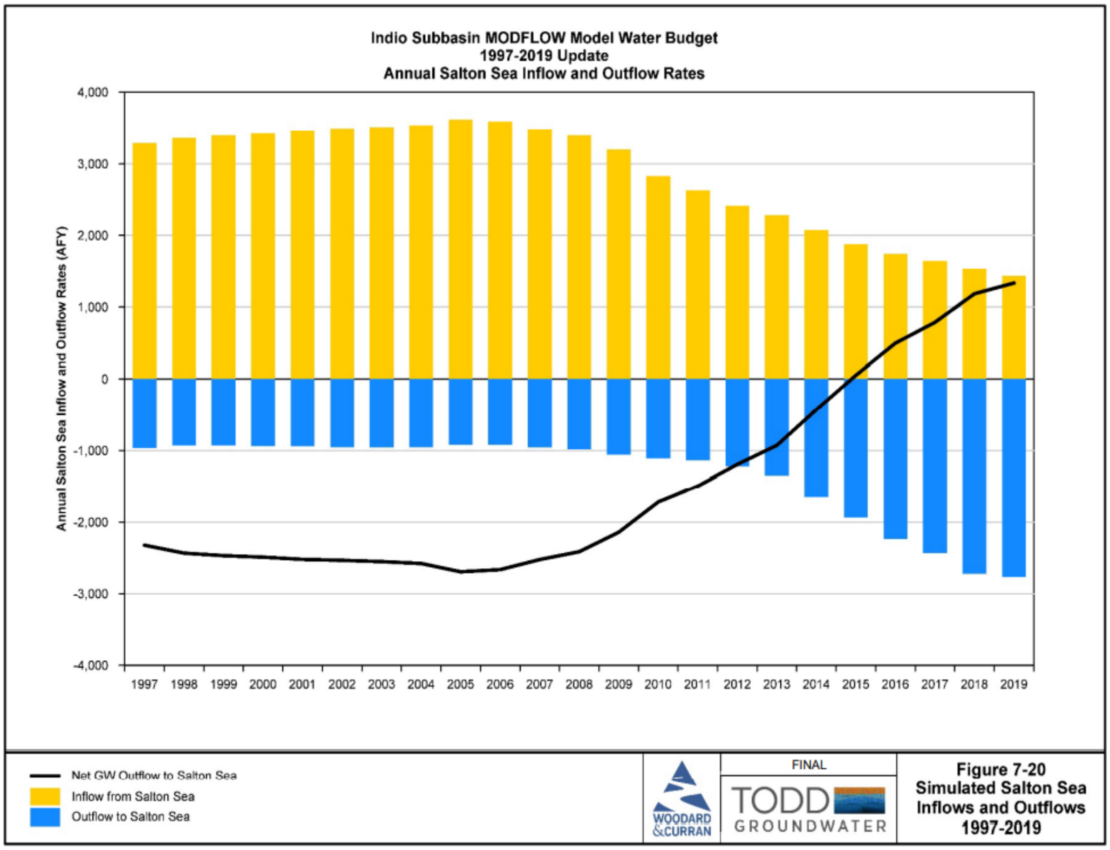



**Figure** 36. Groundwater inflow to the Sea from Coachella Valley. (Source: Indio Subbasin GSAs, 2021)

### 5.3.6 Summary of Recent Historical Inflows Compared to Modeled Inflows

Table 14 provides a summary of recent inflows to the Sea, as discussed in the previous sections. Over the recent period (2015 to 2020), inflow has remained stable. In 2021, total inflow was 40,000 AF higher than the inflow in 2020. SALSA2-predicted inflows are also presented in the table, as summarized in Section 4. Notably, recent inflows (column 8) are consistently higher than the SALSA2-predicted inflows.

Table 14. Recent historical inflows, compared to the SALSA2-predicted inflows (units: AF).

| Year | Imperial Valley Flow Gaged (1) | Imperial Valley Estimated Ungaged (2) | Mexico Flows (3) | CVSC Gaged (4) | Coachella Valley Drain Flow (5) | Local Watershed (6) | Ground-water (7) | Total Inflow to Sea (8) | Mean SALSA2 Inflow, Low Uncertainty | Mean SALSA2 Inflow, Moderate Uncertainty |
|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 885,643 | 79,708 | 75,252 | 42,980 | 27,779 | 4,279 | 11,000 | 1,127,000 | -- | -- |
| 2016 | 902,053 | 81,185 | 69,562 | 46,643 | 33,325 | 4,425 | 11,500 | 1,149,000 | -- | -- |
| 2017 | 864,193 | 77,777 | 68,548 | 45,730 | 31,528 | 4,729 | 11,800 | 1,104,000 | -- | -- |
| 2018 | 837,531 | 75,378 | 60,509 | 44,971 | 29,779 | 4,748 | 12,200 | 1,065,000 | 934,000 | 907,000 |
| 2019 | 810,277 | 72,925 | 63,926 | 52,324 | 27,359 | 4,964 | 12,300 | 1,044,000 | 917,000 | 871,000 |
| 2020 | 817,934 | 73,614 | 63,332 | 51,154 | 30,350 | 4,927 | 12,300 | 1,054,000 | 906,000 | 834,000 |
| 2021 | 856,862 | 77,118 | 61,866 | 46,548 | 34,172 | 4,710 | 12,300 | 1,094,000 | 905,000 | 808,000 |
| AVG 2015-2021 | **853,000** | **76,800** | **66,100** | **47,200** | **30,600** | **4,680** | **11,900** | **1,090,000** | **-** | **-** |

