RECLAMATION
Managing Water in the West

Final Technical Memorandum No. 1

Santa Margarita River Conjunctive Use Project

U.S. Department of the Interior
Bureau of Reclamation

April 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Final Technical Memorandum No. 1.0

Santa Margarita River Conjunctive Use Project

Statistical Analysis of Santa Margarita River Surface Water Availability at the Conjunctive Use Project's Point of Diversion

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Prepared for:

Bureau of Reclamation
Southern California Area Office

U.S. Department of the Interior
Bureau of Reclamation

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STATISTICAL ANALYSIS OF SANTA MARGARITA RIVER SURFACE WATER AVAILABILITY AT THE CONJUNCTIVE USE PROJECT'S POINT OF DIVERSION

The Bureau of Reclamation (Reclamation) has begun work on a feasibility-level study of the Santa Margarita River Conjunctive Use Project (CUP). The CUP is intended to utilize surface water from the Santa Margarita River to enhance groundwater supplies in aquifers located within the Marine Corps Base Camp Pendleton (Camp Pendleton or Base). An environmental impact report and environmental impact statement (EIR/EIS) is concurrently being prepared to identify the environmental impact of various alternatives that may be used to achieve the purpose and need of the proposed CUP. The purpose of this technical memorandum is to develop statistics that describe the availability of Santa Margarita River surface water at the CUP's point of diversion.

Technical Memorandum 1.0 (TM 1.0) is the first in a series of two technical memoranda that describe the hydrology and hydrogeology of the Santa Margarita River. TM 1.0 addresses the historical variation of flows in the Santa Margarita River over the historical period of record and presents statistics that describe those flows in terms of both total water supply and water available for diversion. Technical Memorandum 2.0 (TM 2.0) will report on the expected groundwater yield from the CUP based on the surface water analysis presented in TM 1.0. The determination of the CUP yield will involve an iterative process of optimizing surface and groundwater resources. These surface and groundwater analyses will be developed based on the statistical variability described and identified below.

Stetson Engineers received authority to proceed from Reclamation on September 20, 2005. Mr. Stephen Reich, Ms. Jean Moran, and Ms. Dawn Taffler of Stetson Engineers met with Reclamation's feasibility design team members at a kickoff meeting in Denver, Colorado, on October 24 and 25, 2005. Representatives from Reclamation included Mr. Del Holz, Mr. Tom Bellinger, Mr. Bob Talbot, Mr. Bob Hamilton, and the study team's project manager Ms. Meena Westford. Discussions during the kickoff meeting framed the constraints that would be used for the statistical analysis of water availability over the historical period of record. The purpose of studying Santa Margarita River water availability is to address the probability and occurrence of surface water available for future groundwater modeling runs and eventually the ultimate water yield from the CUP. These model runs will be used to develop management scenarios that maximize groundwater pumping yield from the Base's aquifers.

The statistical analysis and supporting hydrologic study analyzed and reported in TM 1.0 establishes the boundary conditions that will eventually support Reclamation's design of extraction, conveyance, and water treatment facilities. The groundwater modeling analysis to be completed under TM 2.0 will consider enhanced groundwater pumping from the Lower Santa Margarita River Basin using the available surface water identified in this technical memorandum. TM 2.0 will eventually describe the monthly and annual volume of water available for delivery to the Haybarn Canyon Water Treatment Plant.

Surface water availability was analyzed for historical hydrologic conditions based on long-term precipitation and streamflow records. Results of previous studies reflected hydrologic conditions based on historical records from 1980 through 1999 (Stetson, 2001). TM 1.0 utilizes the entire historical hydrologic record to extend the previous study period's hydrologic cycle so that it reflects the driest and wettest periods on record. The flows considered at the point of diversion represent regulated or depleted conditions occurring over the historical period of record, not natural flow conditions that would have been maintained had no development occurred. The use of historical conditions represents the operational water supply available at the point of diversion and provides a more realistic estimation of the CUP's potential yield. Previous estimates of CUP yield provided by Stetson (2001, 2002) and Reclamation (2005) will be updated with values developed in TM 1.0 and TM 2.0. The surface water availability in TM 1.0 was developed for use in the groundwater model. The recoverable water supply will continue to be refined through the groundwater model calibration process.

The 744-square-mile (mi^2) Santa Margarita River basin lies within the counties of San Diego and Riverside in southern California. Hydrological conditions in the Santa Margarita River basin are controlled by wintertime tropical and northern Pacific storm events and, to a minor, degree summer monsoon events. While most of the precipitation occurs as rainfall throughout the watershed, snowfall may occur in the higher mountain ranges located in the upper reaches of the watershed influencing springtime baseflows above Vail Dam. Typical of many Southwestern United States stream systems, extreme peak flows often occur during winter rain events, and minimum baseflows occur during the dry summer months. The flashy nature of the Santa Margarita River and the daily streamflow variability were considered to statistically describe the volume of water available at the point of diversion.

Historical Reconstructed Streamflow at the Point of Diversion

Streamflow in the Santa Margarita River at the CUP's point of diversion (figure 1) was reconstructed using a composite record of observed streamflow data for water years 1925 through 2005. The CUP's proposed point of diversion is expected to be constructed at Camp Pendleton's existing diversion point to O'Neill ditch (Reclamation, 2005). Because no long-term United States Geologic

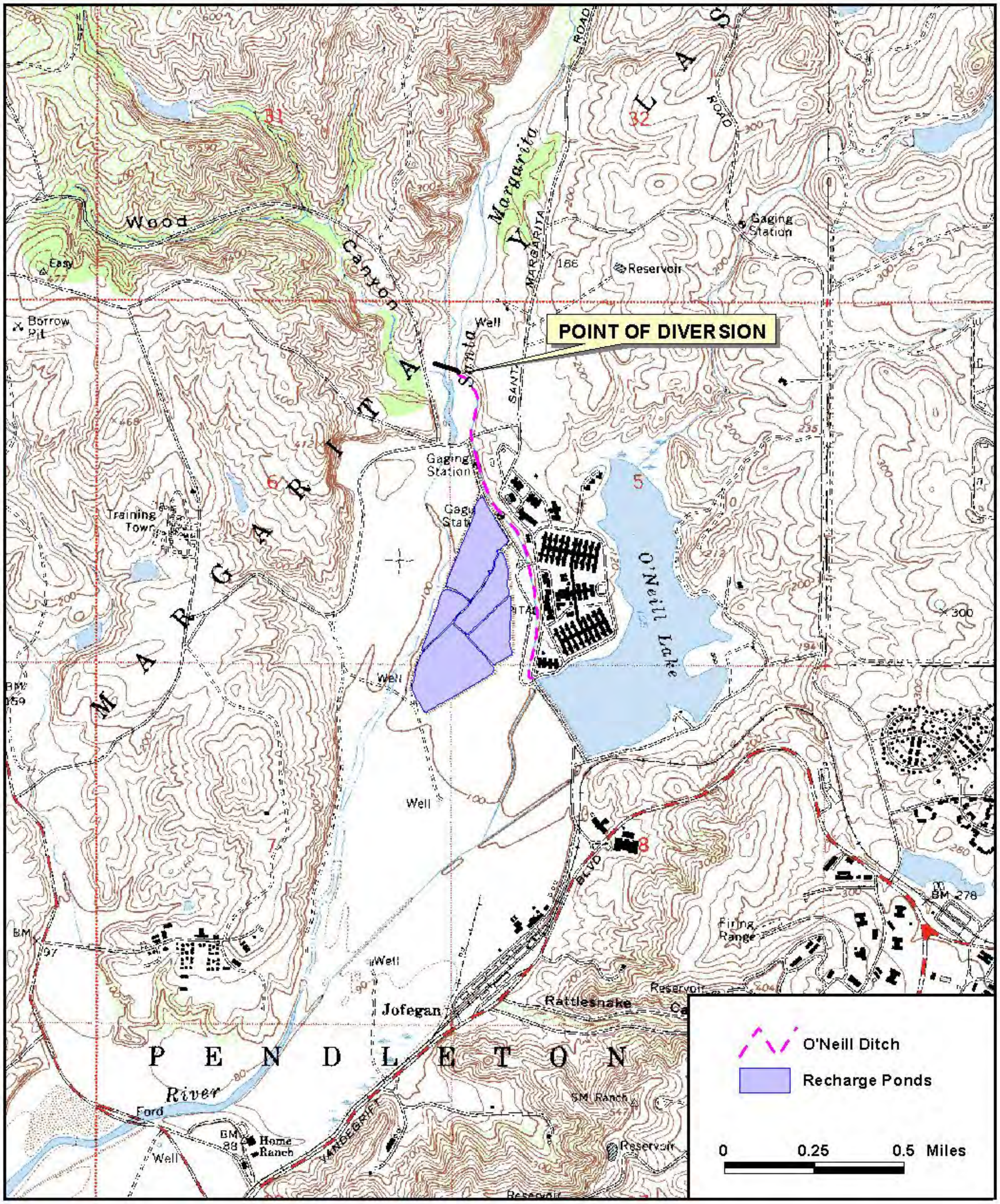

Figure 1. Location of Proposed Point of Diversion for the Santa Margarita River CUP.

Survey (USGS) gauge has ever been established at the existing diversion structure, recorded streamflow data from the USGS gauges listed in table 1 were used to develop a streamflow hydrograph at the diversion point. Figure 2 depicts the location of the historical USGS gauges used to reconstruct flow at the CUP's proposed point of diversion. Historical daily streamflow observed at these gauge sites were used to simulate an 81-year period of record of streamflow at the CUP's point of diversion. Missing data from streamflow gauges with incomplete periods of record were reconstructed and calibrated using established hydrologic methods and available data.

Table 1. Stream Gauging Stations Used to Reconstruct Streamflow in the Santa Margarita River at the Point of Diversion[1]

Station Name	Station ID No.	Operating Agency	Period of Record	Drainage Area (mi^2)
Santa Margarita River near Temecula (Gorge)	11044000	USGS	2/23-Present	588.0
Santa Margarita River at FPUD Sump	11044300	USGS	10/89-Present	620.0
Sandia Creek near Fallbrook	11044350	USGS	10/89-Present	21.1
Santa Margarita River near Fallbrook	11044500	USGS	10/24-9/80	644.0
De Luz Creek near De Luz	11044800	USGS	10/92-Present	33.0
De Luz Creek near Fallbrook	11044900	USGS	10/51-9/67	47.5
Santa Margarita River at Ysidora (various locations)	11046000	USGS	3/23-Present	723.0

[1] mi^2 = square miles.

A spreadsheet model was developed to reconstruct the streamflow in the Santa Margarita River at the point of diversion. The period of record was divided into three temporal intervals based on the period of record established by the available streamflow gauge data. The development of reconstructed streamflow at the point of diversion is based on observed daily streamflow recorded by the USGS and precipitation data from the National Ocean and Atmospheric Administration (NOAA) and Camp Pendleton. Annual and monthly streamflow records, at the point of diversion, were also developed from the hydrologic analysis that relied on the historical daily data. The hydrologic record is described by three time periods defined by the date when streamflow gauges in the lower Santa Margarita River Watershed were established.