Notes:
1. New River near Westmorland (USGS Station ID: 10255550) + Alamo River near Niland (USGS Station ID: 10254730) – New River at International Boundary (USGS Station ID: 10254970); see Section 5.3.2
2. 9% of Column 1; see Section 5.3.2
3. New River at International Boundary (USGS Station ID: 10254970); See Section 5.3.1
4. Whitewater River near Mecca (USGS Station ID: 10259540); See Section 5.3.3
5. Drain flow other than the gaged CVSC. See Section 5.3.3.
6. See Section 5.3.4
7. See Section 5.3.5
8. Sum of columns 1 to 7

## 5.4 Outflows from the Salton Sea Watershed

Outflows from the Salton Sea watershed discussed in this section include ET from the Imperial Valley and Coachella Valley watersheds and evaporation from the Salton Sea.

### 5.4.1 Evapotranspiration from Agricultural Land

From 2004 – 2014, evaporation and ET have been estimated computed by Reclamation using satellite and aerial imagery and field-based inspections to map irrigated agricultural fields, riparian vegetation, and open water in the Lower Basin study area that includes IID and CVWD. These Reclamation estimations are reported each year; however, they are only available in the form of a spreadsheet from 2010 to 2014. Thus, the following ET plots are only available for 2010 to 2014.

#### 5.4.1.1 Imperial Valley Watershed

Figure 37 shows that, over the five-year period of available data, ET from agriculture in IID is consistently lowest in December, increases rapidly to an annual maximum in May, and decreases gradually thereafter. There is no clear increasing or decreasing trend across the five years.

Evaporation from open water sources, as shown in Figure 38, peaks in June instead with more symmetrical rates of increase and decrease throughout the year. Evaporation stays constant from 2011 to 2014 but is substantially lower in 2010. This is due to total acres of open water being recorded as 1,230 in 2010 but averaging over 2,200 acres from 2011 to 2014.

Reported total ET estimates (in AF) are divided by IID's reported net irrigated area to compute a net ET rate of 3.60 AF/acre of irrigated lands. Since net irrigated land has been relatively stable at around 433,540 acres from 2002 to 2021, ET since 2003 is assumed to average 1,561,000 AF/year.

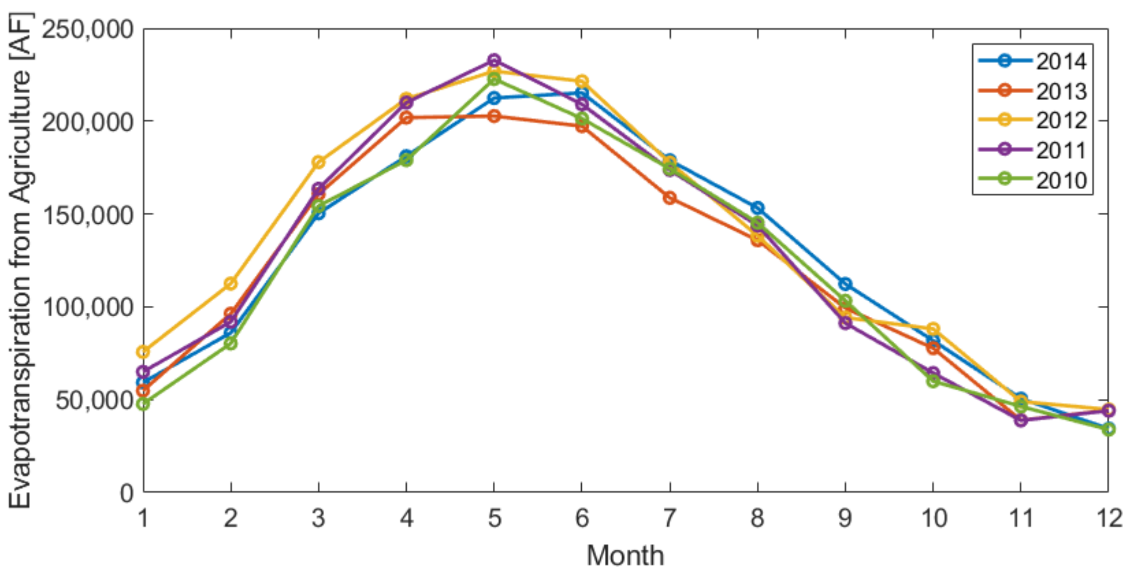



**Figure** 37. Sub-annual ET from agriculture in the Imperial Irrigation District (IID) from 2010 – 2014. (SOURCE: Reclamation, 1995 – 2014)