- **Water Years 1925 to 1980:** The total streamflow at the point of diversion was calculated based on adding the streamflow from the Santa

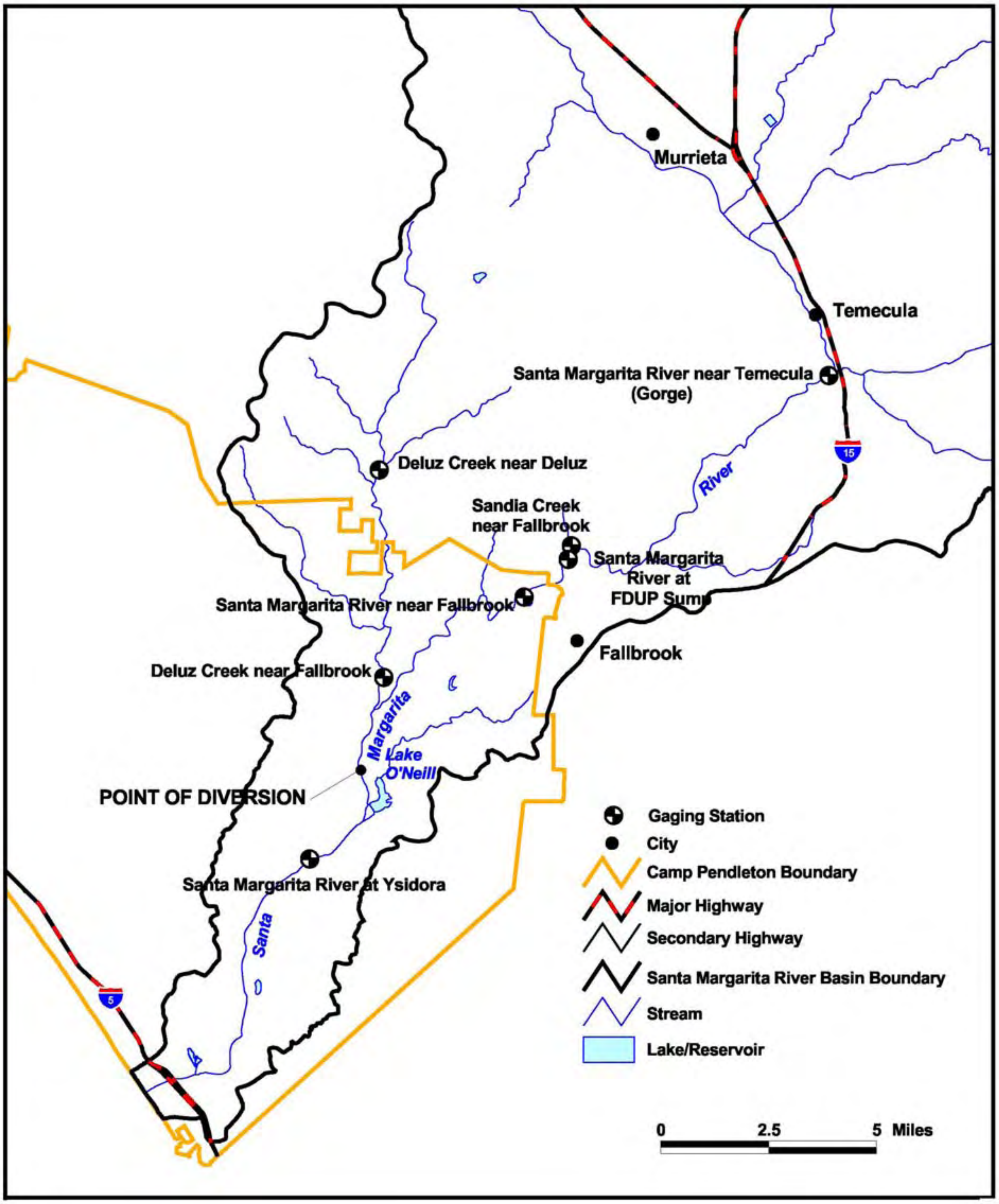

Figure 2. Streamflow Gauging Stations Used to Reconstruct Streamflow in the Santa Margarita River at the Point of Diversion.

Margarita River near Fallbrook gauge (USGS #11044500) to streamflow from DeLuz Creek, plus estimated accretion between the downstream gauges and the point of diversion. The contribution from Sandia Creek was included in the Santa Margarita River near Fallbrook gauge during this period since the former gauge was located downstream from their confluence. During water years 1952 through 1967, streamflow from the DeLuz Creek gauge near Fallbrook (USGS #11044900) accounted for the contribution of streamflow from DeLuz Creek. For all other years, the contribution from DeLuz Creek was calculated using proportionality constant based on ratio of DeLuz Creek gauge and Santa Margarita River near Fallbrook gauge drainage areas.

- **Water Years 1981 to 1989:** The streamflow records in the lower Santa Margarita River basin during water years 1981 through 1989 were deficient due to missing gauge data. During the 1980 flood, the Santa Margarita River near Fallbrook gauge (USGS #11044500) was washed out and was not reconstructed until 1989. A new gauge was installed in 1989 at the Fallbrook Public Utility District (FPUD) Sump on the Santa Margarita River (USGS #11044300), upstream of the confluence with Sandia Creek. The only reliable historical streamflow dataset available during the 1981 to 1989 period of record was from the Santa Margarita River near Temecula gauge (USGS #11044000), commonly referred to as the Gorge.

  To reconstruct streamflow at the point of diversion, the contribution of streamflow below the Gorge was estimated using the Soil Conservation Service (SCS) Curve Number method and the United States Environmental Protection Agency's (USEPA) Hydrologic Simulation Program-Fortran (HSPF). The SCS method was used to calculate surface runoff during precipitation events while the HSPF model was used to simulate baseflows in each drainage area. Stetson Engineers applied these two methods in the development of the Permit 15000 water availability study (Stetson, 2001).

- **Water Years 1990 to 2005:** Streamflow at the point of diversion for the most recent period was developed by summing historical streamflow data from the Santa Margarita River at FPUD Sump (USGS #11044300), Sandia Creek (USGS #11044350), and De Luz Creek (USGS #11044800) gauges, plus estimated accretion between the downstream gauges and the point of diversion. The new DeLuz Creek gauge, located in the upper two-thirds of the DeLuz Creek basin, was multiplied by a proportionality constant to calculate contributions from lower DeLuz Creek. Missing data from De Luz Creek between October 1989 and October 1992 was calculated using a proportionality constant based on ratio of the DeLuz and Sandia Creek (47.5 mi^2/ 21 mi^2) drainage areas. The observed streamflow data obtained from the USGS for water year 2005 was identified as "Provisional" at the time of this analysis.

Geomorphologic conditions significantly influence the occurrence of surface flow and subsurface flow occurring below the Gorge. The geologic map indicates minimal stream channel alluvial sediments at the Gorge, thus the flow at this location is considered to be entirely surface flow. From the Gorge to the confluence with DeLuz Creek, the amount of alluvial sediment ranges from 15 to 20 feet, allowing for a portion of the total water supply to occur as subflow. Below the DeLuz Creek confluence, the alluvium increases considerably, supporting a larger volume of subflow. A general head boundary in the groundwater model evaluates the subflow contribution at the model boundary, identifying subflow contributions on a monthly basis. Thus, the recoverable portion of subflow is accounted for in the groundwater model, which will be examined in more detail in TM 2.0. Due to the occurrence of alluvial sediments in the stream channel, a portion of the baseflow for the drainage areas below the USGS gauges is accounted for in the groundwater model.

The surface water analysis utilized the SCS Curve Number method to calculate the contribution to peak flows occurring during storm events for the drainage areas below the USGS gauges. A California isohyetal map depicting average annual precipitation contours was used to predict the spatial distribution of rainfall in the lower portion of the Santa Margarita River Basin (Daly, 1998). A precipitation ratio, interpreted from the distribution of the average annual isohyetal contours below the USGS gauges, was employed to account for local variability in rainfall when calculating peak flow contributions for ungauged drainage areas. Daily and hourly Oceanside precipitation data were multiplied by the precipitation ratio to calculate precipitation excess, antecedent moisture conditions, and surface runoff during storm events for ungauged drainage areas.

An iterative calibration process using actual and simulated data was employed to reconstruct the streamflow at the point of diversion. The analysis included the investigation of multiple streamflow computational methods to calculate peak flow events and baseflows for ungauged drainage areas and missing data. The methods employed to estimate streamflow during periods of missing data were calibrated to periods of known streamflow to correlate results and identify inconsistencies. Observed flows from the Santa Margarita River near the Ysidora gauge were not used in the surface water calibration process due to the poorly constrained physical conditions that influence the quality of the data, the impact of groundwater pumping from the lower Santa Margarita River basin, and the effect of five different historical gauge locations over 7 miles. The surface water hydrology was developed to statistically describe surface water availability and to reconstruct streamflow at the groundwater model boundary. Additional refinements to streamflow at the point of diversion may occur throughout the groundwater model calibration process.

The reconstructed annual streamflow at the point of diversion in the Santa Margarita River for water years 1925 to 2005 is represented by the bar graph in figure 3. The reconstructed monthly streamflow values for the same period are presented in Attachment A-1. A review of figure 3 indicates that the maximum annual streamflow of 249,500 acre-feet (AF) occurred during water year 1993, and the minimum annual streamflow (2,000 AF) occurred in 1961. This significant range in annual flows typifies the variability of streamflow in the Santa Margarita River, where the wettest year is 125 times greater than the driest year on record. The reconstructed streamflow at the point of diversion represents observed streamflow influenced by historical conditions and activities in the Santa Margarita River Basin. Groundwater pumping in the upper basin, changes in land use, increased development, discharge agreements, and other impacts to changes in hydrology are represented in this historical period of record.

The reliability and usefulness of the reconstructed streamflow is a function of the availability of observed data and a representative period of record. Based on the 81-year period of record, more than 70 percent (%) of the reconstructed flow in the Santa Margarita River at the point of diversion is based on observed flows at USGS gauges. This extensive period of record captures the long-term variability

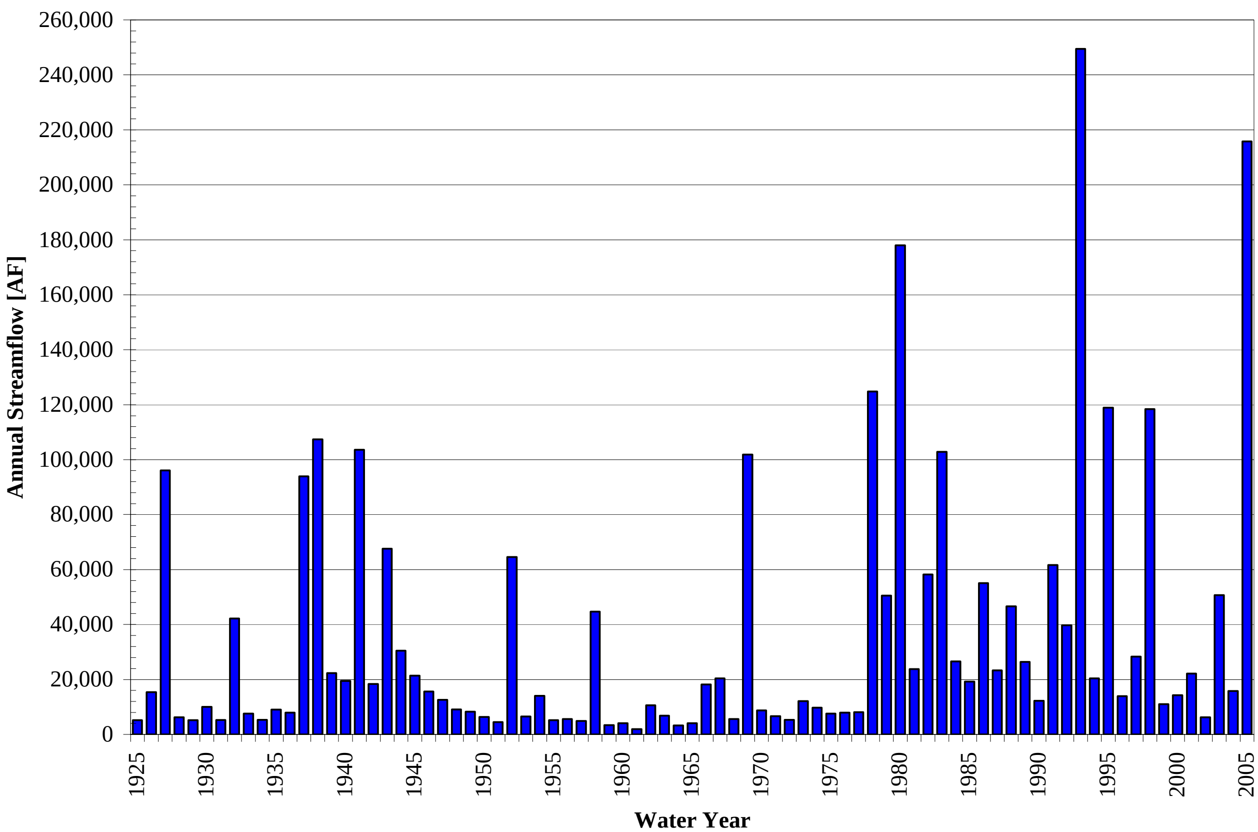

Figure 3. Reconstructed Streamflow in the Santa Margarita River at the Point of Diversion Water Years 1925-2005 [AF].

of surface water in the Santa Margarita River at the point of diversion. The 81-year period of record includes extended dry and wet hydrologic periods. For example, the period from the late 1940s to early 1960s is characteristic of an extended dry-cycle in the Santa Margarita River watershed (Stetson, 2001). Conversely, the 1990s is considered to be an extended wet period. The extended wet and dry cycles can best be described using cumulative departure from mean curves that graphically describe wet and dry cycles (Stetson, 2001, 2002).

Frequency Analysis of Streamflow at the Point of Diversion

A frequency analysis was performed on historical annual streamflow in the Santa Margarita River at the point of diversion for the 81-year period of record to establish the frequency that annual streamflow volumes were historically exceeded. Similar to recurrence intervals assigned to flood events, exceedence intervals are used to establish a basis for predicting the frequency of future annual streamflow values. The historical streamflow for each year is ranked and assigned a percent time exceedence. The frequency curve depicts the frequency at which a given annual streamflow at the point of diversion was historically exceeded during the 81-year historical period (figure 4). Attachment A-2 lists the annual streamflow values at the point of diversion for this period, ranked in descending order.

The exceedence interval provides a statistical expression of the probability that an annual streamflow will be equaled or exceeded in any given year. For this analysis, the exceedence interval represents the period of time, in years, that an annual flow will likely be exceeded and is calculated as the inverse of the percent time exceedence. For example, the median (50%) annual flow (15,400 AF) represents a minimum volume that is expected to be exceeded 1 year out of every 2 years (1 divided by 50%). Streamflow during the other of the 2 years is statistically expected to be less than 15,400 AF.

Similar to flood events in which two or three “10-year” events may occur in a single year, annual streamflow above the median flow value may occur on the Santa Margarita River concurrently from year to year. Storage facilities, including both surface reservoirs and groundwater aquifers, uniquely reduce the natural variability so that the median flow value becomes a more statistically meaningful number in the arid Southwestern United States. Diversion of water to either surface or underground storage reduces the impact of the natural variability to the water supply. Surface water during dry years may be captured and stored, increasing the water available during those years—effectively reducing the occurrence interval of dry years.

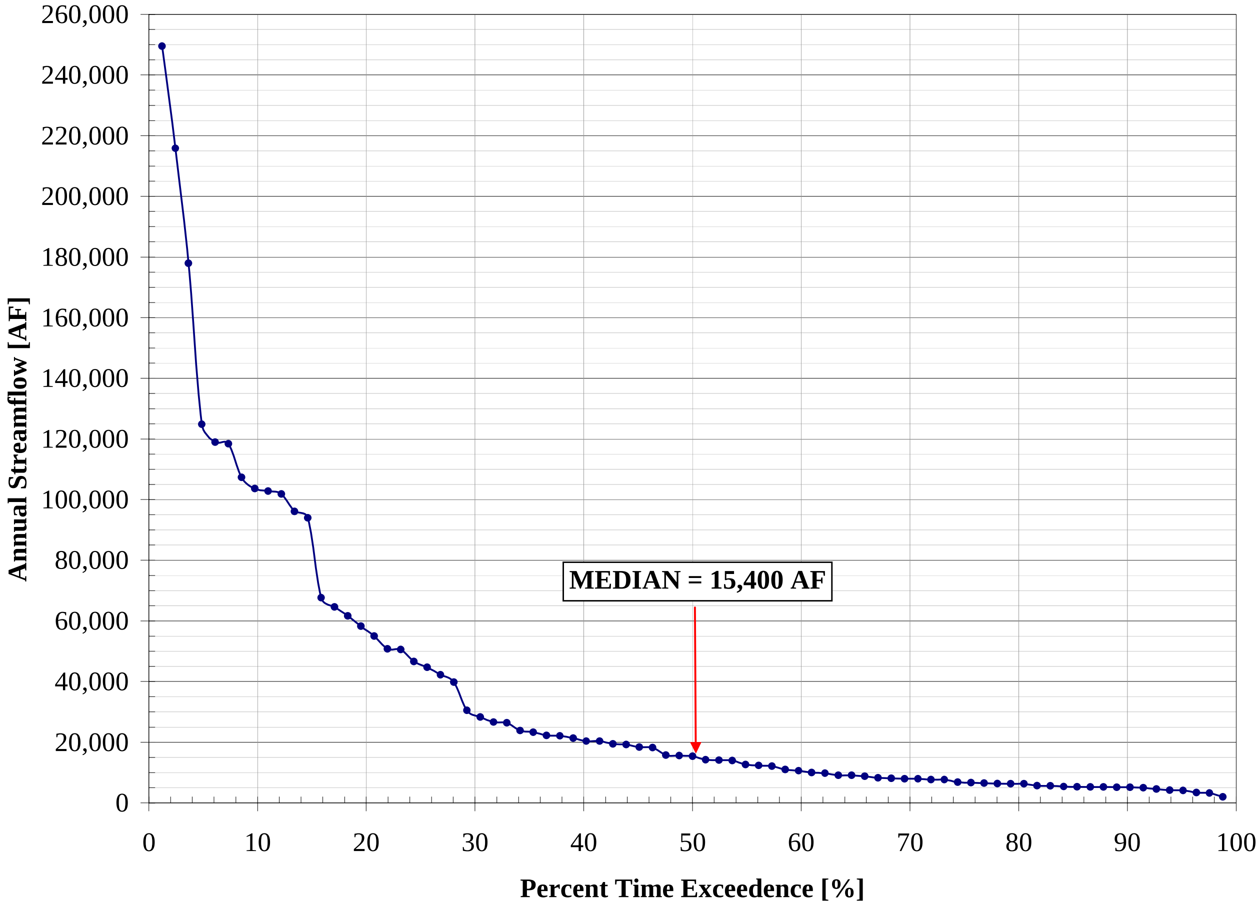

Figure 4. Frequency Distribution of Reconstructed Annual Streamflow at the Point of Diversion for Water Years 1925-2005.

The anticipated annual streamflow for a variety of exceedence intervals, passing the point of diversion on the Santa Margarita River, is shown in table 2. A minimum of 25,500AF have statistically passed the point of diversion once out of every 3 years during the 81-year period of record. Another application of the exceedence interval to project design is to suggest that annual streamflow has historically exceeded 15,400 AF 50% of the time.

The frequency distribution and exceedence intervals represent the historical annual streamflow in the Santa Margarita River at the point of diversion. However, these values do not necessarily represent the potential diversion to O'Neill ditch or the potential yield of the Santa Margarita River CUP. The ability to divert surface water from the Santa Margarita River is dependent upon the frequency of wintertime rainfall events and antecedent conditions, but also relies upon a complicated function of water rights, environmental requirements, and operation of the diversion structure. The quantity of water diverted in a given

Table 2. Exceedence Intervals and Annual Streamflow in the Santa Margarita River at the Point of Diversion for Water Years 1925-2005

Percent Time Exceedence (%)	Exceedence Interval	Annual Streamflow at Point of Diversion [AF]
4	1 in 25 years	159,800
5	1 in 20 years	124,100
7	1 in 15 years	118,700
10	1 in 10 years	103,400
11	1 in 9 years	102,700
13	1 in 8 years	100,300
14	1 in 7 years	94,500
17	1 in 6 years	65,600
20	1 in 5 years	56,900
25	1 in 4 years	45,700
33%	1 in 3 years	25,500
50	1 in 2 years	15,400
75	1 in 1.3 years	6,700
100	1 in 1 years	2,000

year is limited by the diversion capacity (assumed 200 cubic feet per second (cfs)), a bypass requirement (assumed 3 cfs), and the deflation of the diversion structure during the 10-year event or greater streamflow event to allow for sediment to pass from behind the diversion structure. The portion of water supply available for diversion is described in the following section entitled “Maximum Potential Diversion.”

Hydrologic Condition

The long-term reconstruction of annual streamflow at the point of diversion provides a significant dataset to define appropriate boundaries that can be used to categorize hydrologic conditions. The following section of TM 1.0 describes the development of hydrologic conditions that are used to categorize different levels of water availability that would be expected at the point of diversion. The different categories of hydrologic conditions presented in TM 1.0 were discussed with Reclamation’s technical team during the October 24 and 25 meeting.

Hydrologic conditions in the lower Santa Margarita River basin were established in order to statistically group each year's water availability into one of four different categories. Due to the influence of wintertime precipitation events on annual streamflow, October through April wintertime total streamflow volume was used to define the limits of four hydrologic conditions: Very Wet, Above Normal, Below Normal, and Extremely Dry. These four hydrologic conditions establish the boundaries that will be used to identify and statistically describe historical and future streamflow at the point of diversion. Furthermore, these four hydrologic conditions will be used to create limitations and boundary conditions that will be used to establish project yield from the groundwater model.

The four hydrologic conditions for the lower Santa Margarita River basin are based on the wintertime flows during the 81-year reconstructed streamflow in the Santa Margarita River at the point of diversion to O'Neill ditch. The frequency distribution of October through April total streamflow at the point of diversion was used to define the upper and lower boundary of each hydrologic condition. The wintertime streamflow frequency curve is divided into four parts, established by graphical slope breaks (Attachment B-1). These slope breaks allow each water year in the 81-year period of record to be categorized by a hydrologic condition based on the total volume of wintertime streamflow. The range of results extracted from the frequency distribution and graphical slope break analysis for each hydrologic condition are shown in Table 3. The median wintertime streamflow (13,700 AF) represents the break between Above Normal and Below Normal hydrologic conditions, while the average wintertime streamflow (33,100 AF) falls within the Above Normal hydrologic category. This is typical in the arid Southwest, where high volumes of wintertime streamflow during Very Wet hydrologic years significantly increase the range between the average and median streamflow values. The median wintertime streamflow (13,700 AF) is predictably less than the median annual streamflow (15,400 AF) due to the exclusion of nonwinter streamflow values.

Table 3. Delineation of Hydrologic Condition Based on Wintertime Streamflow for Water Years 1925-2005

Hydrologic Condition	Range of Wintertime Streamflow [AF]	Range of Wintertime Streamflow Percent Time Exceedence [%]
Very Wet	239,400 to 56,700	1 to 19
Above Normal	56,699 to 13,700	20 t0 50
Below Normal	13,699 to 5,800	51 to 75
Extremely Dry	5,799 to 1,600	76 to 100

Notes: Wintertime streamflow calculated as the total October through April Santa Margarita River streamflow at the point of diversion. The median wintertime streamflow (13,700 AF) represents the break between Above Normal and Below Normal hydrologic conditions.

Wintertime streamflow at the point of diversion during Very Wet hydrologic conditions ranged between 56,700 and 239,400 AF based on the 81-year historical period. Further review of the annual percent time exceedence for flows that fell within this range indicated these flows occurred between 1 and 19% of the time. Similarly, review of Below Normal hydrologic conditions indicated that streamflow during these periods ranged between 5,800 and 13,699 AF and occurred between 51 and 75% of the time. Interpretation of exceedence intervals of streamflow during the historical period of record further suggests that annual flows will be 5,800 AF or greater at least 75% of the time.

Another aspect of describing the variability of flows during each hydrologic condition can be expressed in median wintertime streamflow values (table 4 and Attachment B-2). The median wintertime streamflow at the point of diversion during Very Wet hydrologic conditions was 99,800 AF. While Very Wet hydrologic conditions occurred 19% of the time on the Santa Margarita River, the median wintertime flow associated with Very Wet conditions occurred only 10% of the time. Similarly, Above Normal hydrologic conditions took place between 20% and 50% of the time, but the median wintertime flow associated with Above Normal conditions (22,100 AF) occurred only 35% of the time.

Table 4. Median Wintertime Streamflow During Each Hydrologic Condition for Water Years 1925–2005

Hydrologic Condition	Median Wintertime Streamflow [AF]	Median Wintertime Streamflow Percent Time Exceedence [%]
Very Wet	99,800	10
Above Normal	22,100	35
Below Normal	8,200	62
Extremely Dry	4,600	87

Maximum Potential Diversion

The availability of surface water in the Santa Margarita River is highly variable. Large storms in the winter months typically provide a significant portion of the total annual flow in the river. The most efficient diversion of peak flow events would be the use of an in-stream dam and reservoir. Development of off-stream reservoirs are similarly infeasible since they demand large diversion and conveyance facilities that would require a design with flow rates exceeding at least 1,000 cfs. As previously stated, the quantity of water diverted under the proposed CUP is limited by the diversion capacity (200 cfs), the assumed year-around bypass requirement (3 cfs), and the deflation of the diversion structure during the 10-year or greater event to allow for sediment to pass from behind the diversion structure, all of which are incorporated into the TM 1.0 analysis. The quantity of water diverted is further limited by storage in Lake O'Neill and the existing and rehabilitated recharge ponds, the groundwater aquifer's recharge capacity, the pumping schedule, and the groundwater aquifer's storage capacity, which will be accounted for in the TM 2.0 analysis.

The maximum potential diversion is defined in TM 1.0 as the water diverted from the Santa Margarita River to O'Neill ditch for use by the CUP and is based on the assumed diversion constraints. Water diverted for use by the CUP includes surface water diverted to both Lake O'Neill and the groundwater recharge ponds. The actual determination of CUP yield will be presented in TM 2.0 based on an iterative process that optimizes surface water diversions and groundwater withdrawals using the lower Santa Margarita Groundwater model. As stated above, the maximum potential surface water available for diversion assumes the following constraints: 200-cfs maximum capacity diversion structure, a 3-cfs bypass, and the deflation of the diversion structure during the 10-year or greater event. This analysis does not take into account overflow spill from the recharge ponds, variable recharge rates, or the capacity of the groundwater basin influenced by groundwater pumping. The maximum monthly streamflow that can potentially be diverted in water years 1925 through 2005 based on the assumed diversion constraints is presented in Attachment C-1.