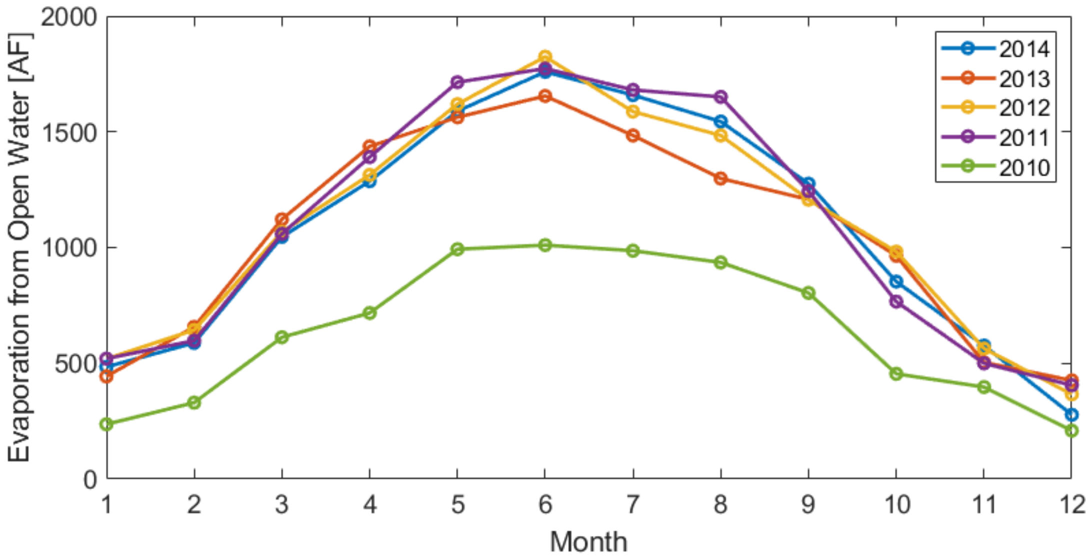



**Figure** 38. Sub-annual evaporation from open water in the Imperial Irrigation District (IID) from 2010 – 2014. (SOURCE: Reclamation, 1995 – 2014)

### 5.4.1.2 Coachella Valley Watershed

Figure 39 shows that, over the five-year period of available data, ET from agriculture in CVWD is consistently lowest in December, increases rapidly to an annual maximum in May, and decreases gradually thereafter. There is no clear increasing or decreasing trend across the five years.

Evaporation from open water sources, as shown in Figure 40, peaks in June instead with more symmetrical rates of increase and decrease throughout the year. The monthly trend in evaporation is consistent from 2010 to 2014.

Reported total ET estimates (in AF) are divided by CVWD reported net irrigated area to compute a net ET rate of 2.23 AF/acre of irrigated lands. Net irrigated land has been relatively stable between 75,000 and 77,000 acres from 2013 to 2019 (average 76,420 acres). Therefore, ET since 2013 is assumed to average 170,650 AF/year.

Note that the ET rate computed for CVWD agricultural lands are not used in the development of future inflow scenarios, but instead are provided here for completeness.

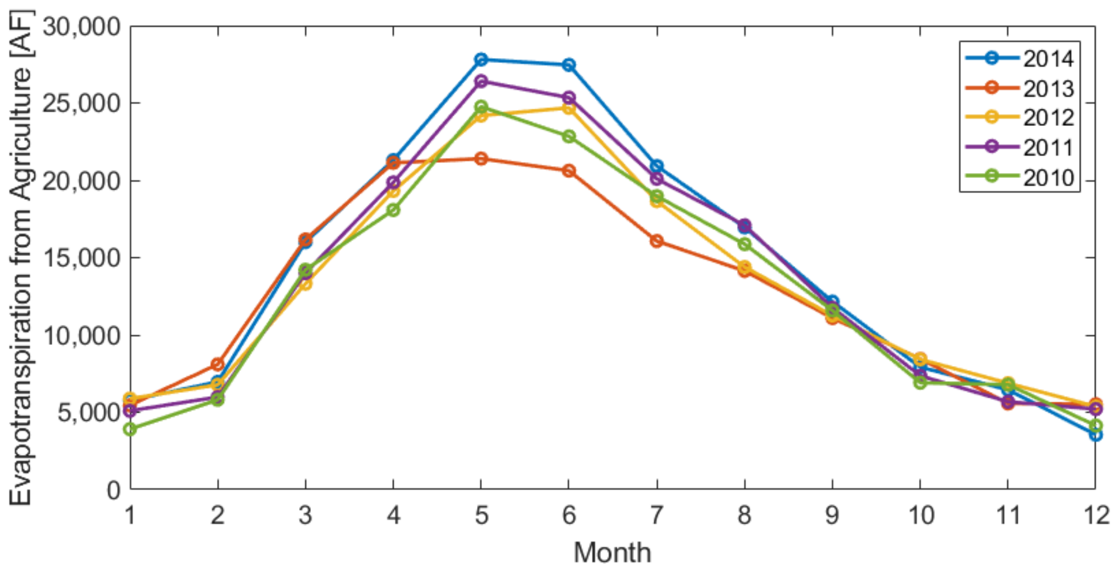



**Figure** 39**.** Sub-annual ET from agriculture in the Coachella Valley Water District (CVWD) from 2010 – 2014. (SOURCE: Reclamation, 1995 – 2014)

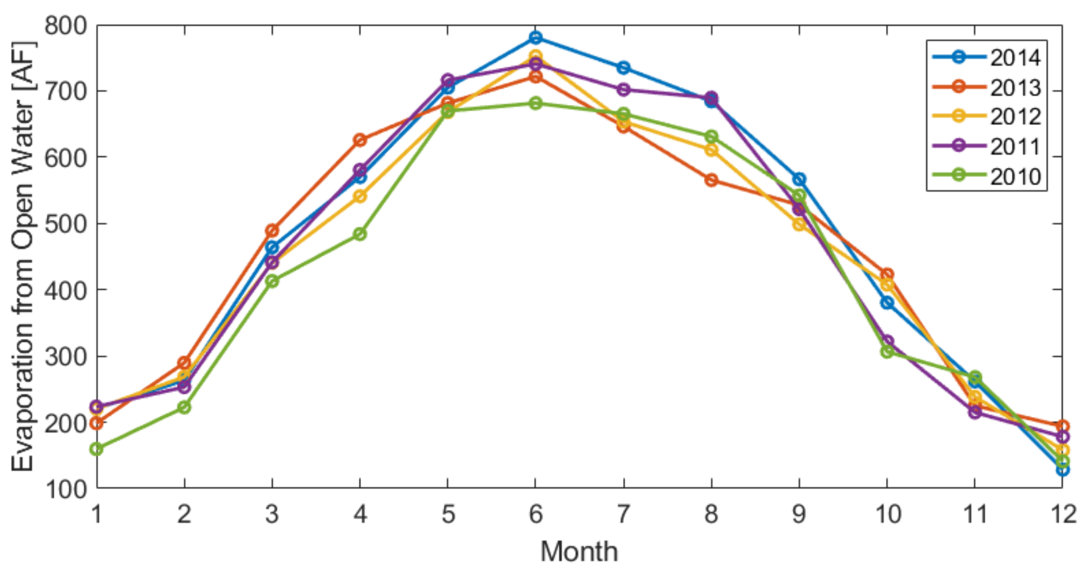



**Figure** 40**.** Sub-annual evaporation from open water in the Coachella Valley Water District (CVWD) from 2010 – 2014. (SOURCE: Reclamation, 1995 – 2014)

#### 5.4.1.3 Climate Change Effects on Evapotranspiration

Table 15 presents the percent increase in ET rates presented in Table 12 applied to the net ET rates determined above for the Imperial Valley, to provide the resulting ET rates for the different climate conditions (low, average, and high traces).

Table 15. Climate change effects on ET in the Imperial Valley

| Condition | Estimated percent increase in ET | ET, Imperial Valley (AF/acre) |
|---|---|---|
| Baseline | - | 3.60 |
| Low Trace | 3.56% | 3.73 |
| Average Trace | 4.46% | 3.76 |
| High Trace | 5.02% | 3.78 |

### 5.4.2 Evaporation from the Salton Sea

Evaporation is the most significant outflow component of the Salton Sea water balance. Evaporation studies in the Salton Sea performed by USGS since the early 1960s used water and energy budgets to compute annual evaporative losses. With this method, annual evaporation was computed as the difference between the sum of all inflows, including precipitation, and the storage volume change in the Salton Sea over the year. Inflow sources included those outlined above while storage volume was computed using water surface elevation measurements and Salton Sea bathymetry. Based on this method, total annual evaporation from the Salton Sea was estimated to be 1.3 million AF/year in the historical period.

While recent inflows (2015–2021) have remained relatively stable, they are nonetheless much lower than the rate of evaporative loss from the surface of the Sea. For this reason, the Sea continues to decline in elevation.

# 6 Future Water Inflow Scenarios and Assumptions

To inform long-term management of the Salton Sea, different future water management scenarios have been created to account for short-term drought reductions and long-term impacts from climate and policy changes.

## 6.1 Short-term Drought Reductions (2023 - 2026)

On October 5, 2022, California users of Colorado River water released a statement proposing to conserve 400,000 AF of water each year from 2023 to 2026 to contribute towards stabilizing elevations in Lake Mead.[11] IID pledged to cut 250,000 AFY, an amount contingent on federal funding and voluntary participation of water users.[12] Other California users of Colorado River Water that signed the statement were the Metropolitan Water District, CVWD, and the Palo Verde Irrigation District.

## 6.2 Water Use for Lithium Production

Appendix C presents a discussion of water use and availability for lithium extraction in the Salton Sea Geothermal Field (SSGF). Operations of geothermal power plants in the SSGF require limited freshwater use. While the exact amount of freshwater used for normal geothermal power plant operations in the SSGF is not available from public sources, estimated freshwater use can be obtained based on very limited information in permit applications and environmental documents (CEC, 2003; CEQA Report-Hell's Kitchen PowerCo 1 and LithiumCo 1 Project, 2022). These documents also provide information on freshwater use associated with the various sorbent and ion-exchanger-based lithium extraction processes that have been proposed in the SSGF.

The environmental documents cited above provide reasonable estimates of overall water use associated with lithium production, accounting for both geothermal generation and lithium extraction. Under the assumption of a doubling of generating capacity for geothermal power in the SSGF from 350MW to 700MW, the assumed annual freshwater use for lithium production for the future water inflow scenarios is 50,000 AFY, which is a mid-range value for 700MW geothermal power generation as presented in Table 1 of Appendix C.

## 6.3 Inflow Scenarios Considered for the Long-Range Plan

The data and methodologies presented in Section 5 were used to prepare a summary of inflow scenarios considered for use in the LRP, as presented in Table 16. Scenario 1 (Continued Baseline) is the average of the inflows over the recent period (2015-2021), as derived in Section 5.3. The total inflow is the same as presented in Table 14, and is repeated here for comparison. Scenarios 2, 3, and 4 are developed using the frequency modeling and climate change assumptions presented in Section 5.2. Scenarios 5 and 6, derived from SALSA2 modeling performed by IID and previously described in Section 4, are presented here for comparison. Each scenario is discussed in more detail below.