A frequency distribution was performed to rank and analyze the maximum potential diversion to Lake O'Neill and the recharge ponds for the 81-year period of record. The annual volume of maximum potential diversion for water years 1925 through 2005 is ranked in descending order in Attachment C-2. The frequency curve shown in figure 5 depicts a comparison between the percent time exceedence of the maximum potential diversion and the annual streamflow at the point of diversion. The gap between annual streamflow and maximum potential diversion is greatest during years characterized by a probability of exceedence of less than 30% (1 in every 3.3 years), typically Very Wet or Above Normal hydrologic conditions. The gap is due to the inability of the proposed facilities to capture large peak flow events. The gap between the two curves also includes the quantity of streamflow bypassed each year to satisfy the 3-cfs bypass requirement. The deviation between available water supply and maximum potential diversion illustrates the importance of designing conveyance systems based on that portion of total annual flow that can realistically captured.

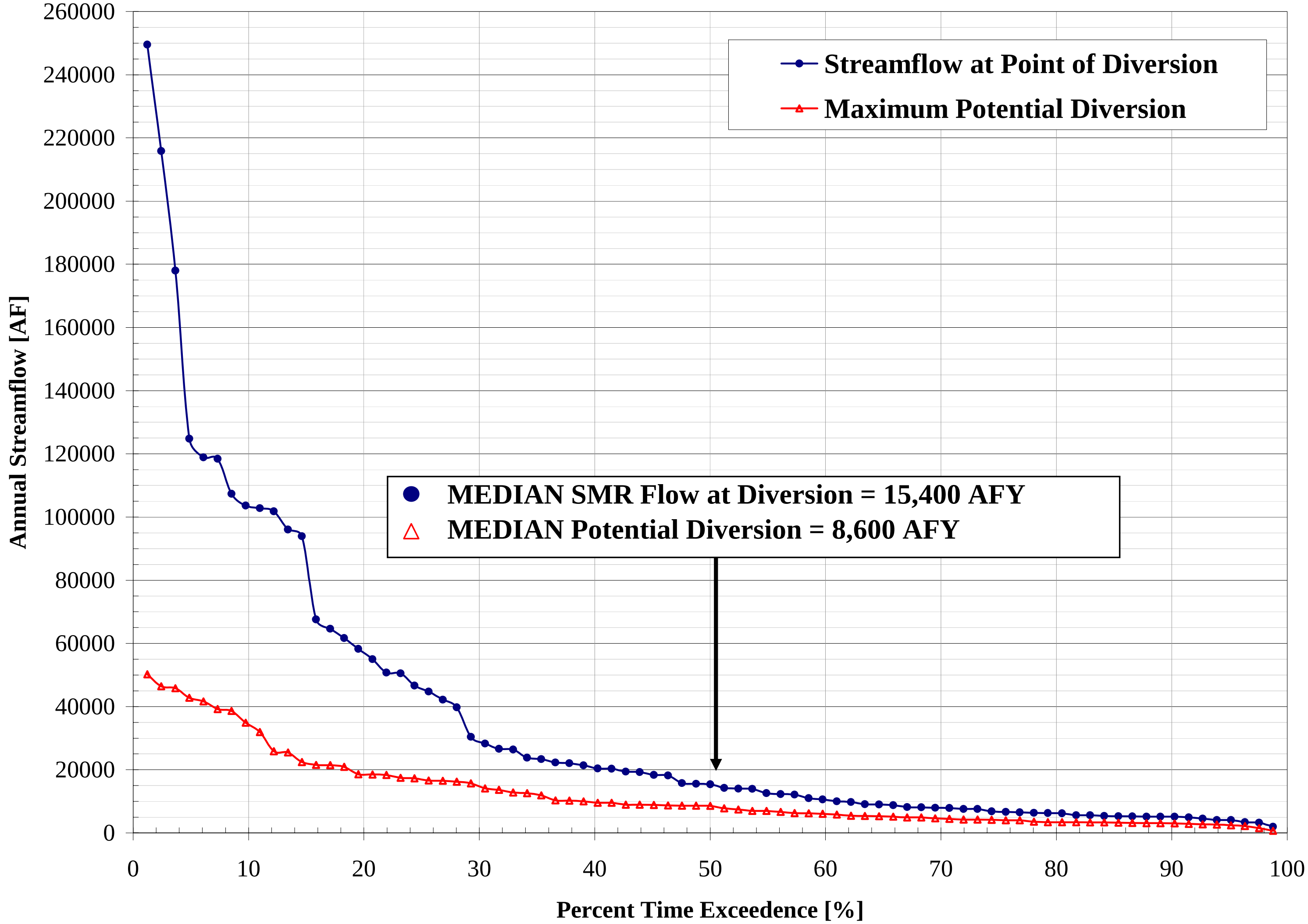

Figure 5. Frequency Distribution of Maximum Potential Diversion and Streamflow at the Point of Diversion for Water Years 1925-2005.

The annual streamflow at the point of diversion and the maximum potential diversion for common exceedence intervals are shown in table 5. The table is reflective of historical conditions and may not necessarily reflect the maximum potential diversion due to changes in future flow regimes due to urban development and upstream mitigation of the water supply stipulated in the 2002 Cooperative Water Resources Management Agreement (CWRMA). The table also fails to account for water that may recharge the groundwater aquifer by infiltrating the stream channel alluvium downstream from the point of diversion. The accounting of water spilling from either Lake O'Neill or the recharge ponds is incorporated in a Reservoir Operations Model (ROM) which is an input to the groundwater model to be analyzed in TM 2.0. The analysis of the groundwater model will provide a final value of maximum potential diversion once recharge to the aquifer, spill from the facilities, and changes due to the CWRMA have been fully accounted for in the development of CUP project yield.

Table 5. Exceedence Interval for Maximum Potential Diversion and Annual Streamflow in the Santa Margarita River at the Point of Diversion for Water Years 1925–2005

Percent Time Exceedence [%]	Exceedence Interval	Annual Streamflow at Point of Diversion [AF]	Potential Diversion [AF]
4%	1 in 25 years	159,800	44,800
5%	1 in 20 years	124,100	42,600
7%	1 in 15 years	118,700	40,400
10%	1 in 10 years	103,400	34,300
11%	1 in 9 years	102,700	31,200
13%	1 in 8 years	100,300	25,800
14%	1 in 7 years	94,500	23,300
17%	1 in 6 years	65,600	21,500
20%	1 in 5 years	56,900	18,600
25%	1 in 4 years	45,700	17,000
33%	1 in 3 years	25,500	12,700
50%	1 in 2 years	15,400	8,600
75%	1 in 1.3 years	6,700	4,100
100%	1 in 1 years	2,000	700

As previously discussed, each water year in the 81-year period of record can be categorized by hydrologic condition based on the total volume of wintertime streamflow. The variability of annual streamflow and maximum potential diversion for the water years grouped in each hydrologic condition is graphically represented in figure 6. The median annual streamflow and median potential diversion for the water years grouped in each hydrologic condition are represented by the vertical bars. The length of the vertical line, centered on each bar, represents the historical range in annual volume for the 81-year period. For example, water passing the point of diversion during Very Wet hydrologic conditions ranged between 61,600 and 249,500 AF with a median value of 103,600 AF, while the water available for diversion during these same years ranged between 12,800 and 50,200 AF with a median value of 35,000 AF. The reason for the disparity between the two ranges and median values is largely due to the volume of water contained in flows greater than 200 cfs which pass the point of diversion during short-duration peak flow events. These large flows cannot be captured by the diversion facilities due to capacity limitations and the deflation requirement. A daily accounting of streamflow rates is provided in the following section to describe the frequency and quantity of large flow events that are either difficult or impossible to capture without an in-stream storage facility.

Peak Surface Flows

In addition to investigating the annual flows at the point of diversion and the maximum potential diversion, Stetson Engineers investigated both daily and monthly surface water flows. Similar to the trends in variability that exists when reviewing annual volumes, the variability in daily and monthly streamflow in any given year is greatest during Very Wet hydrologic conditions and least during Extremely Dry conditions. Water Year 1991 is a typical example of the variability that exists in the Santa Margarita River's monthly and daily streamflow record during Very Wet hydrologic conditions. Daily streamflow at the point of diversion averaged 25 cfs from October 1990 through February 1991 but increased to average more than 400 cfs from March 1991 through April 1991. This demonstrates that low baseflows typically occur in the early winter period following the dry summer months. As spring arrives, the ground has become saturated, and increased precipitation events translate into surface runoff and higher baseflows. Thus, in Very Wet hydrologic conditions, a large portion of the annual flow volume tends to pass the point of diversion over a few days during peak flow events. This results in a significant amount of the annual flow volume that cannot be captured by CUP facilities designed to divert only 200 cfs. The following section presents the variability in daily streamflow during each type of hydrologic condition that affects the volume of water that can be utilized by the CUP.

TM 1.0 has described the difference between water passing the point of diversion (annual streamflow) and maximum potential diversion for use by the CUP.
The disparity between the values is based on the maximum 200-cfs diversion, the 3-cfs bypass, and the need to deflate the diversion structure to allow sediment to pass

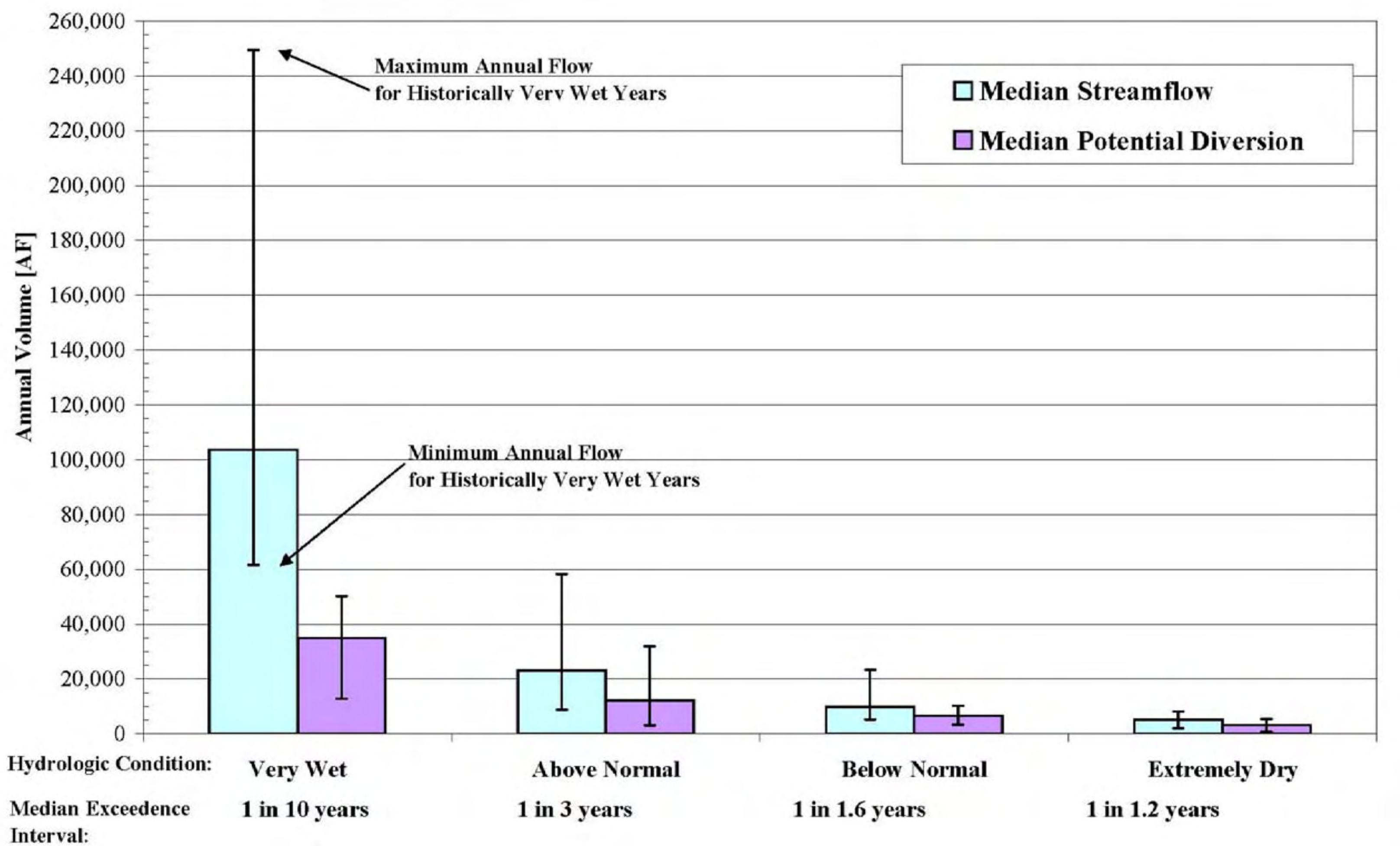

Figure 6. Variability of Annual Streamflow and Maximum Potential Diversion for Each Hydrologic Condition for Water Years 1925-2005.

during the 10-year or greater storm event. Figure 6 graphically depicts the variance during Very Wet hydrologic conditions, demonstrating the median streamflow passing the point of diversion (103,600 AF) is three times greater than the median potential water available for diversion (35,000 AF). The difference between water availability and maximum potential diversion can best be explained by investigating the percent time exceedence of flows greater than 200 cfs.