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[11] http://crb.ca.gov/2022/10/california-water-agencies-pledge-to-conserve-additional-water-to-stabilize-the-colorado-river-basin/

[12] https://calmatters.org/environment/2022/10/california-colorado-river-water/

Table 16. Summary of inflow scenarios to the Salton Sea (units: AFY).

<table>
<tr><th>Number</th><th>Summary</th><th>Imperial Valley Flow Gaged</th><th>Imperial Valley Estimated Ungaged</th><th>Mexico Flows</th><th>Coachella Valley Gaged</th><th>Coachella Valley Drain Flow[1]</th><th>Local Watershed</th><th>Ground-water</th><th>Total</th></tr>
<tr><td>Scenario 1</td><td>Continued Baseline</td><td>853,000</td><td>76,800</td><td>66,100</td><td>47,200</td><td>30,600</td><td>4,680</td><td>11,900</td><td>1,090,000</td></tr>
<tr><td>Scenario 2[2]</td><td>High Probability Inflow Scenario</td><td colspan="2">852,900</td><td>0[3]</td><td colspan="2">70,000</td><td>4,680</td><td>11,900</td><td>889,000</td></tr>
<tr><td>Scenario 3[2]</td><td>Low Probability Inflow Scenario</td><td colspan="2">647,900</td><td>0[3]</td><td colspan="2">70,000</td><td>4,680</td><td>11,900</td><td>684,000</td></tr>
<tr><td>Scenario 4[2]</td><td>Very Low Probability Inflow Scenario</td><td colspan="2">407,900</td><td>0[3]</td><td colspan="2">70,000</td><td>4,680</td><td>11,900</td><td>444,000</td></tr>
<tr><td>Scenario 5</td><td>IID Low Uncertainty (2025-2077 average)</td><td colspan="2">694,000</td><td>48,640</td><td>72,870</td><td>29,150</td><td>10,000</td><td>10,000</td><td>864,700</td></tr>
<tr><td>Scenario 6</td><td>IID Moderate Uncertainty (2025-2077 average)</td><td colspan="2">576,000</td><td>38,000</td><td>48,400</td><td>19,360</td><td>10,000</td><td>10,000</td><td>701,800</td></tr>
</table>

Notes:
1. This column refers to drain flow other than the CVSC.
2. Scenarios 2, 3, and 4 include 50,000 AFY inflow reduction due to lithium allocation.
3. Inflows from Mexico gradually decrease from the baseline value of 66,100 AFY to 0, as further illustrated below.

### 6.3.1 Scenario 1: Continued Baseline

Under this scenario, net inflows and outflows are assumed to remain similar to the most recent period represented by 2015 – 2021. That is, inflows from the Salton Sea are dominated by Imperial Valley contributions via the New and Alamo River. An additional 9% of these flows was added to represent ungaged flows. Coachella Valley inflows were gaged at the USGS Whitewater River gage. Coachella Valley drain flow, as measured by CVWD, was averaged over 2015 – 2021. Local watershed flow was discussed in Section 5.3.4 and was averaged over 2015 – 2021. Groundwater inflow was discussed in Section 5.3.5 and contributes 11,900 AF/year. The inflows for Scenario 1 are itemized below.

| INFLOW TERM | VALUE (AF/year) | JUSTIFICATION |
|---|---|---|
| Imperial Valley gaged | 853,000 | 2015-2021 AVG New River (USGS 10255550) plus Alamo River (USGS 10254730) minus Mexico flows (USGS 10254970) |
| Imperial Valley ungaged | 76,800 | 9% of gaged flow (see Section 5.3.2) |
| Mexico | 66,100 | 2015-2021 AVG New River Int'l Border (USGS 10254970) |
| Coachella Valley gaged | 47,200 | 2015-2021 AVG Whitewater River (USGS 10259540) |

| | | |
|---|---|---|
| Coachella Valley drain | 30,600 | Refers to drain flow other than the CVSC, see Section 5.3.3; average 2105-2021 from Table 14 |
| Local watershed | 4,680 | See Section 5.3.4; average 2015-2021 from Table 14 |
| Groundwater | 11,900 | See Section 5.3.5; average 2015-2021 from Table 14 |
| **TOTAL** | **1,090,000 AF/year** | |

### 6.3.2 Scenario 2: High Probability Inflow

For the high probability inflow scenario, water deliveries to Imperial Valley were based on the CRSS model and resampling hydrology from 2000-2018 (information from Wheeler et al. 2022), as described in Section 5.2.1. For the high probability inflow scenario, the 50th percentile flow (2.535 MAF) is assumed (Table 11). In other words, the model predicts that 2.535 MAF of inflow to Imperial Valley will be exceeded 50 percent of the time. This represents full delivery of water to Imperial Valley.

Based on climate change effects discussed in Section 5.2.2, ET is expected to increase by 3.5 to 5.0% by the end of the century based on application of the Penman Monteith Method (see Table 12). As a conservative estimate for the future inflow scenarios, an increase of 5% is assumed. Therefore, the climate-adjusted ET rate is 3.78 AF/acre of irrigated land (or 5.0% increase from the current estimate of 3.60 AF/acre, see Table 15). The volume of water lost assumes an acreage value of 445,011 acres, which is the average over 2018 to 2021 for the Imperial Valley.