Table 6 shows that the average number days per year in each hydrologic condition when flow at the diversion is less than 200 cfs, between 200 and 240 cfs, greater than 240 cfs without deflating the diversion structure, and the number of days when the diversion structure will deflate during each type of hydrologic condition. The 240-cfs interval is based on the potential ability to divert an additional 40 cfs to an off-stream reservoir, as investigated in Alternative 4 of the Permit 15000 (Stetson, 2001) or to direct use at the Haybarn Canyon Water Treatment Plant. On days when the diversion structure deflates, it is assumed that no water can be diverted.

Table 6. Average Number of Days Each Year Daily Streamflow Exceeds Diversion Capacity (Days Per Year)

	Average Number of Days Per Year			
Hydrologic Condition	**Flow Less than 200 cfs**	**Flow Between 200 and 240 cfs[1]**	**Flow Greater than 240 cfs Without Deflating Diversion Structure**	**Diversion Structure Deflates[2]**
Very Wet	327	4	31	3
Above Normal	355	2	9	0
Below Normal	362	1	3	0
Extremely Dry	363	1	2	0

[1] Interval based on potential 40-cfs diversion to an off-stream storage reservoir (Alternative 4, Permit 15000) or direct use at the Haybarn Canyon Water Treatment Plant.

[2] Deflation of the diversion structure occurs during the 10-year of greater event (Permit 15000).

Of the 30 days in which the flow was greater than 240 cfs during Very Wet hydrologic conditions, approximately 80% of the annual streamflow passed the point of diversion. For example, in 1991, there were 11 days when the flow was greater than 240 cfs. On these 11 days, 45,600 AF passed the point of diversion, which constituted nearly 75% of the annual flow for water year 1991. Similar to Very Wet hydrologic conditions, the peak flows during Above Normal years also dominated the annual flow volume passing the point of diversion. Of the 9 days in which the flow was greater than 240 cfs, approximately 60% of the annual streamflow passed the point of diversion. During years categorized as Below

Normal and Extremely Dry, there are only a few days when the flow was greater than 240 cfs, but even one storm event may account for a significant percentage of that year's total flow.

The computation of the average number of days per year that daily streamflow exceeds diversion capacity has been presented to show the number of days that elevated flows in the Santa Margarita River occur. Elevated streamflow beyond 200 cfs may be due to a peak storm event that occurred either that day or as the result of a previous day's peak flow event. In either case, a statistical analysis of peak storm events is not warranted at this time because the effect of groundwater recharge through the streambed alluvium has not been taken into account. The need to recharge the aquifer and utilize the storage capacitance of the aquifer should be considered before statistical analysis regarding availability of peak daily streamflow is performed.

Hydrologic Trends and Future Period of Record

Due to the hydrologic variability of the Santa Margarita River Basin, the surface water and groundwater analysis (TM 2.0) for the CUP will require the development of a future period of record that is representative of the historical variability of hydrologic conditions. The statistics presented in this technical memorandum are based on the historical 81-year period of record. For the next phase of the water availability analysis, it is recommended that the groundwater model simulate historic trends over a 50-year period of record. The 50-year period of record will be developed to represent hydrology that captures antecedent conditions over extended dry and wet periods.

Long-term precipitation and streamflow datasets can be used to demonstrate hydrologic trends over the historical 81-year period of record for the lower Santa Margarita River Basin. Figure 7 shows a cumulative departure from the mean curve of annual streamflow at the point of diversion and annual precipitation at Lake O'Neill for water years 1925 to 2005. Monthly precipitation records from Lake O'Neill (Marine Corps Base Camp Pendleton [MCBCP] Office of Water Resources [OWR], 2005) were used to evaluate annual precipitation trends at the point of diversion. The annual departure from the mean graph is used to depict wet and dry cycles over an extended period of record. The solid line describes the hydrologic trend, where a downward slope indicates that the trend is to dry conditions and an upward slope indicates that the trend is to wetter conditions. The dashed line shows the long-term average annual precipitation at Lake O'Neill (14.2 inches) and the long-term average annual streamflow at the point of diversion (35,600 AF) during the 81-year period of record.

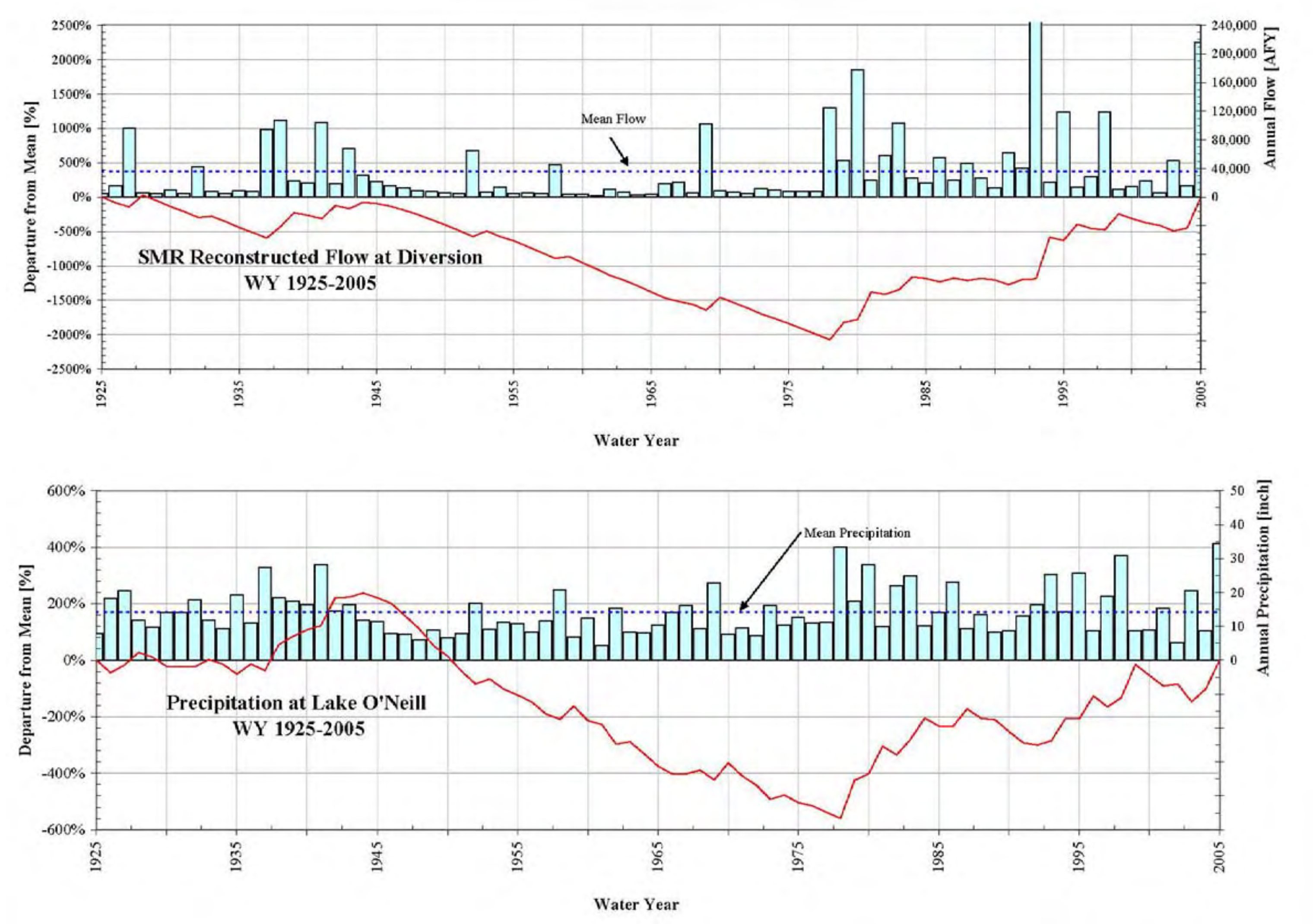

Figure 7. Cumulative Departure from the Mean Curves for Water Years 1925-2005.

The cumulative departure from the mean curve reveals that an extended dry period occurred from 1945 to 1978, followed by a prolonged wet period from 1979 to 1984. A moderately dry period occurred from 1985 to 1991, followed by a significantly wet period from 1993 to 1999. This pattern is similarly represented in both the precipitation and streamflow cumulative departure from the mean curves.

Stetson Engineers recommends that groundwater model years 1-50 should be chosen based on both extended dry and wet periods. One possible scenario for the future 50-year record would start with an Above Normal year, followed by an extended drought period, followed by another wet period, and eventually ending with normal hydrologic conditions. Stetson Engineers and Reclamation staff will work together to determine the best 50 years to provide an appropriate hydrologic record that can be used to optimize the design of the CUP's water supply facilities. This will require multiple iterations in the surface water and groundwater modeling process before a final composite record is established.

Conclusions and Recommendations

Results of TM 1.0's analyses confirm the wide variability of surface flows indicative of streams and rivers in the Southwestern United States. Large quantities of water are contained in peak flow events that commonly occur in the winter during Above Normal and Very Wet hydrologic conditions. Surface water availability during drier Below Normal and Extremely Dry hydrologic conditions occur from less frequent rainfall events and sustained baseflow releases from springs and groundwater sources. Review of the 81-year period of record, available for the lower Santa Margarita River watershed shows that total annual surface flow passing the point of diversion for the CUP has ranged between 2,000 and 249,500 AF between 1925 and 2005. During the same period, the maximum potential surface diversion available to the proposed CUP would have ranged between 700 and 50,200 AF. The maximum potential surface diversion for this analysis assumes a 200-cfs diversion structure, a 3-cfs bypass, and the deflation of the diversion structure during the 10-year or greater event. This maximum potential surface diversion does not take into account overflow spill from the recharge ponds, variable recharge rates, or the capacity of the groundwater basin influenced by groundwater pumping, which will be addressed in TM 2.0.

Four hydrologic conditions were established to statistically describe both the annual surface water at the point of diversion and the maximum potential diversion. The basis for the division of the four hydrologic conditions was a graphical interpretation method common to flood frequency analysis and other types of surface water flow characterizations. Reflective of the variability in streamflow volumes, the division of hydrologic conditions indicates that extreme wet cycles and extreme dry cycles occur less frequently than Above Normal and Below Normal Conditions. Table 7 summarizes the quantity of annual streamflow at the point of diversion and the maximum potential diversion to the CUP for the 81 years categorized by the four hydrologic conditions, based on historical streamflow only. Based on the statistical analysis provided in the previous section, the median potential diversion for Very Wet, Above Normal, Below Normal, and Extremely Dry conditions is expected to occur approximately 10%, 30%, 60%, and 85% of the time, respectively.

Table 7. Summary of Median Annual Available Streamflow and Maximum Potential Diversion for Water Years 1925-2005

Hydrologic Condition	Median Available Streamflow [AF]	Median Potential Diversion [AF]
Very Wet	103,600	34,900
Above Normal	23,000	12,200
Below Normal	9,900	6,600
Extremely Dry	5,200	3,200

The values presented in table 7, and the discussion of probability of exceedence presented in this technical memorandum, present two important concepts critical to the optimization of a long-term supply of water from the CUP. First, large quantities of water pass the point of diversion in very short periods of time during all hydrologic conditions. Lastly, the wide range in median annual available streamflow and maximum potential diversion underscore the importance of the groundwater aquifer capacitance to store large surface flow events for use during Extremely Dry and Below Normal hydrologic conditions.

One constraint imposed to TM 1.0's analysis of the annual available streamflow and maximum potential diversion includes its limitations to historical conditions only. Increased groundwater pumping in the upper basin has reduced baseflow levels in the Santa Margarita River, which have subsequently reduced the water available at the point of diversion. The effect of upstream groundwater development is most pronounced during Below Normal and Extremely Dry hydrologic conditions. Conversely, increased urban runoff may mitigate some baseflow reductions but has not been quantified for the purpose of this analysis. There are many factors that have contributed to the historic value of flow in the Santa Margarita River reaching the point of diversion, which have not been enumerated in this technical memorandum. Factors which will likely contribute to future changes in the flow regime at the CUP's point of diversion will be further investigated and accounted for in the evaluation of the 50-year hydrologic cycle applied to the analyses in TM 2.0.