In the Coachella Valley, the Indio Subbasin Water Management Plan Update (Indio Subbasin GSAs, 2021) was utilized as the source for future inflow to the Sea (Figure 41). The scenario representing future projects with climate change was selected as the most appropriate scenario with 70,000 AFY as the flow representing future conditions at the Sea.[13] This represents the total inflow from the tile drainage system to the Sea from the Coachella Valley, including from the gaged CVSC.

[13] Figure 41 includes only subsurface flows from the farm tile drainage systems that intercept return flows from applied irrigation water and rising groundwater. Point discharges (e.g., from POTWs) to the Coachella Valley Stormwater Channel are not included in the subsurface flows projected in Figure 41.

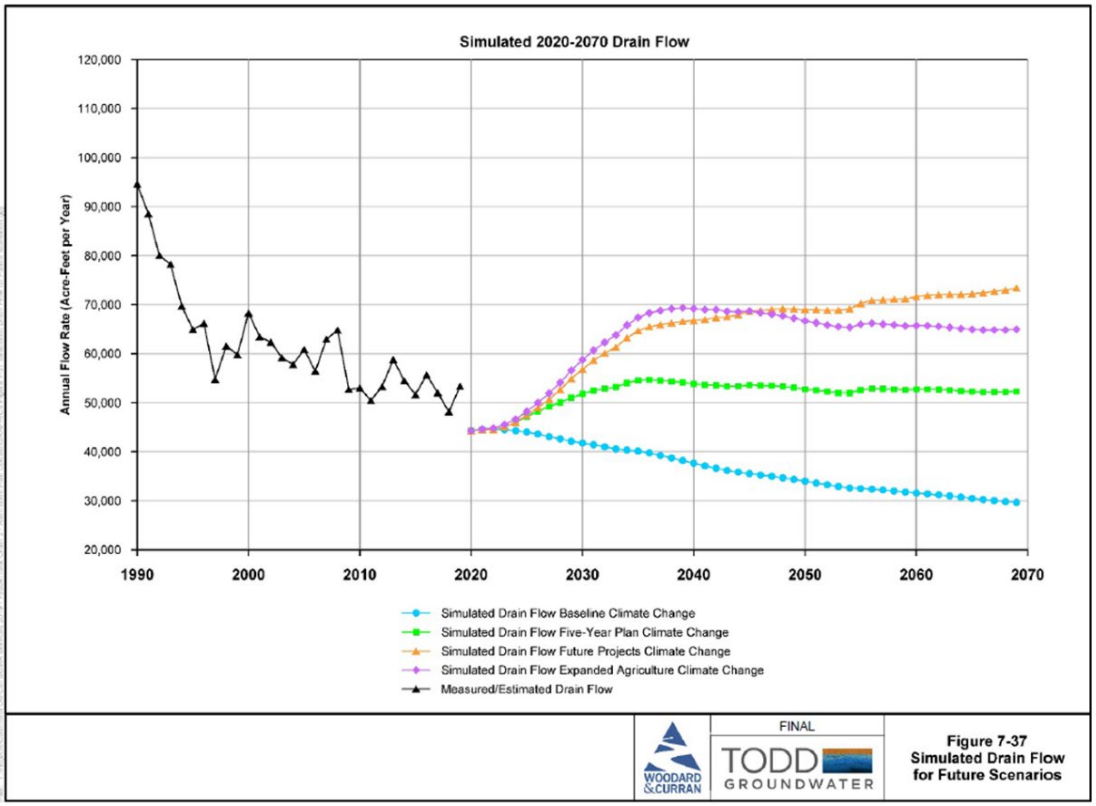


**Figure** 41**.** Simulated Drain Flow for Future Scenarios, Representing Total Inflow to the Salton Sea from the Coachella Valley. (SOURCE: Indio Subbasin GSAs, 2021)

For Scenario 2, the local watershed and groundwater terms remain the same as the baseline values. The inflows for Scenario 2 are itemized below.

| INFLOW TERM | VALUE (AF/year) | JUSTIFICATION |
|---|---|---|
| Imperial Valley | 852,900 | Inflow to Imperial Valley (2,535,000 AFY) minus ET at 3.78 AF/acre of irrigated land |
| Mexico | 0 | Mexico flows gradually decrease to zero from the Scenario #1 value of 66,100 AFY |
| Coachella Valley | 70,000 | Simulated drain flow for future projects with climate change scenario (Indio Subbasin GSAs, 2021) |
| Local watershed | 4,680 | See Section 5.3.4 |
| Groundwater | 11,900 | See Section 5.3.5 |
| Lithium Allocation | -50,000 | Lithium is a new and growing water use in the basin. |
| **TOTAL** | **889,000 AF/year** | |

### 6.3.3 Scenario 3: Low Probability Inflow

For the low probability inflow scenario, the 90th percentile flow (2.33 MAF) from the CRSS model resampling hydrology from 2000-2018 is assumed (Table 11). In other words, the model predicts that 2.33 MAF of inflow to Imperial Valley will be exceeded 90 percent of the time. Evapotranspiration in the Imperial Valley is estimated as for Scenario 2, assuming an increase of 5 percent over baseline ET values.