To accurately specify the surface water available for diversion to the CUP, the following recommendations should be followed:

1. Commence TM 2.0 CUP water yield optimization.
2. Initiate Peer-Review of the existing groundwater model by Reclamation.
3. Adopt the four hydrologic conditions presented in TM 1.0.
4. Adopt the exceedence interval of each hydrologic condition presented in TM 1.0.
5. Update hydrology with flows from CWRMA. Address other aspects of urban development in the upper basin with respect to future changes in the flow regime at the point of diversion.
6. Establish a 50-year future hydrologic cycle that reflects prolonged droughts, wet periods, and normal hydrologic conditions that have been identified in TM 1.0.
7. Using the groundwater model, identify water available to the CUP, both upstream of and downstream from the point of diversion.
8. Using the groundwater model, refine the ROM to maximize the water diverted to O’Neill ditch, Lake O’Neill, and the recharge ponds.
9. Update water available for diversion following the surface water/groundwater optimization process.

The recommendations have been provided to establish a methodology for ultimately determining the yield of the CUP. Extensive hydrologic and hydrogeologic field investigations were initiated and completed in 2005 in order to refine previous estimates of groundwater yield from the CUP. Following development of the future 50-year hydrologic cycle, which includes changes and constraints identified by Reclamation and the Study Team, the surface and groundwater withdrawals will be optimized using the groundwater model. TM 2.0 will provide the project yield, the maximum potential diversion, and exceedence interval for each hydrologic condition.

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ATTACHMENT A-1

Reconstructed Monthly Streamflow in the Santa Margarita River at the Point of Diversion [AF]
Water Years 1925 to 2005

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1925	226	480	1,282	786	461	554	747	193	180	114	63	101	**5,187**
1926	316	462	635	537	1,169	538	10,653	561	296	102	48	58	**15,374**
1927	208	421	1,072	718	85,231	4,670	1,840	918	508	179	86	207	**96,059**
1928	528	757	980	1,013	946	1,010	393	234	165	66	58	101	**6,250**
1929	375	528	757	902	742	725	522	172	123	27	72	234	**5,178**
1930	177	161	291	3,196	882	1,874	510	1,893	339	249	211	219	**10,002**
1931	336	498	500	630	1,549	435	409	333	195	83	101	165	**5,234**
1932	308	498	1,901	1,147	32,271	3,326	939	592	408	274	231	283	**42,179**
1933	510	512	845	2,157	945	695	608	495	266	176	172	244	**7,624**
1934	308	397	675	1,347	790	602	346	209	250	165	127	146	**5,363**
1935	323	415	1,181	1,289	1,895	1,969	813	445	242	155	154	176	**9,056**
1936	269	390	458	521	3,981	873	789	271	141	68	75	108	**7,944**
1937	544	414	4,818	5,165	39,381	31,348	7,710	2,159	1,077	567	398	347	**93,929**
1938	485	662	1,058	1,136	3,752	89,463	5,110	2,362	1,069	904	717	644	**107,361**
1939	863	891	3,154	2,883	6,209	2,786	1,756	923	548	466	384	1,408	**22,273**
1940	723	801	906	5,256	6,069	1,501	1,925	774	482	267	296	433	**19,434**
1941	642	749	7,634	1,725	12,051	45,646	25,364	5,406	1,857	924	872	746	**103,615**
1942	1,428	1,470	2,204	2,832	2,406	3,051	2,088	963	669	455	379	435	**18,381**
1943	540	638	892	28,288	10,465	19,548	3,882	1,279	802	497	377	397	**67,605**
1944	674	707	5,701	1,704	12,291	4,786	1,576	1,000	740	487	392	402	**30,460**
1945	507	5,729	1,129	1,158	2,151	6,233	1,526	747	508	316	889	476	**21,369**
1946	496	661	5,614	889	1,424	2,821	1,644	609	375	610	218	230	**15,591**
1947	502	3,659	2,632	1,182	877	1,223	646	484	461	337	276	351	**12,632**
1948	458	540	1,678	831	2,128	1,045	852	512	388	260	219	191	**9,103**
1949	461	405	1,337	1,901	1,109	893	630	485	310	255	225	218	**8,230**
1950	261	610	541	1,594	1,523	604	423	315	171	105	73	120	**6,340**
1951	170	532	365	856	469	603	530	222	67	20	638	69	**4,542**
1952	551	188	4,572	26,974	1,109	25,979	4,132	749	209	42	15	87	**64,609**
1953	140	1,081	1,583	2,223	498	506	216	95	27	19	56	58	**6,502**
1954	100	202	176	3,398	4,549	3,786	1,509	228	44	25	24	21	**14,061**
1955	104	1,061	426	1,701	702	529	141	427	38	18	18	12	**5,177**
1956	12	114	199	3,204	376	170	1,469	47	4	0	0	0	**5,594**
1957	0	2	7	2,862	447	1,243	78	323	7	0	0	0	**4,968**
1958	411	70	393	527	4,436	12,322	25,664	808	77	7	10	0	**44,727**
1959	13	100	170	397	2,088	318	260	90	1	0	0	0	**3,437**
1960	3	16	405	1,427	1,063	432	612	62	3	0	0	37	**4,061**
1961	21	169	139	541	193	411	127	103	85	38	58	77	**1,962**
1962	101	194	928	1,569	5,128	1,873	513	234	88	0	0	0	**10,628**
1963	63	113	171	194	3,206	1,118	266	174	99	30	33	1,372	**6,837**
1964	53	1,232	130	816	226	353	271	116	73	14	0	0	**3,285**
1965	0	268	310	201	414	523	1,949	183	105	64	33	74	**4,126**
1966	68	8,055	5,367	2,247	1,373	644	241	149	26	28	31	5	**18,234**
1967	107	1,328	8,134	4,596	1,538	1,524	1,923	662	361	113	40	54	**20,381**
1968	75	823	1,465	337	590	1,832	241	99	50	11	28	86	**5,637**
1969	122	341	475	15,358	67,202	14,255	2,001	1,176	642	174	39	43	**101,827**

ATTACHMENT A-1

Reconstructed Monthly Streamflow in the Santa Margarita River at the Point of Diversion [AF]
Water Years 1925 to 2005

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1970	84	478	316	618	1,434	5,283	315	187	69	2	0	0	**8,784**
1971	77	1,161	2,800	493	865	408	431	261	116	26	0	7	**6,645**
1972	191	160	3,029	645	547	427	166	85	54	4	0	0	**5,306**
1973	259	1,380	553	1,485	4,045	3,238	670	313	101	32	19	43	**12,138**
1974	73	679	209	5,783	402	2,027	355	168	75	10	1	12	**9,792**
1975	272	129	1,326	296	1,122	2,071	1,901	316	138	32	1	0	**7,605**
1976	34	173	205	220	3,128	1,623	457	169	56	7	1	1,835	**7,907**
1977	212	136	249	3,439	409	1,039	260	647	72	11	1,614	24	**8,111**
1978	53	95	818	33,863	31,235	44,255	7,514	3,026	1,259	708	580	1,398	**124,804**
1979	666	889	3,447	13,521	10,046	12,671	4,570	1,855	836	791	599	633	**50,524**
1980	1,257	978	828	19,313	101,834	32,035	10,775	5,828	1,439	1,123	1,284	1,256	**177,950**
1981	541	418	2,381	3,419	4,586	9,731	615	502	436	428	371	396	**23,824**
1982	320	7,898	491	12,233	1,706	30,072	3,444	765	447	356	258	259	**58,248**
1983	313	2,347	7,201	9,865	10,569	47,244	18,874	1,502	670	516	482	3,244	**102,829**
1984	7,106	3,695	10,814	500	417	428	2,193	324	411	192	271	244	**26,597**
1985	486	1,709	13,136	490	838	650	310	318	310	338	359	309	**19,252**
1986	262	18,164	4,143	2,585	13,387	9,462	2,741	227	223	313	281	3,237	**55,025**
1987	351	5,391	3,315	6,900	3,130	541	2,864	193	154	137	182	173	**23,332**
1988	8,093	1,539	12,573	3,462	6,390	174	13,435	159	219	177	211	197	**46,628**
1989	175	5,207	15,901	313	235	2,488	108	960	225	223	241	313	**26,390**
1990	639	433	479	2,188	3,044	1,009	1,577	1,431	948	238	163	158	**12,306**
1991	486	556	596	965	4,742	45,571	3,825	1,812	1,334	575	643	542	**61,648**
1992	618	347	2,087	3,813	14,398	9,696	2,954	2,425	1,124	849	804	656	**39,771**
1993	518	428	3,349	141,238	72,272	14,956	6,592	4,769	2,839	1,130	771	645	**249,507**
1994	1,138	736	811	998	8,476	3,708	1,672	1,145	700	329	302	339	**20,352**
1995	367	420	483	40,173	16,646	45,945	8,212	2,841	1,735	957	624	509	**118,912**
1996	623	923	1,170	1,331	4,545	2,681	939	714	379	206	214	220	**13,946**
1997	705	3,459	3,255	12,939	2,970	1,254	1,683	573	254	320	230	676	**28,318**
1998	359	916	3,187	4,378	73,584	13,537	9,600	8,151	2,235	1,259	634	575	**118,415**
1999	658	1,255	1,089	1,614	1,166	1,049	1,954	658	516	431	285	317	**10,992**
2000	308	229	280	383	5,628	3,957	1,399	750	402	299	323	294	**14,252**
2001	1,342	643	674	3,540	7,786	3,523	1,893	1,104	602	338	361	302	**22,108**
2002	372	1,184	832	716	602	548	496	477	277	305	292	203	**6,304**
2003	385	969	3,002	1,280	18,665	13,183	6,253	2,772	1,754	1,038	707	738	**50,746**
2004	695	951	1,434	1,333	6,368	1,880	1,069	605	446	323	337	331	**15,772**
2005	13,083	2,757	14,191	90,077	67,191	14,521	5,818	2,910	1,599	1,417	1,205	1,060	**215,828**
Average	712	1,335	2,419	6,995	10,280	8,389	3,010	1,003	482	298	281	390	**35,596**
Median	336	610	1,058	1,569	2,151	1,874	1,469	512	296	192	214	219	**15,374**
Maximum	13,083	18,164	15,901	141,238	101,834	89,463	25,664	8,151	2,839	1,417	1,614	3,244	**249,507**
Minimum	0	2	7	194	193	170	78	47	1	0	0	0	**1,962**

ATTACHMENT A-2

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Exceedence Interval and Reconstructed Annual Streamflow In the Santa Margarita River at the Point of Diversion for Water Years 1925 to 2005

Water Year	Reconstructed Streamflow at Point of Diversion [AF]	Percent Time Exceedence [%]	Exceedence Interval [years]
1993	249,507	1%	82.0
2005	215,828	2%	41.0
1980	177,950	4%	27.3
1978	124,804	5%	20.5
1995	118,912	6%	16.4
1998	118,415	7%	13.7
1938	107,361	9%	11.7
1941	103,615	10%	10.3
1983	102,829	11%	9.1
1969	101,827	12%	8.2
1927	96,059	13%	7.5
1937	93,929	15%	6.8
1943	67,605	16%	6.3
1952	64,609	17%	5.9
1991	61,648	18%	5.5
1982	58,248	20%	5.1
1986	55,025	21%	4.8
2003	50,746	22%	4.6
1979	50,524	23%	4.3
1988	46,628	24%	4.1
1958	44,727	26%	3.9
1932	42,179	27%	3.7
1992	39,771	28%	3.6
1944	30,460	29%	3.4
1997	28,318	30%	3.3
1984	26,597	32%	3.2
1989	26,390	33%	3.0
1981	23,824	34%	2.9
1987	23,332	35%	2.8
1939	22,273	37%	2.7
2001	22,108	38%	2.6
1945	21,369	39%	2.6
1967	20,381	40%	2.5
1994	20,352	41%	2.4
1940	19,434	43%	2.3
1985	19,252	44%	2.3
1942	18,381	45%	2.2
1966	18,234	46%	2.2
2004	15,772	48%	2.1
1946	15,591	49%	2.1
1926	15,374	50%	2.0
2000	14,252	51%	2.0
1954	14,061	52%	1.9
1996	13,946	54%	1.9
1947	12,632	55%	1.8
1990	12,306	56%	1.8

ATTACHMENT A-2

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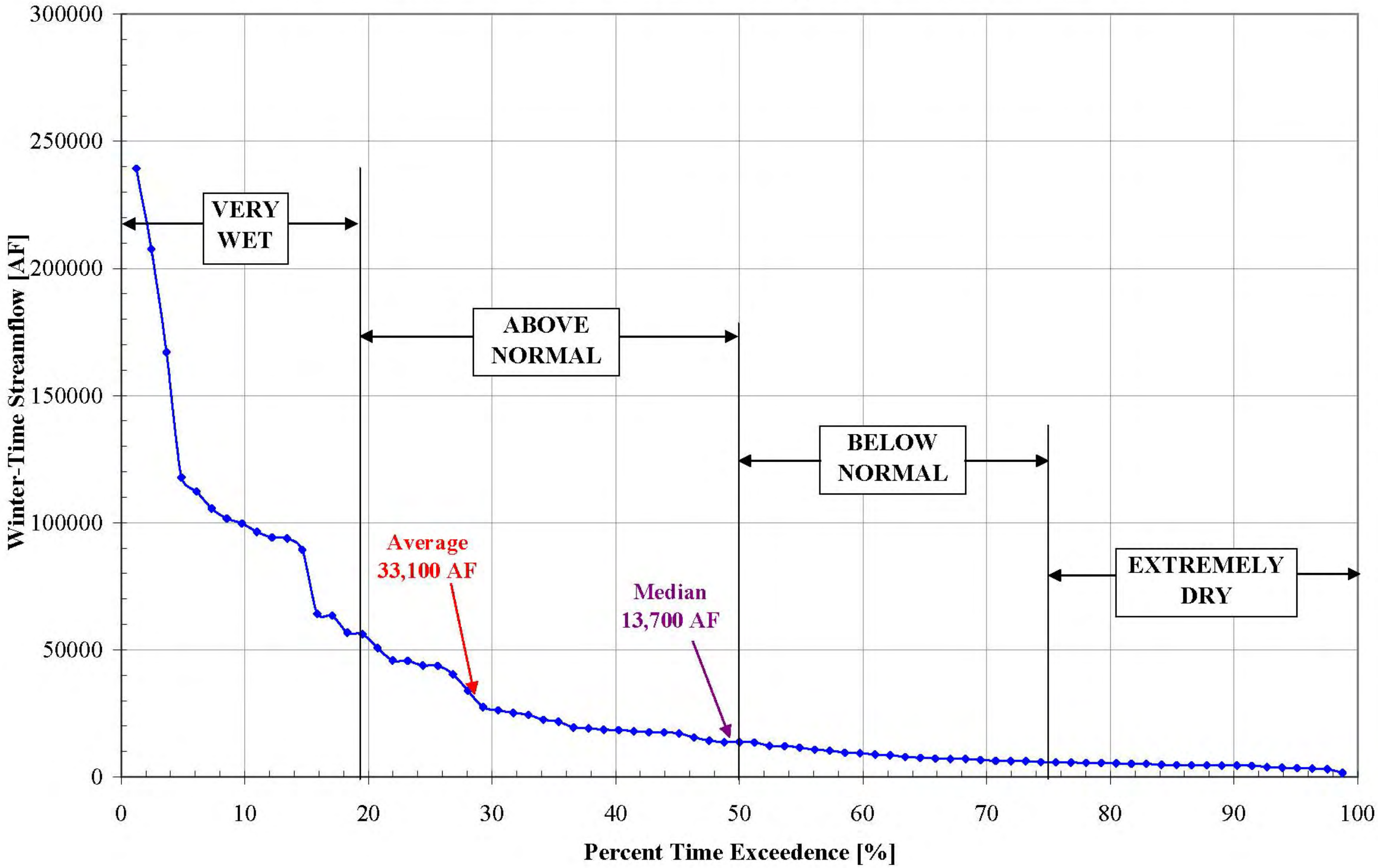
Exceedence Interval and Reconstructed Annual Streamflow In the Santa Margarita River at the Point of Diversion for Water Years 1925 to 2005

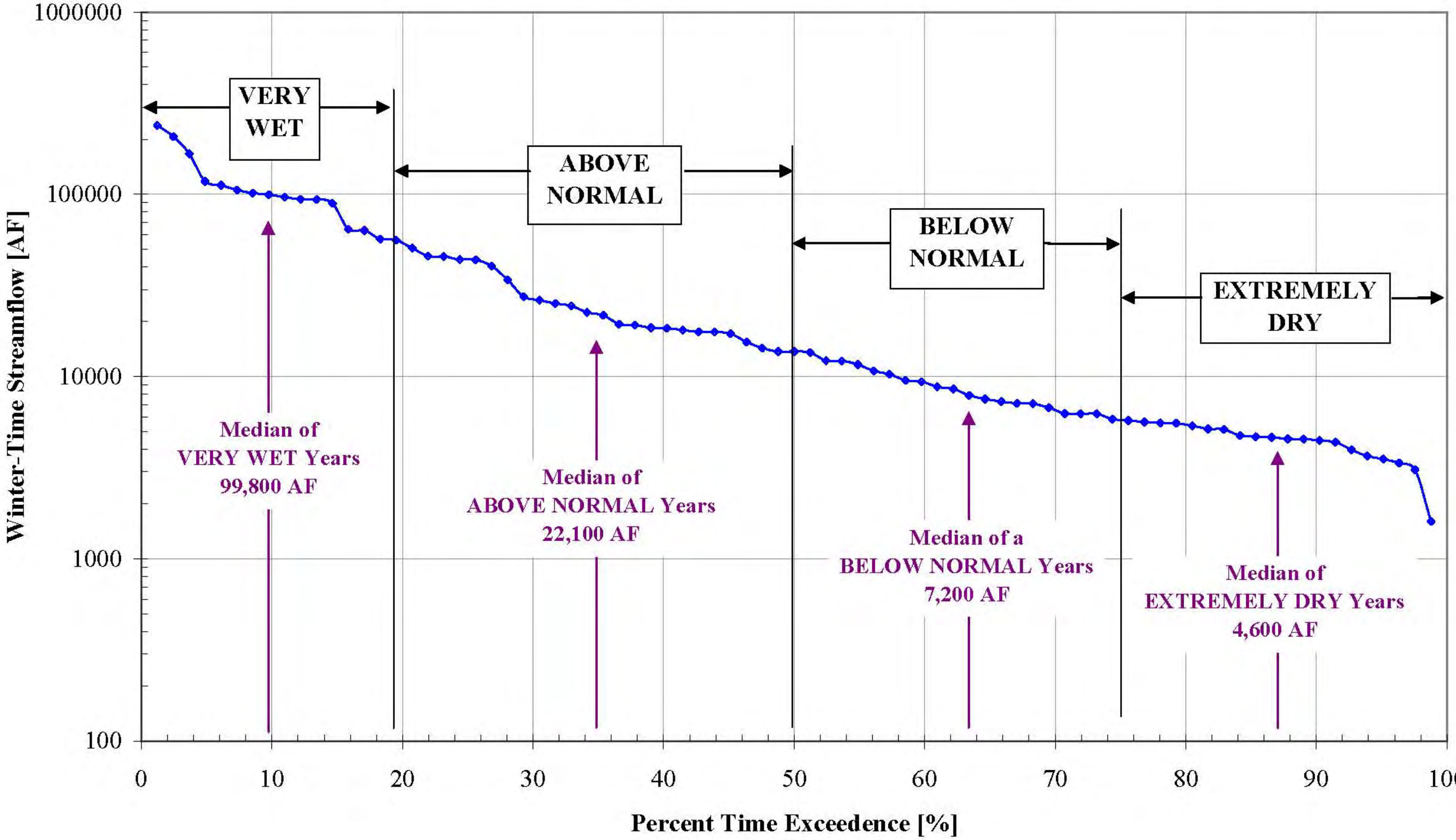
Water Year	Reconstructed Streamflow at Point of Diversion [AF]	Percent Time Exceedence [%]	Exceedence Interval [years]
1973	12,138	57%	1.7
1999	10,992	59%	1.7
1962	10,628	60%	1.7
1930	10,002	61%	1.6
1974	9,792	62%	1.6
1948	9,103	63%	1.6
1935	9,056	65%	1.5
1970	8,784	66%	1.5
1949	8,230	67%	1.5
1977	8,111	68%	1.5
1936	7,944	70%	1.4
1976	7,907	71%	1.4
1933	7,624	72%	1.4
1975	7,605	73%	1.4
1963	6,837	74%	1.3
1971	6,645	76%	1.3
1953	6,502	77%	1.3
1950	6,340	78%	1.3
2002	6,304	79%	1.3
1928	6,250	80%	1.2
1968	5,637	82%	1.2
1956	5,594	83%	1.2
1934	5,363	84%	1.2
1972	5,306	85%	1.2
1931	5,234	87%	1.2
1925	5,187	88%	1.1
1929	5,178	89%	1.1
1955	5,177	90%	1.1
1957	4,968	91%	1.1
1951	4,542	93%	1.1
1965	4,126	94%	1.1
1960	4,061	95%	1.1
1959	3,437	96%	1.0
1964	3,285	98%	1.0
1961	1,962	99%	1.0

Frequency Distribution of Discharge at the Point of Diversion Santa Margarita River based on Winter-Time Streamflow during Water Years 1925 to 2005



ATTACHMENT B-1

Frequency Distribution of Discharge at the Point of Diversion Santa Margarita River based on Winter-Time Streamflow during Water Years 1925 to 2005



ATTACHMENT B-2

ATTACHMENT C-1

Monthly Maximum Potential Diversion from the Santa Margarita River [AF]
Water Years 1925 to 2005

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1925	43	302	1,098	601	295	370	569	33	25	0	0	0	**3,334**
1926	143	283	450	353	1,002	354	3,555	377	119	4	0	2	**6,641**
1927	32	243	887	534	3,847	4,485	1,662	734	330	28	0	54	**12,835**
1928	345	579	795	828	774	825	219	66	33	0	0	2	**4,465**
1929	194	349	572	717	575	541	343	15	7	0	42	94	**3,451**
1930	16	12	106	2,133	715	1,689	331	1,709	160	65	34	43	**7,013**
1931	152	319	315	445	1,362	251	230	148	33	0	0	3	**3,259**
1932	123	320	1,681	963	8,674	3,141	760	408	230	89	46	105	**16,540**
1933	325	333	660	1,972	778	510	430	311	87	6	4	65	**5,481**
1934	123	219	491	1,162	624	417	168	27	71	7	0	1	**3,311**
1935	140	236	997	1,104	1,687	1,785	634	261	64	6	35	10	**6,958**
1936	84	212	274	337	2,666	689	611	86	9	0	0	0	**4,967**
1937	374	236	1,669	4,138	8,400	9,688	6,775	1,975	898	383	214	168	**34,918**
1938	301	483	873	951	2,619	10,549	4,932	2,177	891	720	532	465	**25,493**
1939	678	713	2,634	2,698	5,020	2,602	1,577	739	370	282	199	1,030	**18,543**
1940	539	623	722	2,401	3,879	1,317	1,747	589	303	83	111	255	**12,568**
1941	458	571	2,047	1,541	6,016	12,181	11,264	5,012	1,678	740	687	567	**42,762**
1942	1,244	1,292	2,020	2,648	2,239	2,867	1,910	779	490	271	194	256	**16,209**
1943	355	459	708	4,021	5,501	8,686	3,704	1,094	623	312	193	219	**25,875**
1944	490	528	3,329	1,520	4,695	4,503	1,398	815	561	303	207	223	**18,572**
1945	322	2,718	944	974	1,984	5,428	1,348	563	330	132	680	298	**15,719**
1946	311	483	1,784	705	1,097	1,958	1,466	425	197	426	36	53	**8,939**
1947	317	2,632	1,745	998	711	1,006	468	300	283	153	92	172	**8,878**
1948	273	362	1,493	647	1,285	861	674	328	210	76	35	24	**6,266**
1949	277	227	1,153	1,712	943	708	452	301	131	70	42	43	**6,058**
1950	77	432	356	1,013	851	419	244	131	17	0	0	0	**3,540**
1951	16	354	180	672	302	419	358	54	0	0	403	0	**2,759**
1952	407	70	1,247	3,784	936	7,374	2,898	565	51	0	0	1	**17,333**
1953	11	903	1,368	1,937	332	322	48	16	0	0	0	0	**4,936**
1954	22	59	40	1,929	2,023	3,139	1,330	74	0	0	0	0	**8,616**
1955	6	524	243	1,419	535	358	40	294	6	0	0	0	**3,425**
1956	0	35	20	1,143	204	33	768	0	0	0	0	0	**2,203**
1957	0	0	0	1,817	281	729	31	276	0	0	0	0	**3,134**
1958	393	1	257	451	2,359	6,671	7,640	624	1	0	0	0	**18,397**
1959	0	17	29	216	1,820	143	194	21	0	0	0	0	**2,439**
1960	0	0	336	1,197	891	262	441	5	0	0	0	31	**3,163**
1961	0	25	11	387	37	227	3	0	0	0	0	0	**689**
1962	1	45	546	925	3,811	1,689	335	61	1	0	0	0	**7,413**
1963	0	0	6	10	915	603	88	9	0	0	0	1,289	**2,919**
1964	0	619	3	599	54	170	94	12	0	0	0	0	**1,552**
1965	0	177	178	23	282	364	1,639	14	0	0	0	0	**2,677**
1966	0	2,554	3,223	2,063	1,207	460	62	8	0	0	0	0	**9,576**
1967	10	412	3,816	2,814	1,372	1,286	1,519	477	182	0	0	0	**11,889**
1968	0	703	1,091	153	418	588	71	0	0	0	0	0	**3,024**
1969	0	201	293	2,950	6,466	8,343	1,823	992	464	24	0	0	**21,556**