For Scenario 3, Coachella Valley inflows are the same as for Scenario 2. The local watershed and groundwater terms remain the same as the baseline values. The inflows for Scenario #3 are itemized below.

| INFLOW TERM | VALUE (AF/year) | JUSTIFICATION |
|---|---|---|
| Imperial Valley | 647,900 | Inflow to Imperial Valley (2,330,000 AFY) minus ET at 3.78 AF/acre of irrigated land |
| Mexico | 0 | Mexico flows gradually decrease to zero from the Scenario #1 value of 66,100 AFY |
| Coachella Valley | 70,000 | Simulated drain flow for future projects with climate change scenario (Indio Subbasin GSAs, 2021) |
| Local watershed | 4,680 | See Section 5.3.4 |
| Groundwater | 11,900 | See Section 5.3.5 |
| Lithium Allocation | -50,000 | Lithium is a new and growing water use in the basin. |
| **TOTAL** | **684,000 AF/year** | |

### 6.3.4 Scenario 4: Very Low Probability Inflow

For the very low probability inflow scenario, the 95th percentile flow (2.09 MAF) from the CRSS model resampling hydrology from 2000-2018 is assumed (Table 11). In other words, the model predicts that 2.09 MAF of inflow to Imperial Valley will be exceeded 95 percent of the time. Evapotranspiration in the Imperial Valley is estimated as for Scenario 2 and 3, assuming an increase of 5 percent over baseline ET values.

For Scenario 4, Coachella Valley inflows are the same as for Scenario 2 and 3. The local watershed and groundwater terms remain the same as the baseline values. The inflows for Scenario 4 are itemized below.

| INFLOW TERM | VALUE (AF/year) | JUSTIFICATION |
|---|---|---|
| Imperial Valley | 407,900 | Inflow to Imperial Valley (2,090,000 AFY) minus ET at 3.78 AF/acre of irrigated land |
| Mexico | 0 | Mexico flows gradually decrease to zero from the Scenario #1 value of 66,100 AFY |
| Coachella Valley | 70,000 | Simulated drain flow for future projects with climate change scenario (Indio Subbasin GSAs, 2021) |

| | | |
|---|---|---|
| Local watershed | 4,680 | See Section 5.3.4 |
| Groundwater | 11,900 | See Section 5.3.5 |
| Lithium Allocation | -50,000 | Lithium is a new and growing water use in the basin. |
| **TOTAL** | **444,000 AF/year** | |

### 6.3.5 Scenario 5: IID Low Uncertainty

This scenario uses the low uncertainty results of the Salton Sea modeling efforts performed by IID, which are summarized in Section 4. The low uncertainty scenario is intended to represent flows and assumptions that are similar to current conditions. Modeled flows from 2025-2077 were averaged to determine the values in the table below.

| INFLOW TERM | VALUE (AF/year) | JUSTIFICATION |
|---|---|---|
| Imperial Valley | 694,000 | Average predicted flows from 2025-2077; also see Section 4. |
| Mexico | 48,640 | Average predicted flows from 2025-2077; also see Section 4. |
| Coachella Valley gaged | 72,870 | Average predicted flows from 2025-2077; also see Section 4. |
| Coachella Valley drain | 29,150 | Average predicted flows from 2025-2077; also see Section 4. |
| Local watershed | 10,000 | Average predicted flows from 2025-2077; also see Section 4. |
| Groundwater | 10,000 | Average predicted flows from 2025-2077; also see Section 4. |
| **TOTAL** | **864,700 AF/year** | |

### 6.3.6 Scenario 6: IID Moderate Uncertainty

This scenario uses the moderate uncertainty results of the Salton Sea modeling efforts performed by IID, which are summarized in Section 4. The moderate uncertainty scenario is intended to represent flows and assumptions that represent more extreme or uncertain conditions. Therefore, under moderate uncertainty, inflows will be lower than the IID low uncertainty case. Modeled flows from 2025-2077 were averaged to determine the values in the table below.

| INFLOW TERM | VALUE (AF/year) | JUSTIFICATION |
|---|---|---|
| Imperial Valley | 576,000 | Average predicted flows from 2025-2077; also see Section 4. |
| Mexico flows | 38,000 | Average predicted flows from 2025-2077; also see Section 4. |
| Coachella Valley gaged | 48,400 | Average predicted flows from 2025-2077; also see Section 4. |
| Coachella Valley drain | 19,360 | Average predicted flows from 2025-2077; also see Section 4. |
| Local watershed | 10,000 | Average predicted flows from 2025-2077; also see Section 4. |
| Groundwater | 10,000 | Average predicted flows from 2025-2077; also see Section 4. |
| **TOTAL** | **701,800 AF/year** | |

## 6.4 Inflow Scenarios Modeled for the Long-Range Plan

Three inflow scenarios were modeled for the LRP, the high probability inflow scenario, the low probability inflow scenario, and the very low probability inflow scenario (Scenarios 2, 3, and 4 from Table 16). Figure 42 presents the graphical representation of annual inflows to the Salton Sea for the three inflow scenarios over the period of 2010 to 2060. Key assumptions for the inflow scenarios are described above and are summarized as follows:

- Water deliveries to IID are based on CRSS model and resampling hydrology from 2000-2018 (information from Wheeler et al. 2022). The assumption that the current dry conditions in the 21st century will continue over the following four decades is a relatively stressful scenario from the hydrologic perspective. The three scenarios use the 50$^{th}$ percentile exceedance flow (high probability inflow scenario, 2.535 MAF), 90$^{th}$ percentile exceedance flow (low probability inflow scenario, 2.33 MAF), and 95$^{th}$ percentile exceedance flow (very low probability inflow scenario, 2.09 MAF).
- Mexico inflows are assumed to decline from current levels to zero by 2035, and those flows are assumed to be recycled south of the border.
- Water used for lithium production is assumed to reduce inflows to the Sea by 50,000 AFY by 2035 and remain constant thereafter. This is a new and growing water use in the basin.
- Climate change is estimated to increase ET in the Imperial Valley, based on average temperature from 2035-2064 (30-year window). It reaches this value by 2035 and remains at this level for the rest of the simulation period.
- The current drought results in a decrease of 250,000 AF of water allocation to IID from 2023 to 2026 (4 years), based on published reports. This is to be met by land fallowing, so the net decrease of flow to the Salton Sea is 89,000 AF. For the low probability inflow and very low probability inflow assumptions, the reduction continues and fallowing is replaced by efficiencies which are implemented over 5 years.

With the above assumptions, the high probability inflow scenario stabilizes at 889,000 AFY, the low probability inflow scenario stabilizes at 684,000 AFY, and the very low probability inflow scenario stabilizes at 444,000 AFY, with a transition from current conditions as shown in Figure 42.

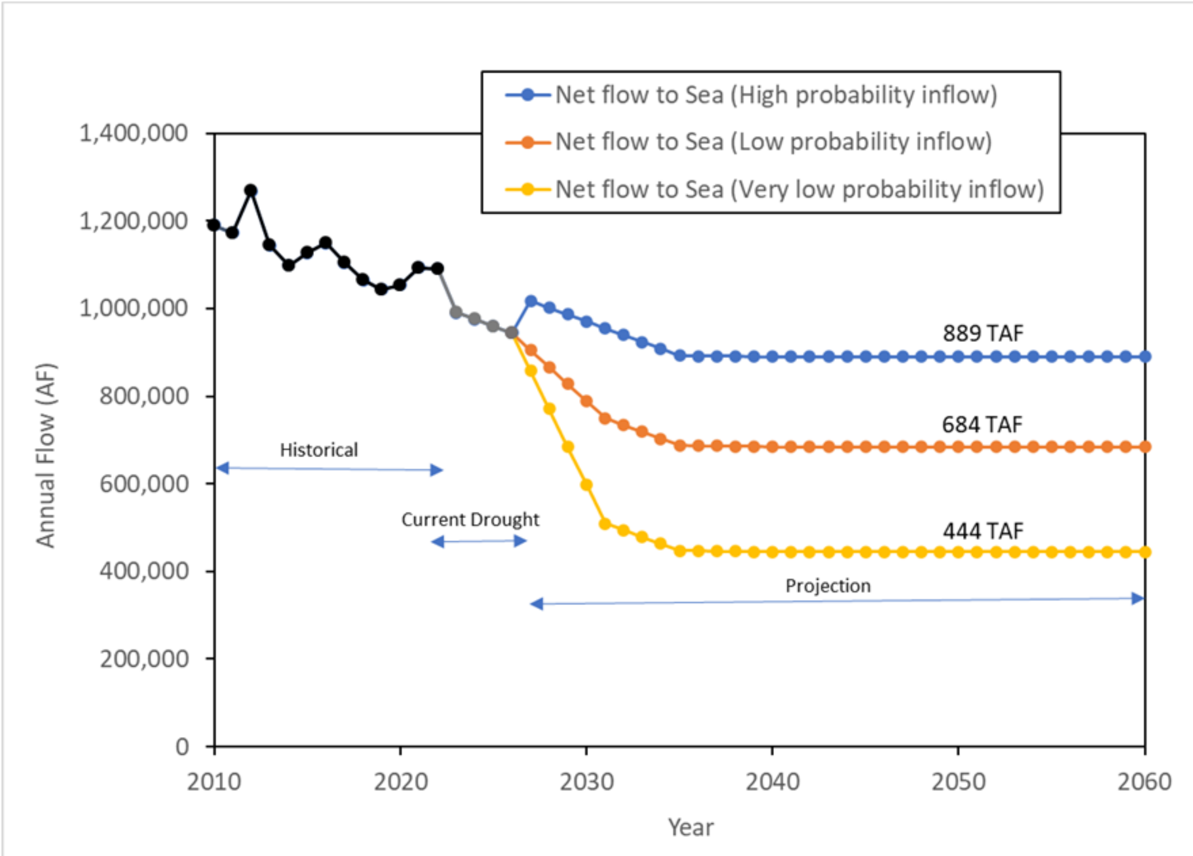


**Figure** 42. Graphical representation of the annual inflows to the Salton Sea for the high probability, low probability, and very low probability inflow scenarios over the period 2010 to 2060.

# 7 Conclusions

As depicted and discussed in Section 5, the key drivers of change in future inflow scenarios to the Salton Sea are projected to be Imperial Valley flows to the Salton Sea and climate change impacts to ET. New water demands related to geothermal and lithium development are expected to be an additional draw on inflows into the Salton Sea.

Inflow scenarios discussed in Section 6 represent the range of possible inflows to the Salton Sea, which account for variability in future climate conditions and policy changes surrounding Colorado water deliveries. These future hydrology scenarios do not account for fluctuations in flow during shorter, sub-annual time periods. During drought conditions, these short time-scale lowflow periods may be of greater concern than long-term average flows. More extreme climate impacts to Lake Mead elevations are possible in the 21st century, which could have significant impacts on Imperial Valley deliveries.

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