ATTACHMENT C-1

Monthly Maximum Potential Diversion from the Santa Margarita River [AF]
Water Years 1925 to 2005

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1970	0	318	131	434	857	2,114	136	20	0	0	0	0	**4,010**
1971	0	697	1,962	309	698	223	269	80	2	0	0	0	**4,240**
1972	125	2	2,229	460	375	243	5	0	0	0	0	0	**3,439**
1973	180	1,219	368	1,235	2,092	3,022	492	132	9	0	0	0	**8,749**
1974	0	529	24	2,204	235	1,064	176	12	0	0	0	0	**4,245**
1975	191	1	997	112	862	1,801	1,220	133	3	0	0	0	**5,320**
1976	0	77	31	37	2,124	1,439	278	19	0	0	0	1,357	**5,363**
1977	109	13	83	1,789	242	648	92	519	2	0	548	0	**4,045**
1978	0	1	664	7,836	8,608	8,699	6,896	2,842	1,081	523	395	1,107	**38,651**
1979	481	710	3,145	5,559	7,246	6,794	4,190	1,671	658	607	414	454	**31,931**
1980	1,073	800	644	4,523	6,190	12,298	10,371	5,563	1,260	938	1,099	1,077	**45,834**
1981	356	240	912	1,188	1,232	2,201	436	318	258	243	186	218	**7,789**
1982	136	1,141	306	2,577	908	2,524	1,280	581	268	171	74	80	**10,046**
1983	129	1,217	1,304	1,451	3,219	7,158	3,977	1,317	491	332	298	571	**21,464**
1984	702	1,526	922	316	245	244	685	139	232	8	87	66	**5,171**
1985	301	544	3,048	306	671	465	132	133	131	154	174	131	**6,190**
1986	77	2,130	705	573	1,752	2,377	598	44	47	128	96	1,061	**9,588**
1987	168	426	796	1,156	1,317	357	408	12	3	3	9	5	**4,659**
1988	509	528	939	1,174	564	8	2,006	5	41	2	29	19	**5,824**
1989	3	397	1,231	148	78	521	0	453	46	39	57	134	**3,109**
1990	455	255	294	1,733	1,764	824	1,278	1,080	769	82	31	22	**8,587**
1991	302	377	412	780	1,158	6,760	3,647	1,628	1,156	390	459	363	**17,432**
1992	434	168	1,316	1,994	4,098	5,229	2,775	2,240	945	665	620	478	**20,961**
1993	333	250	2,112	7,951	9,021	11,161	6,414	4,585	2,596	945	587	467	**46,421**
1994	954	557	626	813	4,472	2,857	1,493	960	522	146	129	160	**13,690**
1995	182	242	298	9,752	6,934	11,367	7,146	2,657	1,557	772	439	331	**41,678**
1996	439	745	986	1,067	3,167	2,271	761	530	201	29	32	43	**10,269**
1997	521	1,174	2,496	6,087	2,804	1,070	1,346	388	76	136	46	500	**16,642**
1998	175	742	1,453	1,734	8,567	9,524	6,756	6,321	2,057	1,075	450	396	**39,249**
1999	473	1,076	905	1,430	999	864	1,629	474	337	247	101	139	**8,674**
2000	124	56	96	198	3,225	2,910	1,220	565	224	115	138	116	**8,986**
2001	1,097	464	490	2,051	3,317	3,193	1,715	920	424	153	177	124	**14,124**
2002	188	992	648	532	435	363	317	293	101	120	109	44	**4,142**
2003	201	790	1,997	1,096	3,808	5,226	3,268	2,587	1,575	853	522	559	**22,484**
2004	510	773	1,243	1,148	2,915	1,696	891	420	268	139	153	152	**10,307**
2005	3,619	2,291	2,924	10,322	8,466	10,321	4,974	2,726	1,421	1,233	1,020	882	**50,199**
Average	286	560	1,005	1,774	2,434	2,973	1,804	806	341	178	151	204	**12,516**
Median	175	397	795	1,148	1,317	1,439	761	328	119	28	35	44	**8,587**
Maximum	3,619	2,718	3,816	10,322	9,021	12,298	11,264	6,321	2,596	1,233	1,099	1,357	**50,199**
Minimum	0	0	0	10	37	8	0	0	0	0	0	0	**689**

ATTACHMENT C-2

RANKED

Exceedence Interval and Maximum Potential Diversion from the Santa Margarita River at the Point of Diversion for Water Years 1925 to 2005

Water Year	Maximum Potential Diversion [AF]	Percent Time Exceedence [%]	Exceedence Interval [years]
2005	50,199	1%	82.0
1993	46,421	2%	41.0
1980	45,834	4%	27.3
1941	42,762	5%	20.5
1995	41,678	6%	16.4
1998	39,249	7%	13.7
1978	38,651	9%	11.7
1937	34,918	10%	10.3
1979	31,931	11%	9.1
1943	25,875	12%	8.2
1938	25,493	13%	7.5
2003	22,484	15%	6.8
1969	21,556	16%	6.3
1983	21,464	17%	5.9
1992	20,961	18%	5.5
1944	18,572	20%	5.1
1939	18,543	21%	4.8
1958	18,397	22%	4.6
1991	17,432	23%	4.3
1952	17,333	24%	4.1
1997	16,642	26%	3.9
1932	16,540	27%	3.7
1942	16,209	28%	3.6
1945	15,719	29%	3.4
2001	14,124	30%	3.3
1994	13,690	32%	3.2
1927	12,835	33%	3.0
1940	12,568	34%	2.9
1967	11,889	35%	2.8
2004	10,307	37%	2.7
1996	10,269	38%	2.6
1982	10,046	39%	2.6
1986	9,588	40%	2.5
1966	9,576	41%	2.4
2000	8,986	43%	2.3
1946	8,939	44%	2.3
1947	8,878	45%	2.2
1973	8,749	46%	2.2
1999	8,674	48%	2.1
1954	8,616	49%	2.1
1990	8,587	50%	2.0
1981	7,789	51%	2.0
1962	7,413	52%	1.9
1930	7,013	54%	1.9
1935	6,958	55%	1.8
1926	6,641	56%	1.8

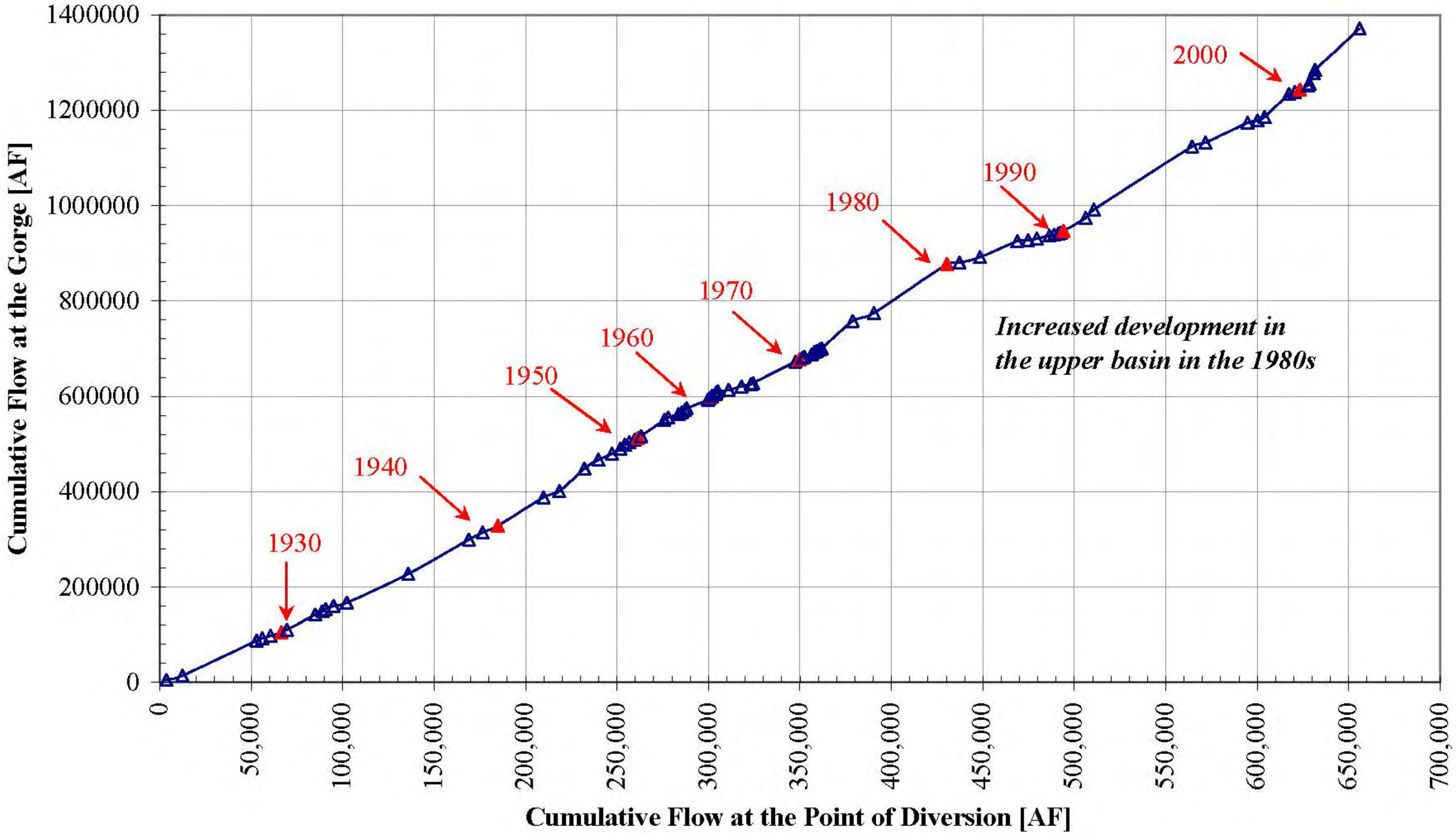
ATTACHMENT C-2

RANKED
Exceedence Interval and Maximum Potential Diversion from the Santa Margarita River at the Point of Diversion for Water Years 1925 to 2005

Water Year	Maximum Potential Diversion [AF]	Percent Time Exceedence [%]	Exceedence Interval [years]
1948	6,266	57%	1.7
1985	6,190	59%	1.7
1949	6,058	60%	1.7
1988	5,824	61%	1.6
1933	5,481	62%	1.6
1976	5,363	63%	1.6
1975	5,320	65%	1.5
1984	5,171	66%	1.5
1936	4,967	67%	1.5
1953	4,936	68%	1.5
1987	4,659	70%	1.4
1928	4,465	71%	1.4
1974	4,245	72%	1.4
1971	4,240	73%	1.4
2002	4,142	74%	1.3
1977	4,045	76%	1.3
1970	4,010	77%	1.3
1950	3,540	78%	1.3
1929	3,451	79%	1.3
1972	3,439	80%	1.2
1955	3,425	82%	1.2
1925	3,334	83%	1.2
1934	3,311	84%	1.2
1931	3,259	85%	1.2
1960	3,163	87%	1.2
1957	3,134	88%	1.1
1989	3,109	89%	1.1
1968	3,024	90%	1.1
1963	2,919	91%	1.1
1951	2,759	93%	1.1
1965	2,677	94%	1.1
1959	2,439	95%	1.1
1956	2,203	96%	1.0
1964	1,552	98%	1.0
1961	689	99%	1.0

ATTACHMENT D-1

Comparison of Streamflow
SMR at the Gorge Vs. Inflow to Vail Lake
Double Mass Curve



Comparison of Streamflow
SMR at the Gorge Vs. Reconstructed flow in the SMR at Point of Diversion
Double Mass Curve